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## GEOGRAPHICAL INDICATIONS AND CAPSICUM DIVERSITY: A COMPREHENSIVE REVIEW OF INDIAN GI TAGGED CHILLIES

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### ABSTRACT

Chilli (*Capsicum* spp.) is one of the globally important crop with immense culinary, economic and medicinal importance. India, with its diverse agroclimatic zones, is home to a remarkable range of chilli cultivars that are regionally unique in flavour, pungency, colour, and cultural importance. To protect and preserve these unique traits, Geographical Indication (GI) tags play a vital role by serving as a legal and cultural tool to recognise and safeguard the identity and authenticity. This article offers a comprehensive overview of eleven GI-tagged varieties of chilli across India, including Naga Mirchi, Guntur Sannam, Byadagi, Mizo, Bhiwapur, Kholra, Harmal, Edayur, Ramnathapuram Mundu, Banaras Lal Bharwa, and Warangal Chapata chilli, highlighting their distinctive sensory and nutritional attributes, historical relevance, cultivation practices, and commercial applications. This review highlights the significance of GI-tagged chilli varieties in preserving regional identity, cultural heritage, and promoting sustainable agricultural practices.

**Keywords :** Chilli, GI tag, Pungency, Colour, Spice.

### Introduction

Chilli belongs to the genus *Capsicum*, exhibits remarkable diversity with over 400 different horticultural types cultivated worldwide. It is used for various purposes, as a vegetable and spice, and in various forms, including fresh, canned, pickled, sauce, frozen, fermented, dehydrated, or processed into chilli powder. It is also employed as food additive, because of their sensory attributes such as bright colour, pungency, unique flavour, and aroma (Deepika *et al.*, 2024). Furthermore, it is a good source of vitamins A, C, and E, but their concentration depends on the cultivar (Bosland and Votava, 2000). In addition, it possesses medicinal properties as an antioxidant, anti-cancerous compound, and capsaicin, which serves as a muscular pain reliever (Shivanand, 2005; Zamljen *et al.*, 2023). These qualities enhance the importance of chilli in nutrition and medicine.

The genus *Capsicum* is highly diversified with around 40 species, originated from the tropical regions of America (Reifschneider, 2000). Rich horticultural

diversity of the genus was such that it has often confused the taxonomists. Chilli was introduced to India by the Portuguese sailors in the 15<sup>th</sup> century, and had spread across the country by late 19<sup>th</sup> century. The long history of cultivation led to rich morphological diversity, especially in the Southern Peninsula, North Eastern Himalayas, and the Gangetic plains (Pradheep & Veeraragavatham, 2006).

In India, chilli is an important food ingredient, popularly known as mirchi and recognised as the 'miracle spice' due to its widespread use. India is a leading force in the global dried chilli market, being the world's largest producer, consumer, and exporter. In 2022, the world's dry chilli production reached an estimate of 8.06 million tonnes, with India contributing 2.05 million tonnes, representing approximately 25.42% of the global production (Deepika *et al.*, 2024).

Indian chillies are globally renowned for their unique commercial qualities, especially pungency and colour. Pungency in chilli is due to capsaicinoids, a group of alkaloid compounds which triggers the

burning sensation (Greenway, 2013; Arguelles, 2022). The primary pungency contributing component is capsaicin. Extent of burning sensation is measured using Scoville Heat Units (SHU), named after Wilbur Scoville, who introduced the organoleptic test (Scoville, 1912). Modern measurement relies on High Performance Liquid Chromatography (HPLC), which calculates SHU by assessing capsaicinoid concentration, typically multiplying capsaicin (in ppm) by a factor of 16 (Collins *et al.*, 1995). American Spice Trade Association (ASTA) defined "pungency units" as one part capsaicin equivalent per million parts dried pepper mass, with SHU derived by multiplying this value by a factor of 15 (Guzman & Bosland, 1995). Different ranges of SHU values and its classification is mentioned in Table 1.

The ASTA (American Spice Trade Association) colour value is a standardised measure of extractable pigment concentration, such as capsanthin and capsorubin, determined according to the AOAC 2002 method with the modification introduced by Topuz *et al.*, 2009 and Velazquez *et al.*, 2019 via spectrophotometry at 460 nm. The calculation follows the formula:

$$\text{ASTA Colour} = \frac{\text{Absorbance 460} \times 164 \times \text{IF}}{\text{Sample weight (g)}}$$

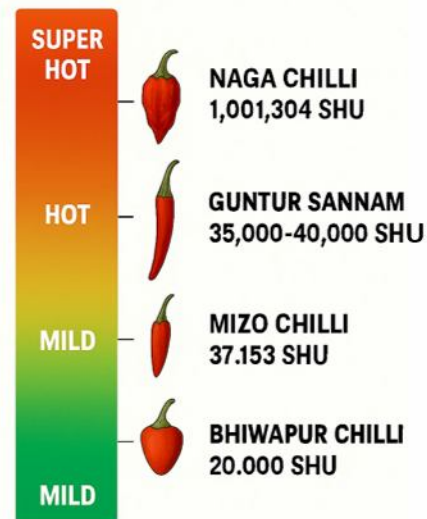
IF is the deviation factor of the spectrophotometer. Values exceeding 250 ASTA are preferred for industrial extraction, while 100–250 ASTA is commercially viable (Babu *et al.*, 2014; Arpaci *et al.*, 2020).

**Table 1 :** Classification of *Capsicum* cultivars based on Scoville Heat Units (SHU)

SHU Range	Pungency level	Examples	Reference
0	No heat	Bell pepper	Crapnell & Banks, 2021
100–2,500	Very mild	Pepperoncini, Banana pepper	Othman <i>et al.</i> , 2011
2,500–10,000	Mild to moderate	Jalapeno, Poblano	Popelka <i>et al.</i> , 2017
10,000–50,000	Hot	Serrano, Cayenne	Po <i>et al.</i> , 2018
50,000–350,000	Very pungent	Habanero, Scotch Bonnet	Csillery, 2006
900,000–2,200,000	Super-hot	Ghost Pepper, Carolina Reaper	Kaiser and Ernst, 2018

*Capsicum* species have spread globally, adapting to diverse climatic conditions ranging from tropical to temperate (Pickersgill, 1997). This adaptation results in the development of region-specific traits, such as unique pungency, flavour, and colour, tied to the distinct environmental conditions of those areas and niche market needs (Fig. 1). Geographical Indications (GIs) play a vital role in protecting and recognising these location-specific chilli varieties, ensuring their authenticity and preserving their economic value (Fig. 2). GI is a sign used on products from a specific geographical area, possessing qualities, reputation, or characteristics essentially linked to that origin (WTO, 2020; Singh and Bharti, 2023). GIs not only safeguard the authenticity of goods, preventing false claims and protecting the reputation of these distinctive chillies, but also empower local producers to secure premium prices, thereby strengthening rural economies and promoting sustainable development (Cerdan *et al.*, 2010; Pellin and Vieira, 2015 and Dias and Mendes, 2017). Further, GI facilitate market access, uplifts marginalized communities, and contributes to the conservation of biodiversity and genetic resources (Brasil, 2014; Artencio *et al.*, 2019 and Garcia *et al.*, 2019).

## SCOVILLE SCALE



**Fig. 1 :** Scoville Heat Scale of GI-Tagged Indian Chillies

In India, the GI Act has enabled the granting of tags under the Registration and Protection Act, 1999 to numerous agricultural products, aiding in the protection of traditional knowledge and enhancing the income of rural producers (Kishore, 2018). Within these agricultural commodities, chilli holds a special

place. Various chilli types, cultivated in specific regions under unique environmental conditions and practices, have been awarded GI tags in India, recognising their distinctive attributes. This article aims to provide a detailed account of chillies that have received GI tags in India. By examining their unique traits, historical significance, and the impact of GI certification, this article highlights the importance of GI in preserving the identity and enhancing the global value of chillies.

### 1. Naga chilli:

The North East region of India is considered as a hotspot for chilli diversity (Mathur *et al.*, 2000). Among them, Naga chilli also known as Naga Mircha or Raja Mircha, which means King of Chillies. It is indigenous to Nagaland, Assam, Manipur, parts of Mizoram, Arunachal Pradesh, Meghalaya, and even the North Eastern regions of Bangladesh (Bhuyan *et al.*, 2015) and is called with different names like Naga chilli in Nagaland, Bhut Jolokia in Assam, and U-Morok in Manipur (Sanatombi *et al.*, 2010; Kumar *et al.*, 2011; Verma *et al.*, 2013). In Nagaland, it is cultivated mainly in Kohima, Peren, Mon, and Dimapur districts across 16,579 sq. km. Its cultivation dates back to 1000 BC, and domestication is intertwined with the North East civilisation. It is famous as one of the hottest chillies in the world with SHU of 1,001,304 (Bosland and Baral 2007; Verma *et al.*, 2013). It is used as spice, pest control, and even warfare by Naga tribes, forming a crucial part of their cultural identity. Recognising its cultural and commercial value, GI tag for the Naga Chilli was granted in 2003 (Table 2).

Initially, Naga chilli was classified as *C. frutescens* (Mathur *et al.*, 2000). Bosland and Baral (2007) placed Naga chilli in between *C. chinense* and *C. frutescens*, with more similarity to *C. chinense*, based on RAPD markers. A unique 13-base pair deletion in the 5.8S gene of ITS region distinguishing it from other chillies (Purkayastha *et al.*, 2012). Molecular characterization of Naga chilli revealed higher expression of pungency related genes such as *CS* (capsaicin synthase), *pun1* (capsaicinoid and capsinoid synthesis), *pAMT* (putative aminotransferase), and *KAS* ( $\beta$ -ketoacyl-ACP synthase) (Kehie *et al.*, 2016).

The monsoon season with high humidity is ideal for cultivation of Naga chilli (Anon *et al.*, 2008). The unique soil and climatic conditions of the North East region allow expression of high pungency, which cannot be easily replicated elsewhere. It thrives well in uplands and valleys with 1200 to 4050 mm rainfall and

6 (winter) to 36°C (summer) temperature (Geographical Indications Journal, 2008). Extreme low and high temperatures is believed to increase its pungency. It is cultivated in hilly regions and plains during kharif and rabi seasons, respectively (Baruah *et al.*, 2014). Rabi crop is more pungent than kharif because of cooler nights, better soil nutrient conditions due to the foreseason kharif paddy and lower humidity, which together stimulate higher capsaicin production (Borgohain and Devi, 2007; Sanju *et al.*, 2012).

Seeds are sown in nursery, and seedlings are ready to transplant in 4-5 weeks, when they attain 5-6 leaves. Either it is intercropped with paddy under jhum cultivation or raised in homestead gardens. Generally, the transplanting is practiced, but in paddy fields, direct seeding is more common during February and March (Bhagowati and Changkija, 2009). Bamboo and banana-enriched soils leads to promote higher pungency. Deep, loose, clay loam soils rich in organic matter (pH 5.5–6.0) yield the best crops (Borgohain and Devi, 2007; Anon., 2008). Plants grow up to 45–200 cm tall with dark green stems and pendant creamy-white to light-green flowers with blue anthers and purple filaments. It behaves as a semi-perennial plant (Borgohain and Devi, 2007) with wide morphological variability (Murmu *et al.*, 2014). It will take 5 months to reach the harvesting stage.

Fruit colour varied from light green, yellowish green to dark green in young fruits and changes to light red, dark red and even chocolate colour upon ripening, with a rough, wrinkled surface. Mature fruit measures 5.9–8.5 cm in length, 2.5–3.0 cm in width and weighs 4–10 g (Malakar *et al.*, 2019). Hundred grams of mature fruit comprises moisture (68.50 g), ash (1.34 g), protein (4.00 g), fat (1.10 g), and carbohydrates (56.25%). Capsaicinoid content of Naga mirchi varies from 2.45 to 5.36 per cent (Liu and Nair, 2010; Sarwa *et al.*, 2012), compared to that of less than 1 per cent in most other Indian chillies, making the former ideal for capsaicin extraction (Ochoa-Alejo and Ramirez-Malagon, 2001). Fruits have a poor shelf life and deteriorate fast if stored under normal conditions for long period. However, in cold storage, protection could be extended up to 8-10 months. Its market price fluctuates from Rs. 600–800/kg in peak months (April to July) and drops to Rs. 200/kg between September and January (Malangmeih and Rahaman, 2016; Meetei *et al.*, 2016).

Naga chilli holds considerable ethno-medicinal value as counter-irritant, anti-arthritic, analgesic, and antioxidant. Anti-cancer properties of capsaicin is used in the treatment of asthma, gastrointestinal issues,

muscle recovery, toothache, and digestive diseases (Higashiguchi *et al.*, 2006; Bhagowati and Changkija, 2009 and Sarwa *et al.*, 2012).

## 2. Guntur sannam chilli

Guntur sannam chilli (*Capsicum annuum* var. *longum*), popularly known as S4 type chilli, is renowned for its distinctive slender fruits. The Telugu word "Sannam" means thin or slender, reflecting the shape and size of this chilli. It is native to Andhra Pradesh and primarily cultivated in the Guntur, Prakasam, Warangal, and Khammam districts (Sharma, 2019).

Guntur with its adjacent districts is renowned as the "chilli capital of India" (Raviteja and Dwivedi, 2023). Sannam chilli has been cultivated in the Guntur region for over 400 years. Guntur Market Yard is the largest chilli market in Asia, and it influences the domestic and international prices of chillies. Considering the importance of Guntur in chilli cultivation, Andhra Pradesh government established the Regional Research Station at LAM near Guntur. Guntur region is characterised by a temperature range of 20 to 40°C, humidity between 60 to 80 per cent, and annual rainfall of 700 to 1500 mm. Guntur chilli's unique attributes, including its colour and pungency, are influenced by the warm and humid climatic conditions of the region. The strong association of Guntur with chillies, both in name and production history, underscores the importance of chilli in the cultural, economic, and agricultural landscape of the region. Guntur Sannam chilli has been granted GI status in 2010 (Table 1) considering the above factors. This chilli is being exporting to China, Vietnam, USA, UK, and Southeast Asia (Sutariya *et al.*, 2025).

The fruit typically measures 5 cm or more in length and 0.5 to 1.5 cm in diameter, with a thick, glossy skin. It is characterized with 0.226 per cent capsaicin (35,000 to 40,000 SHU units), and is widely used to extract capsaicin. Ripened fruit is bright red, with an ASTA value of 32.11. Nutritionally, it is rich in vitamin C (185 mg/100g) and protein (11.98g/100g), making it a valuable ingredient in both culinary and medicinal applications (Geographical Indications Journal, 2009). There are four recognised grades of Guntur Sannam chilli: S.S. (Sannam Special), which is light red and over 5 cm in length; S.G. (Sannam General), light red with 3 to 5 cm length; S.F. (Sannam Fair), which has a dull red colour and similar length as that of Sannam General; and N.S. (Non-Specified), which is of miscellaneous quality (Geographical Indications Journal, 2009).

Guntur sannam chilli is propagated by seeds. Seeds are sown in the nursery at the end of July or the first week of August. Seed rate per hectare is 6.25 kg. After 30 to 40 days of sowing, transplanting is practised with a spacing of 15 cm between plants and 50 to 60 cm in the rows. Some farmers are practising direct sowing also, which is popularly called as the chutki method. In chutki method, 4 - 5 seeds are hand dibbed at appropriate distance and the field was irrigated soon after sowing. Another light irrigation is followed after 3 - 4 days. Seedlings will emerge in 15 to 20 days and when these are 10 -15 cm height, thinning is practiced to reduce crop density as one plant per hill. The flowering starts 40 days after transplanting, with a peak flowering at 60 to 80 DAS. Around 200 flowers will be produced per plant. Flower production is influenced by moisture and fertility status of soil as well as incidence of pests such as thrips and mites. It requires a warm and humid climate for its growth and dry weather during the period of maturation. The peak harvesting season is from December to May (Geographical Indications Journal, 2009).

## 3. Byadagi chilli

Byadagi is a place in the Haveri district of Karnataka. It is situated at an altitude of 500 to 700 meters above sea level and experiences high humidity levels ranging from 65 to 95 per cent, a temperature of 20 to 38°C, and annual rainfall between 500 and 800 mm. Chilli (*C. annum*) with deep red colour and very low pungency grown in this region is popularly known as Byadagi chilli (Bushetti and Krishnamurthy, 2023). It is grown in Dharwad, Haveri, and Gadag districts in an area of 145,000 hectares. (Geographical Indications Journal, 2010). Byadagi chilli was awarded with GI registration in 2011.

ASTA value of Byadagi chilli is as high as 80 to 130, capsaicin content is as low as 0.03 per cent (8000–15000 SHU). The deep red colour is due to the presence of high capsanthin and capsorubin content. Intense colour get further enhanced by dry weather during fruit maturity. The black and red lateritic soils of Karnataka, rich in potash and organic matter, further contribute to enhancing the colour (Jagadeesha *et al.*, 1998). The fruits are 12-15 cm long, thin, with a wrinkled surface. This chilli is used as a source of natural colour in the food industry (Renuka, 2014).

The Byadagi chilli includes several types, with the two main variants namely Byadagi Kaddi (BK) and Byadagi Dabbi (BD). The Kaddi type is slender, light green, and grows up to 15 cm in length, maturing to a deep red colour with high colour value and a negligible

pungency. It is known for its resistance to pests and diseases, well-suited to rainfed conditions and used as an important ingredient in spicy food preparations like bisibele bath, sambar, chutney, particularly in Udupi cuisine. The Dabbi type, shorter and slightly curved, is used for both fresh and dried chilli purposes. BD is highly susceptible to thrips and mites (Ananthaluishnan, 1973, Amin, 1979) and is used as a susceptible local check of above sucking insects (Jagadeesha *et al.*, 1998). It is best suited for oleoresin extraction and masala preparation due to its deep red colour. A newer variant, Dyavanur Delux, is larger and has high demand in the market (Bushetti and Krishnamurthy, 2023). DNA barcoding using ITS2, matK, and rbcL successfully differentiated GI-tagged Byadagi Dabbi and Kaddi chillies from related cultivars, confirming its authenticity and genetic distinctiveness (Meghana and Reshma 2025).

Sowing will be done from May to June, and seedlings are transplanted 40-45 DAS. It is primarily grown as rain-fed crop. The plant grows up to 1 meter height and 1 meter spread, with thin, light green leaves. Flowering commences 40 days after transplanting (DAT), with peak flowering at 60 to 80 DAT. Peak flower production is influenced by moisture and fertility status of soil. The crop will be ready for harvest in about four months. Red ripe chilli will be harvested during November-December, (Geographical Indications Journal, 2010).

Byadagi chillies are sold primarily at the Byadagi market. This market yard is famous as the second largest red chilli market in the country. Byadagi Kaddi (BK) and Byadagi Dabbi (BD) fetches market value of around Rs. 380 and Rs. 430 per kg, respectively. Byadagi chilli is exported to Malaysia, Indonesia, United States, Canada, UAE, Singapore, Nepal, and Sri Lanka. Vibrant colour, mild flavour, and non-irritating profile of chilli support its demand in both ethnic markets and modern spice industries. (Bushetti and Krishnamurthy, 2023). The oleoresin of Byadgi chilli is used in food industries, confectioneries, the beverage industry, cosmetic industry, pharmaceutical industry, meat industry, poultry and cattle feed industry.

#### 4. Mizo chilli

Mizo chilli, locally known as Hmarchte, belongs to *C. frutescens*. It is widely cultivated in Mizoram (Roy and Chandan, 2018) and omnipresent in North Eastern (NE) states (Baruah and Barua, 2004; Mandal and Loya, 2021). Fruits are small, measuring 2.0–4.0 cm in length and about 1.0 cm in diameter. They have a capsaicin level of 37,153 SHU and ASTA colour value of 38, causing its high pungency and vibrant

colour, respectively (Hoffman *et al.*, 1983). It is a key ingredient in spicy cuisine, chutneys, pickles, hot sauces, and noodle dishes (Dutta *et al.*, 2015). These factors made Mizo Chilli distinctly different from other bird's eye chilli varieties. Geographical indication (GI) tag was awarded to Mizo chilli in 2015 (Table 2).

Mizo Chilli is cultivated on hill slopes under the jhum or shifting cultivation system, typically as an intercrop with paddy to supplement farmer's income. Very low yield and high price fluctuation in the market prevents farmers to raise it as a single crop. Seeds are sown by broadcasting and dibbling methods in the month of April before the monsoon. Usually chemical fertilisers or pesticides are not used, burning of forest biomass ensures high availability of potash, which helps the crop to grow well and provides good colour to the fruit. Cultivation is rainfed, which is supported by rainy season extending for six to eight months. Harvesting season is from October to December, with an average yield of about 1.36 MT/ha (Geographical Indications Journal, 2014).

Mizo chilli is classified into three grades based on size, colour, and pungency as grade A, B, and C. Grade A is the smallest, thinnest and highly pungent with a shiny red colour, with high preference and fetches the highest market price. Grade B is slightly longer and thicker than Grade A, with dark red colour and slightly reduced pungency. Grade C closely resembles grade B but is slightly longer. Among these 3 grades, grade A is the most preferred. It is being exported to neighbouring countries such as Bangladesh, China, and Thailand.

#### 5. Bhiwapur chilli

Bhiwapur chilli, a variety of *C. annum* originates from the Bhiwapur region in Nagpur district, Maharashtra (Ravindran *et al.*, 2024; Varivar *et al.*, 2024). Bhiwapur chilli is renowned for its high capsaicinoid content with 20,000–35,000 SHU and deep red colour with ASTA colour value 36.3. Fruits are smaller in size, measuring 1.5 inches in length with a thick outer covering, which prevents breakage and provides a long shelf life. Bhiwapur chilli imparts a striking colour and pungency to food without causing acidity. Additionally, the chilli powder made from this chilli does not attract pests and can be stored up to a year. These factors make Bhiwapur chilli a preferred choice for culinary uses. GI registration for Bhiwapur chilli was obtained in 2016 (Table 2).

The soil in Bhiwapur region is rich in micro-nutrients such as iron, manganese, and copper, with good water holding capacity. The tropical climate of

Bhiwapur, with an average annual temperature of 30°C and rainfall ranging between 1250-1350 mm, creates an ideal environment for chilli growth (Singh *et al.*, 2023). Seeds are sown in July, and transplanting is done in the 1<sup>st</sup> week of August. Flowering starts 45-50 DAT, and green chillies appear 60 days after transplanting which mature to red colour on the plant itself. Bhiwapur chilli has a crop duration of 240 - 270 days. Farmers will harvest red chillies before they get fully dried which is locally called “toda or doda.” These will be kept for sun drying and processed into chilli powder.

These chillies are an excellent source of vitamin A, B, C, molybdenum, potassium and magnesium. Nutritional content of 100 g Bhiwapur chilli constitutes 166 calories of energy, 8.8 g of carbohydrates, 5.3 g of sugar, 1.5 g of dietary fibre, 1.9 g of protein, and 0.4 g of fat. It offers various medicinal properties such as relief from arthritis pain, digestive issues, and inflammation of the lungs (Geographical Indications Journal, 2016).

## 6. Khola chilli

Khola chilli (*C. annuum*) is cultivated exclusively in the Khola village, located on the hilly slopes of the Western Ghats in South Goa (Variyar *et al.*, 2024). This region is characterised by a unique climate with cool, humid, and cloudy conditions in July-August, followed by hot and humid conditions in October. These climatic conditions enhances vegetative growth and gives brilliant red colour to fruits during maturation. Fruits are medium pungent (17,100 SHU), with a brilliant red colour (34.3 ASTA units), and have a thick outer covering which contributes to a longer shelf life. It is one of the longest chilli type in Goa, with fruit length ranging from 5.6 to 7.4 cm, with a diameter of 1.2 to 1.4 cm. The famous restaurants and papad makers prefer the Khola chilli because of its peculiar colour and taste. This chilli got GI tag in the year 2019 (Mukherjee *et al.*, 2023; Ravindran *et al.*, 2024).

Khola chillies are propagated through seeds. Initially, seeds are sown in nursery beds, and 5-6 weeks old seedlings of 15-20 cm height are transplanted after the onset of monsoon, in June. The seed rate is 1-1.5 kg per hectare. These chillies thrive well in nitrogen- rich soils of pH 5.5 to 6.5, which helps in plant growth and pigment synthesis, especially fruit colour and quality (Jang, 2024). This chilli is cultivated under rainfed conditions with no chemical fertilisers. Organic farming practices such as green manuring and intercropping with legumes further enhance soil nitrogen and reduce soil erosion during

heavy rainfall (Bidari & Hebsur, 2011). The plant grows up to a height of about 80 cm, with an upright habit and narrow spread. The flowering commences 25-30 DAT, with a peak flower production at 40-45 DAT. On average, it will produce around 300 fruits per plant. The crop is ready for harvest in about three to four months, typically from August to September, with a total crop duration of six months. Farmers are traditionally involved in the cultivation of Khola chilli from May to October.

Fruit consists of 12.10 per cent protein, 15.52 per cent fat, and 60.04 per cent carbohydrate, with an energy value of 428.24 kcal per 100g. It is also rich in vitamin A and C. Further it contains a higher amount of minerals such as potassium (14080.00 mg/kg), manganese (705.28 mg/kg), iron (217.95 mg/kg), and magnesium (705.28 mg/kg). This higher mineral composition is due to the mineral rich soil. Fruit also has high content of reducing sugars (13 per cent) and proline content (85 per cent), indicating better energy production and stress resilience, making it more adaptable to environmental stress (Kumar & Sahi, 2014; Kishor, 2015).

Women farmers of Khola region are involved in preparing value added products from Khola chillies, including recheado masala, green chilli pickle, raw mango pickle, red chilli sauce, Khola chilli powder and Khola chilli flakes (Geographical Indications Journal, 2019). The Khola chilli cultivators group was awarded with the prestigious plant genome saviour community award in 2016 for its efforts in conserving the local Khola variety through traditional cultivation methods.

## 7. Harmal chilli

Harmal chilli, grown in Harmal village in Pernem Taluka, Goa (Ravindran *et al.*, 2024; Variyar *et al.*, 2024), is known for its medium to high pungency (0.18% capsaicin and 28,200 SHU) and a distinct reddish-brown colour (48.8 ASTA). The fruits are narrow and triangular in shape, measuring 2.70 to 3.70 cm in length and 1.10 to 1.40 cm in diameter, with non-wrinkled skin and a strong stalk, which enhances its shelf life. These chillies are unique in their size, skin texture, and spicy flavour, making them highly valued in local cuisine and a highly prized spice in the region (Geographical Indications Journal, 2020).

Harmal chilli is cultivated in lateritic soils with a PH of 5.5 to 6.5. Land preparation starts in the month of December and is traditionally grown after the kharif paddy. Seeds are sown in nursery and will take about 12-15 days to germinate. Transplanting is done after 40-45 days when the seedlings reach a height of 20 to 30 cm. A spacing of 30 to 40 cm is maintained

between plants, and the seed rate adopted is 1 to 1.5 kg per hectare. Farmers follow a traditional practice of mixing fertilisers with dry ash or dry cow dung and applying it in the root zone, which will help in slow release of fertilisers. The soil in Harmal village is neither too dry nor too wet; instead it remains in a moist condition. This ensures adequate moisture in the root zone for optimal root growth. The application of organic manures and fertilisers enhances root activities. To control pests and diseases, farmers usually resort to garlic water spray. The plant has an upright habit, grows up to 100 cm with a narrow spread. Flowering starts 25-30 DAT, reaches peak stage at 40-50 DAT. Fruiting and are ready for harvest in about 3 to 3½ months after transplanting and continues till May first week. Harvesting begins in March, with the peak period occurring from the end of April to the first fortnight of May. The total duration of the crop is 140-150 days and farmers of Harmal village will be engaged in chilli production from December to May. Each plant bears around 250-300 fruits providing a yield of 1.0 to 1.5 tons of dry chillies per hectare (Geographical Indications Journal, 2020).

Harmal chilli has a high energy value (413.17 Kcal per 100g), contains 13.52 per cent protein, and is rich in nutrients and minerals such as magnesium, calcium, iron, sodium, and potassium. Harmal chilli is exclusively used in dry form either as whole powder or blended with other masalas or powders in different proportions to suit Goan cuisines such as chicken xacuti masala, garam masala for khatkhate and rechad masala (fish masala). Its smooth texture and medium to high pungency make it an important ingredient in Meeth Mirsangie (a chilli-salt paste), Vindaloo, and other traditional Goan recipes (Sen *et al.*, 2023).

### 8. Edayur chilli

Edayur chilli (*C. annuum*), locally known as Edayur Mulaku, is a traditional cultivar grown for over 150 years in Valanchery and Angadippuram blocks in Malappuram district, Kerala. It is cultivated on hills, hillocks, and lateritic soils, and is characterised by its exceptionally long fruits, unique flavour, aroma, and low pungency (Pavani *et al.*, 2015). It is ideal for making “fried chillies” and “kondattom mulaku” (sun-dried curd chillies). Capsaicin content is only 0.008–0.028 per cent with SHU value is 3097.13 and so it is not suitable for making chilli powder.

Edayur chilli is grown in kharif season as a transplanted crop. Before sowing, seeds are soaked in water overnight, and are covered with a wet cotton towel. The towel must be wet frequently during over night to avoid drying. Seeds are sown during next day

morning and will get germinated in one week. Seeds will be sown during April, and seedlings will be transplanted 40 DAS during May-June, before the onset of heavy South West monsoon. It is grown in low lying areas in soils having good aeration and a pH of 6-7. It is an annual, semi-upright plant growing 75–85 cm tall, with solitary white drooping flowers. Flowering starts 40-50 DAT, and harvesting starts after one month of flowering. Fruits are moderately triangular, long, smooth, and change from green to bright red on ripening. Pedicel attachment to the stem is weak, which facilitates easy harvest. At the start of harvest season, the fruits are of larger size with less pungency and are in great demand as these are primarily used for making fried chilli. After two months, the size of the fruit will be reduced, whereas pungency will increase, showing a negative correlation between the fruit size and pungency. Yield is about 3.5–5 tonnes per hectare.

Hundred gram of fruit comprise 84.5–87.3 per cent moisture, 1.9–2.9 per cent protein, 2.0–3.2 per cent oleoresin, along with vitamin C (20.0–32.9 mg/100g), niacin (0.07–1.02 mg/100g), rutin (20.0–27.7 mg/100g), and minerals like potassium, sodium, calcium, magnesium, and iron (Geographical Indications Journal, 2020).

### 9. Ramanathapuram Mundu chilli

Ramanathapuram Mundu chilli, is growing exclusively under the coastal saline belt of Ramanathapuram, Sivagangai, Tuticorin and Virudhunagar districts of Tamil Nadu. It is otherwise called chatty mundu. The name "Mundu" comes from the Tamil word meaning "fat and round," depicting the fruit's shape and confirming the chilli's Tamil origin (Kruthika, 2024). Fruits have thick pericarp (0.24 mm) and measure 0.5-1.4 inches long and 2.4-3.1 cm in diameter (Kabilan *et al.*, 2021). Fruits are dark red (ASTA colour value of 37.4) at maturity, with smooth, thick skin and medium pungency (17,500 SHU) with high oleoresin content (14.86 per cent), and aroma, making it popular in South Indian cuisine and as a natural food colourant (Kumar *et al.*, 2021). It is traded as Ramnad S9 red mundu chilli, and because of its unique flavour and aroma, this chilli acquired national and international praise and got a GI tag (Table 2). It is exported to China, America, Europe, Thailand, Italy and Japan (Kruthika, 2024).

Growing tracts of Ramanathapuram Mundu chilli are characterized with black cotton soils with moderate to high alkalinity (pH 7.5-9.0) and low annual rainfall (460.0 mm). It is grown as a direct sown crop during September- October with the help of monsoon showers

(North East monsoon). It is raised as a rain fed crop and is highly tolerant to drought and salinity (Rajamanickam *et al.*, 2023). Seed rate adopted is 2.5 kg to 3 kg per acre. The plant has a semi-erect growth habit, dark green leaves, and drooping flowers. Dried fruits are having great demand, and after harvesting, they will be exported (Geographical Indications Journal, 2022).

### 10. Banaras Lal Bharwamirch

Banaras Lal Bharwamirch, a highly valued chilli type predominantly grown in the North-Eastern region of Uttar Pradesh, especially Varanasi and nearby districts like Azamgarh, Jaunpur, Ghazipur, and Ballia, is known for its low pungency, nutritional value, and distinctive culinary use. Traditionally, it is used in the preparation of stuffed red chilli pickle "Laal Mirch ka Bharwa Achar". Fruits are not very hot but develop a unique, thin, paper-like skin ideal for pickling. Unripe fruits are non-bitter, but the ripened ones are slightly bitter. Fruits are long and wide, with 9.50 cm and 2.08 cm respectively, and a single fruit weighs around 8-12 grams (Geographical Indications Journal, 2023).

Banaras Lal Bharwamirch is cultivated in well-drained loamy soils, rich in organic matter, with a pH of 6.5-7.5. The seeds are sown in August, and transplanting will be done 40-45 DAS. Spacing followed is 45cm x 45 cm and the plant reaches a height of more than two feet. Harvesting starts 75 DAT and produces about 40 fruits per plant, contributing to an impressive yield of 34.96 tons per hectare. Fruits are rich in vitamins such as C, B6, K1, and A and minerals like potassium, copper, and have small amounts of protein and fibre (Geographical Indications Journal, 2023).

### 11. Warangal Chapata chilli

Warangal Chapata chilli, a distinct landrace of *C. annuum* is cultivated in approximately 3,000 hectares across Warangal, Hanumakonda, Mulug, and Jayashankar Bhupalapally districts of Telangana. The cultivation of this chilli has started 80 years ago, particularly within the Velama community. It is locally known as "Tomato chilli" due to its blocky, tomato-like appearance (Shiva *et al.*, 2010). The fruits are bigger in size with thick-walled, moisture-retentive, and low in brittleness fruit rind, with distinct sunken bases and depressed apices, contributing to their unique appearance (Kumari *et al.*, 2021). This chilli is renowned for its brilliant red colour (134.1-149.1 ASTA units), mild pungency, and high oleoresin content (6.37%-6.75%), making it ideal for oleoresin extraction and natural colouring in the food and

beverage industry (Srinivas *et al.*, 2017). It has low capsaicin (0.02 - 0.04 per cent) with mild Scoville Heat Units (3,100-6,500), making it suitable for pickling and culinary uses requiring low heat.

Warangal Chapata chilli is available in three pod types, i.e double patti, single patti, and odalu and each type is characterised by a distinct shape and structure. Double Patti fruits are short, stout, sunken at the base, and highly pigmented with brilliant red colour and negligible pungency, making them premium for paprika and oleoresin extraction. Single Patti pods are longer with a round base and blunt ends, while Odalu types are the longest with variable tip shapes and slightly lower colour intensity. Odalu type is widely cultivated for its use in dried chilli trade and fresh fruit applications such as pickling. The fruit measures 8-15 cm in length and 2 to 4.8 cm in girth. Rich red colour enhances its market appeal and trade names like "Nagaram Kaaya (urban fruit)" and "Moodu Mukkula Kaaya (three lobed fruit)" reflect local shape variations (Tirupathamma *et al.*, 2018).

Warangal Chapata chilli is cultivating in sandy clay loam to heavy clay soils of pH 6.5 to 7.5, which is rich in phosphorus and potassium. The average temperature in the growing tract ranges from 20 to 34°C and rainfall is 970 mm. Sowing is done between July third week to August first week, and the seed rate adopted is 1.5 to 2.0 kg per acre. Seedlings of 40 to 50 days old are best for transplanting which is usually done during the first week of September to the first week of October. Flowering starts 45-50 DAT, and each plant bears 100 to 120 fruits. The fruits will mature in 50-60 days and will turn from orange red to deep red colour. (Janaki *et al.*, 2015; Srinivas *et al.*, 2017). Harvesting will be done between February and March and the average yield is 12-16 Q/acre. Each plant produces fewer but larger fruits with weak pedicle attachment, which facilitates easy harvesting, (Geographical Indications Journal, 2024). The flowers and fruits are prone to severe infestation by thrips, as the flowers are big and the fruits are succulent (Kumari *et al.*, 2021). Growing of Maize or Jowar around the field as a border crop in three to four rows will help to avoid pest infestation.

Protein and crude fibre in this chilli range from 17.57-18.55 per cent and 35.61-39.49 per cent, respectively. It contains essential minerals like iron, calcium, and magnesium. Warangal Chapata chilli has high demand in domestic markets such as Enumamula (Warangal), Nagpur, Mumbai, Ahmedabad, and parts of Uttar Pradesh and global markets, West Asian and European countries. Because of GI tag, there is a rise

in price from ₹300 to ₹550 per kilogram (Ganesh, 2023).

### GI tagged chilli varieties of India

Sl. No	Geographical Indications	Application Number	Applicant Name	Date of Filing	Class	Goods	Geographical Area	Certificate Number	Certificate Date	Registration Valid Upto
1	Naga Mirchi	109	The Secretary, Department of Horticulture & Agriculture	22/08/2007	31	Agriculture	Nagaland	99	02/12/2003	21/08/2027
2	Guntur Sannam chilli	143	Spice Board	29/10/2008	30	Agriculture	Andhra Pradesh	122	28/05/2010	28/10/2028
3	Byadagi chilli	129	Spice Board	01/08/2008	30	Agriculture	Karnataka	147	27/01/2011	31/07/2028
4	Mizo chilli	377	North Eastern Regional Agricultural Marketing Corporation Ltd (NERAMAC)	27/01/2012	30	Spices (Chilli)	Mizoram	223	23/03/2015	26/01/2032
5	Bhiwapur chilli	473	Bhiwapur Mirchi Utpadak Samuha Gat	26/03/2014	30	Agriculture	Maharashtra	278	09/03/2017	25/03/2034
6	Khola chilli	618	The Khola /Canacona Chilli Cultivator's Group Association (TKCCGA)	06/08/2018	30	Agricultural	Goa	356	28/08/2019	05/08/2028
7	Harmal chilli	642	The Harmal-Pernem Chilli (Mirchi) Growers Association	14/01/2019	30	Agricultural	Goa	387	14/09/2021	13/01/2029
8	Edayur chilli (Edayur Mulaku)	662	Edayoor Chilli Growers Association (ECGA)	03/10/2019	30	Agriculture	Kerala	388	14/09/2021	02/10/2029
9	Ramanathapuram Mundu chilli	720	Ramnad Mundu Chilli Producer Company Limited	16/11/2020	31	Agricultural	Tamil Nadu	441	22/02/2023	15/11/2030
10	Banaras Lal Bharwa mirch (Red Pickel chilli)	823	Pragatisheel Arajiline Farmer Producer Company Limited	03/02/2022	31	Agriculture	Uttar Pradesh	587	30/03/2024	02/02/2032
11	Warangal Chapata chilli	984	Thimmampet Chilly Farmer Producer Company Limited	06/09/2022	30	Agriculture	Telangana	665	28/03/2025	05/09/2032

### Conclusion

India's GI-tagged chilli cultivars are living expressions of regional agro-biodiversity and traditional cultivation wisdom. Each GI-tagged chilli cultivar expresses its unique traits shaped by its environmental conditions, genetic constitution, market

needs and cultivation practices. Some of them like Naga Mircha and Mizo Chilli, are very hot, having high Scoville Heat Units (SHU) and used for their intense pungency. Others, such as Warangal Chapata, Byadagi and Harmal chillies, are deep red in colour with high ASTA values, making them ideal for natural

pigment extraction. Guntur Sannam has moderate heat with consistent colour and oleoresin content, serving both culinary and industrial uses. Banaras Lal Bharwamirch are known for their low pungency, distinct aroma, and suitable for traditional pickled preparations. This wide range of traits from intense

heat to vibrant colours highlights the rich genetic diversity of Indian chilli landraces, and it emphasises the need to preserve these region specific cultivars through Geographical Indication (GI) protection for the interests of both farmers and consumers.



**Fig. 2 :** GI-Tagged Chillies and Their Regional Origins in India

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