

Prospects of Tea Processing in India

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ABSTRACT

Tea, derived from the *Camellia sinensis* plant, holds significant cultural, economic and health importance globally. This review explores the diverse types of tea including black, green, oolong, white and herbal each offering distinct flavors, aromas and potential health benefits attributed to their antioxidant-rich composition. India, particularly Assam and Darjeeling, plays a pivotal role in global tea production despite facing challenges such as climate variability and technological advancements. The tea processing journey from plucking to packaging, is crucial in ensuring the quality and flavor of the final product. Herbal teas, crafted from various plant materials, offer caffeine-free alternatives appreciated for their unique flavors and health-promoting properties. Assessing tea quality involves sensory evaluation tailored to consumer preferences, augmented by Molecular Assisted Selection (MAS). MAS accelerates tea breeding by pinpointing genetic markers linked to preferred flavors and aromas, ensuring consistent quality standards to meet consumer demands efficiently. As global tea consumption continues to rise, addressing cultivation, processing challenges and sustainability practices becomes imperative for industry growth and preserving tea's rich cultural heritage. Tea's diverse varieties and qualities ensure its enduring appeal as a beloved beverage celebrated worldwide for both its sensory pleasures and potential wellness contributions.

Keywords: *Camellia sinensis*, Herbal teas, Antioxidants, Caffeine, Health benefits

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INTRODUCTION

Tea, scientifically known as *Camellia sinensis*, belongs to the *Theaceae* family. It is an evergreen shrub or small tree native to East Asia, specifically China and India and is cultivated in many other regions around the world. The leaves of the tea plant are harvested for making various types of tea, including green tea, black tea, oolong tea and white tea. The tea plant is characterized by its glossy, dark green leaves and small white flowers. *Camellia sinensis* is prized not only for its cultural and social significance but also for its health-promoting properties attributed to its rich content of polyphenolic compounds such as catechins and flavonoids, which have antioxidant and potential health benefits (Godswill *et al.*, 2020). Teas derived from *Camellia sinensis* have been consumed for centuries and continue to be popular globally for their diverse flavors and potential health benefits.

India is one of the largest producers of tea globally, renowned for its rich and diverse tea-growing regions. The production of tea in India is primarily concentrated in states like Assam, West Bengal, Tamil Nadu and Kerala. Assam, with its vast tea estates, leads India's tea production due to its ideal climate with ample rainfall and fertile Brahmaputra River valley soil (Bajaj, 2021). It is particularly famous for its robust and malty black teas. West Bengal, notably Darjeeling, produces high-quality aromatic teas known as Darjeeling teas, favored for their unique muscatel flavor and delicate aroma (Datta, 2010). Tamil Nadu, in the south, mainly produces black teas, while Kerala focuses on both black and green tea production. The tea industry in India is a significant contributor to the economy, providing employment to millions of people and supporting a thriving export market. Tea cultivation in India typically involves large tea estates as well as smaller tea gardens, each contributing to the country's rich tea heritage and diverse tea offerings in both domestic and international markets (Mondal & Samaddar, 2021).

MATERIALS AND METHOD

Processing procedure

The standard procedure for processing tea powder involves several key steps to ensure the quality and flavor of the final product (Kumar

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et al., 2018). The general outline of the process is:

Plucking

Tea leaves are carefully plucked from the *Camellia sinensis* plant. The quality of the leaves and the timing of harvesting (usually young and tender leaves) significantly impact the flavor and aroma of the tea powder.

Withering

The freshly plucked tea leaves undergo withering, where they are spread out in a well-ventilated area or on trays. This process reduces moisture content in the leaves, making them more pliable for subsequent processing steps.

Rolling

The withered leaves are then rolled to break down the cell walls and release enzymes that initiate oxidation. Rolling can be done manually or mechanically, depending on the scale of production and desired outcome.

Oxidation/Fermentation

For certain types of tea (like black tea), oxidation is a crucial step where the rolled leaves are spread out in a humid environment to promote enzymatic browning. This process alters the chemical composition of the leaves and develops characteristic flavors and colors.

Drying

Once the desired level of oxidation is achieved, the tea leaves are dried to halt the oxidation process. Drying can be done using hot air drying, pan firing or oven drying, depending on the type of tea and regional preferences.

Grinding/Milling

After drying, the tea leaves are typically sorted and graded based on size and quality. The leaves may then be finely ground or milled into powder using specialized machinery. This step is crucial for producing tea powder, which is used for various applications such as instant tea mixes or culinary purposes.

Packaging

Finally, the tea powder is packaged into appropriate containers to preserve freshness and flavor. Packaging materials and methods vary depending on the intended market and shelf-life requirements.

Challenges of tea processing in India

The tea processing industry in India faces multifaceted challenges spanning from farming to processing. In terms of farming, issues such as climate change-induced weather variability, including erratic rainfall and extreme weather events, threaten consistent tea yields and quality. Labor shortages exacerbate these challenges, impacting crucial tasks like plucking and pruning. Managing pests and diseases remains a persistent challenge, necessitating effective yet sustainable control measures. On the processing front, ensuring consistent tea quality throughout stages like withering, oxidation and drying is crucial but requires modernization of infrastructure and technology. Furthermore, maintaining environmental sustainability amidst increasing global demands for eco-friendly practices adds complexity. Addressing these challenges requires comprehensive strategies integrating technological advancements, sustainable practices and robust labor management to sustain India's position as a leading tea producer and exporter (Kumarihami



Figure 1: Black tea

& Song, 2018).

Types of Tea

Tea, a beloved beverage enjoyed worldwide, comes in various types, each offering unique flavors, aromas and health benefits. Tea can be broadly categorized into several types based on their processing methods and characteristics. Here are the main five types of tea which are mostly consumed in India (Kaur *et al.*, 2019):

Black Tea

Black tea, derived from the *Camellia sinensis* plant, is the most oxidized type of tea, resulting in its bold flavor, dark color and robust character. The leaves are withered, rolled, oxidized (allowed to react with oxygen) and then fired to halt oxidation (Gulati, 2013). Black teas are often strong and rich, with variations in flavor based on factors such as region and processing techniques. Black tea is rich in antioxidants, particularly polyphenols like theaflavins and thearubigins, which contribute to its potential health benefits such as promoting heart health and improving digestion (Wiseman *et al.*, 1997, Kumar *et al.*, 2024). Commonly enjoyed with or without milk and sugar, black tea remains a popular choice for its stimulating effects and comforting taste, making it a staple in many cultures around the world.

Green Tea

Green tea is another popular type of tea, known for its delicate flavor and potential health benefits. It undergoes minimal oxidation, preserving its natural green color and delicate flavor profile (Ahmed & Stepp, 2013). Green teas can range from grassy and vegetal to nutty and sweet, with variations in aroma and taste influenced by factors like terroir and processing methods. Green tea is traditionally enjoyed plain or with a touch of honey and lemon. It contains a



Figure 2: Green tea

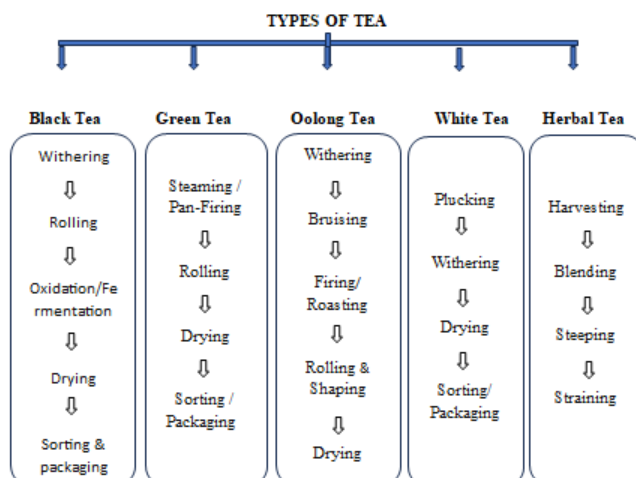




Figure 3: Oolong tea



Figure 4: White tea

moderate amount of caffeine, providing a mild stimulant effect without the jittery feeling often associated with coffee (Hinojosa-Nogueira *et al.*, (2021).

Oolong Tea

Oolong tea is a traditional Chinese tea that falls between green and black tea in terms of oxidation levels, resulting in a unique flavor profile (Xu & Chen, 2002). The leaves are withered, bruised and oxidized to varying degrees before being fired to stop oxidation. Oolong teas can range from floral and fruity to toasty and creamy, with a wide spectrum of flavors and aromas depending on the level of oxidation.

White Tea

White tea is known for its delicate flavor and subtle aroma and it's considered one of the least processed types of tea. White tea is a popular variety cultivated across various regions including India, China and Sri Lanka (Kumarihami & Song, 2018). Originating from China's Fujian province, white tea boasts a rich history of production using traditional methods that span centuries. The regions of Darjeeling and Assam in India also yield exceptional white teas celebrated for their nuanced and delicate flavors (Hazra *et al.*, 2019).



Figure 5: Herbal tea

Herbal Tea

Herbal tea, also known as tisane, differs from traditional tea (such as black, green, white or oolong tea) in that it is not made from the leaves of the *Camellia sinensis* plant. Instead, herbal teas are made by steeping various herbs, spices, flowers, fruits and other plant materials in hot water (Niraula, 2019). Herbal teas come in a wide variety of flavors and can be caffeine-free, making them a popular choice for those seeking a caffeine alternative (Mars, 2009).

Table 1: Composition & benefits of different types of tea

Types of Tea	Composition	Benefits	Side Effects
Black Tea	Polyphenols, Caffeine, Flavonoids, Theaflavins, Thearubigins	Antioxidant properties, mild stimulant effect, flavor enhancement, potential health benefits	Caffeine sensitivity (insomnia, nervousness, rapid heartbeat), Iron absorption inhibition, Teeth staining, Gastrointestinal issues
Green Tea	Catechins (especially EGCG), Caffeine, Amino Acids, Vitamins & Minerals	Rich in antioxidants, may support metabolism, calming effects of L-theanine	Caffeine sensitivity (insomnia, nervousness, rapid heartbeat), Stomach irritation, Iron absorption inhibition, Potential drug interactions
Oolong Tea	Polyphenols (including catechins and theaflavins), Caffeine, Amino Acids, Vitamins & Minerals	Antioxidant properties, potential metabolic support, calming effects of L-theanine	Caffeine sensitivity (insomnia, nervousness, rapid heartbeat), Stomach irritation, Bone health concerns (calcium absorption inhibition), Potential drug interactions
White Tea	Antioxidants (polyphenols, catechins, flavonoids), Caffeine, Amino Acids, Vitamins & Minerals	High antioxidant content, gentle energy boost, relaxation benefits of L-theanine	
Herbal Tea	Phytochemicals (polyphenols, flavonoids, terpenes), Vitamins & Minerals, Essential Oils	Varied health benefits depending on herbs used, may support immune function and digestion	Allergic reactions (skin rashes, itching, respiratory symptoms), Interaction with medications, Pregnancy and breastfeeding concerns, Digestive discomfort

Source: Luczaj & Skrzydlewska, (2005), Kochman *et al.*, (2020), Chen *et al.*, (2010), Chaturvedula & Prakash, (2011).



Types of Herbal Tea and Their Benefits

Chamomile Tea

Chamomile tea, crafted from dried flowers of *Matricaria chamomilla* or *Chamaemelum nobile*, is celebrated for its calming effects and delicate flavor. Caffeine-free, it's favored for relaxation and promoting sleep, with a gentle floral taste hinting at apple or hay. Steeping flowers in hot water extracts beneficial compounds believed to aid digestion, boost immune health and relieve stress (Hosen & Madhu, 2023). Chamomile also boasts antibacterial, anti-inflammatory, antioxidant properties, benefiting liver health and treating conditions like diarrhoea and stomach ulcers by reducing acidity and inflammation (McKay & Blumberg, 2006).

Peppermint Tea

Peppermint tea is a refreshing herbal infusion made from the dried leaves of the peppermint plant, scientifically known as *Mentha × piperita*. It is a popular beverage known for its invigorating aroma and crisp, minty flavor. Peppermint tea has a long history of consumption, dating back centuries, revered not only for its delightful taste but also for its believed therapeutic qualities, particularly in soothing gastrointestinal discomfort. The tea is naturally caffeine-free, making it a popular choice for those seeking a calming and refreshing drink any time of day. Peppermint tea is believed to have various health benefits, including aiding digestion, relieving indigestion and bloating, alleviating nausea and soothing headaches and muscle tension. Additionally, the menthol in peppermint tea provides a cooling sensation and may help clear nasal congestion and alleviate respiratory symptoms (McKay & Blumberg, 2006).

Ginger Tea

Ginger tea, from *Zingiber officinale*, is celebrated for its spicy flavor and health benefits. Caffeine-free, it's enjoyed any time, especially for comfort or wellness in colder weather. Known in traditional medicine for aiding digestion, relieving nausea, reducing inflammation and boosting immunity, ginger tea's active compounds like gingerol and zingerone offer potent antioxidants and anti-inflammatory effects, also soothing menstrual cramps and muscle soreness (Shahrajabian *et al.*, 2019).

Hibiscus Tea

Hibiscus tea, made from dried *Hibiscus sabdariffa* calyces, is renowned for its tangy flavor and crimson color. It's cherished globally for its caffeine-free nature, suitable for any time of day, hot or cold. Rich in antioxidants like flavonoids and anthocyanins, it supports cardiovascular health, aids digestion and hydrates. Its tart taste offers a refreshing option to sugary drinks, potentially lowering blood pressure, reducing inflammation and boosting immune function (McKay *et al.*, 2010).

Echinacea Tea

Echinacea tea, derived from *Echinacea purpurea*, features roots, leaves and flowers prized for immune support and easing colds. Mildly earthy with sweetness, it's comforting and believed to harbor flavonoids, polysaccharides and alkamides enhancing immunity, reducing inflammation and potentially bolstering antioxidant defences. Echinacea tea aids wellness without claiming to cure all, popular among those preferring natural immune support (Lindenmuth & Lindenmuth, 2000).

Rooibos Tea

Rooibos tea, also known as red bush tea, originates from South Africa's Western Cape region and is cherished for its rich flavor, vibrant red hue and myriad health benefits. Unlike traditional *Camellia sinensis* teas, rooibos is naturally caffeine-free, making it ideal for a soothing, anytime beverage. Its smooth, slightly sweet taste with notes of nuttiness and caramel offers a delightful alternative to caffeinated drink. Rich in antioxidants like flavonoids and polyphenols, rooibos tea combats free radicals, potentially lowering chronic disease risks and promoting well-being. Its anti-inflammatory properties may aid conditions such as arthritis and allergies. Additionally, rooibos tea supplies essential minerals such as calcium, magnesium, potassium that support bone health, muscle function and blood pressure regulation. This combination of refreshing taste and potential health benefits has made rooibos tea a beloved choice among global tea enthusiasts (Von Gadow *et al.*, 1997; Olivier *et al.*, 2012).

Sage Tea

Sage tea, derived from *Salvia officinalis* leaves, is renowned for its savory flavor, distinct aroma and potential health benefits. Caffeine-free and enjoyed throughout history across cultures, sage tea offers a robust taste with hints of mint and pine. It's valued for soothing sore throats, easing digestion and supporting overall well-being. Rich in antioxidants, essential oils and vitamins like K and A, sage tea is believed to possess anti-inflammatory, antimicrobial properties, bolstering immunity, reducing inflammation and protecting against oxidative stress (Sa *et al.*, 2009; Yazgan, 2020). Traditionally used to relieve colds, flu and respiratory issues, sage tea's antimicrobial actions may combat infections, while its calming effects offer relief from coughs. Sage tea also supports cognitive function, enhancing mental clarity and focus, further enhancing its appeal (Yazgan, 2020).

Lemon Balm Tea

Lemon balm tea, crafted from *Melissa officinalis* leaves, offers a soothing, caffeine-free infusion suitable for any time of day. Mild in taste, it can be enjoyed alone or blended for unique flavors, providing a gentle alternative to caffeinated drinks. Valued for its potential health benefits, lemon balm tea promotes relaxation, reduces stress and anxiety and supports overall well-being. Rich in antioxidants, notably rosmarinic acid, it offers anti-inflammatory and antimicrobial properties, protecting against oxidative stress and bolstering immune function. Essential oils like citral and citronellal enhance its aroma and health benefits (Carnat *et al.*, 1998). Traditionally used to alleviate insomnia, anxiety and digestive discomfort, lemon balm tea's calming properties aid relaxation, enhance sleep quality and soothe digestive issues such as bloating. It also supports cognitive function and mood, enhancing mental clarity and emotional well-being (Ullah & Hassan, 2022).

Rose Hip Tea

Rose hip tea, derived from *Rosa canina* dried fruits, delights with its tart, tangy flavor, vibrant color and numerous health benefits. Caffeine-free and rich in vitamin C and antioxidants, it promotes overall well-being. Offering a fruity, slightly floral taste with hints of sweetness, rose hip tea supports immune health, skin health and heart health. High in antioxidants like vitamin C, it combats oxidative stress, reduces inflammation and boosts immune function (Ilbay *et al.*, 2013). Rich in flavonoids, carotenoids and polyphenols, rose hip tea maintains its vibrant color and enhances

health benefits. Traditionally used to ease colds, flu and respiratory infections, its vitamin C content strengthens immunity, lessening illness severity and duration. Rose hip tea also supports skin health, stimulating collagen production and guarding against premature aging (Ayati *et al.*, 2018).

Passionflower Tea

Passionflower tea, derived from *Passiflora incarnata* leaves, stems and flowers, offers a gentle, caffeine-free infusion cherished for its calming effects. Enjoyed for centuries, it promotes relaxation, reduces anxiety and insomnia and supports overall well-being. Rich in flavonoids, alkaloids and antioxidants, passionflower tea is valued for its sedative and anxiolytic properties, soothing the nervous system, alleviating stress and enhancing sleep quality (Ibarra-Flores *et al.*, 2021). Traditionally used to ease anxiety, insomnia and nervous tension, it fosters relaxation, uplifts mood and improves mental well-being. Passionflower tea also supports digestive health, relieves muscle tension and alleviates mild pain, further enhancing its appeal in promoting sleep and reducing anxiety levels (Ngan & Conduit, 2011; Yarnell, 2018).

Corn silk tea

Corn silk tea, crafted from Zea mays silky threads, is caffeine-free with a delicate taste, widely enjoyed for promoting urinary tract health and overall well-being. Rich in polysaccharides, flavonoids and saponins, it offers diuretic, anti-inflammatory and antioxidant properties, aiding toxin elimination, supporting kidney function and reducing urinary tract infection risks (Ab Razak *et al.*, 2022; Singh *et al.*, 2023). Traditionally used for urinary tract infections, kidney stones and bladder inflammation, its diuretic effects enhance urine flow, flush bacteria and alleviate discomfort. Corn silk tea also benefits digestive health, stabilizes blood sugar levels and aids detoxification, making it a holistic choice for health maintenance (Parihar *et al.*, 2022).

Tea & Quality

In tea cultivation, emphasizing quality is paramount due to its role as a leisurely beverage cherished for sensory pleasure. Taste and aroma are crucial metrics for assessing quality across various types like black, green, oolong, white, or herbal teas. Each type values distinct traits; for example, black tea prizes catechins for flavor complexity and antioxidants, whereas green tea prefers lower catechin levels to avoid bitterness (Siddiqui *et al.*, 2004). Evaluating tea quality involves rigorous sensory tests on processed samples, ensuring adherence to taste and aroma standards. Molecular techniques such as Molecular Assisted Selection (MAS) expedite breeding by identifying alleles linked to desirable flavors, thus consistently meeting consumer preferences (Tanaka & Taniguchi, 2007).

CONCLUSION

In conclusion, tea from the *Camellia sinensis* plant is culturally, economically and health-wise significant worldwide. Its types—black, green, oolong, white and herbal—each offer distinct flavors, aromas and potential health benefits due to their antioxidant richness. India, especially Assam and Darjeeling, plays a crucial role in global tea production, despite facing challenges like climate variability and technological needs. Tea processing, from plucking to packaging, ensures the final product's quality and flavor. Herbal teas, made from diverse plant materials, are valued for unique flavors and health benefits without caffeine. Assessing tea quality involves careful sensory evaluation tailored to

consumer preferences. As global demand for tea grows, addressing cultivation, processing challenges and sustainability is vital for industry growth and preserving tea's cultural legacy. Tea's variety and qualities make it a timeless beverage cherished worldwide for its sensory pleasures and potential wellness contributions across diverse cultures and markets.

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