Journal of Spices and Aromatic Crops
Vol. 34 (1) : 50-60 (2025)
10.25081/josac.2025.v34.i1.9775

Indian Society for Spices

Drying studies in Indian bay leaf (*Cinnamomum tamala* (Buch.-Ham.) T. Nees & Eberm.) under warm and humid conditions of the Bay Islands

Sohini Ghosh [1,2], Ajit Arun Waman[2*], Pooja Bohra[2] & R Karthika Devi[2]
[1]*School of Life Sciences, Garden City University, Bengaluru, Karnataka*
[2]*Division of Horticulture and Crop Improvement, ICAR- Central Island Agricultural Research Institute, Sri Vijaya Puram, Andaman and Nicobar Islands*
**Email: ajit.hort595@gmail.com*

Received 14 June 2025; Revised 25 August 2025; Accepted 27 August 2025

Abstract

Indian bay leaf or tejpat (*Cinnamomum tamala* (Buch.-Ham.) T. Nees & Eberm) is an important spice that has been used for flavouring of cuisines and as an ingredient in pharmaceutical and allied industries. At present, the leaves are largely harvested from the trees grown in the backyards or from the wild and dried under the sun or shade in most of the growing areas. However, as the cultivation of the crop is also extending in non-native regions including the Bay Islands, identification of region-specific method of drying was envisaged. In the present study, five drying methods *viz.,* vacuum drying, sun drying, oven drying (45 °C and 55 °C) and air drying were compared to know their effect on quality parameters of tejpat under island conditions. Moisture content in the fresh samples was 49.89%, which was reduced to 4.54% (sun drying) to 6.78% (air drying). The dry recovery was found to be the highest in air drying. Oleoresin content was highest in the sun drying method, while essential oil content did not vary. Chlorophyll a, chlorophyll b and total chlorophyll content were found to be the highest in air dried samples, which remained on par with vacuum drying. Total carotenoids content was the highest in case of vacuum drying. RHS colour chart codes exhibited variations among the dried produce. Considering the better dry recovery, better retention of chlorophyll content and ease of operation, air drying could be recommended for farm level processing of tejpat under warm and humid areas. In the times of high rainfall and humidity, mechanical drying could be adopted to facilitate better drying.

Keywords: Chlorophyll, tejpat, tree spice, quality

Introduction

Fresh herbs and spices, owing to their high moisture content, are considered highly perishable and hence, they are dried to create shelf-stable products (Orphanides *et al.* 2016). Drying preserves the quality of spices by reducing moisture content, which inhibits growth of microorganisms and minimizes the biochemical changes (Calin-Sanchez *et al*. 2011; Diaz-Maroto *et al.* 2002). Content of bioactive compounds defines the quality of medicinally important dried spices, whereas colour and fresh-like characteristic aroma define the quality of culinary dried spices (Rahimmalek and Goli 2013). In any case, drying is an important operation that governs the overall quality as well as shelf life of the produce (Orphanides *et al.* 2016).

Lauraceae is an important family of flowering plants with *ca*. 58 genera reported so far. *Cinnamomum* is a significant genus of this family with *ca*. 227 accepted species, some of which are known to have commercial value. Indian bay leaf (*Cinnamomum tamala* (Buch.-Ham.) T. Nees & Eberm) is one such species indigenous to India, Bangladesh, Nepal, Bhutan, Laos, Vietnam and China (https://powo.science.kew.org), wherein it is referred to by names such as tejpat, tejpatta, Malabar leaf, Indian cassia *etc*. Traditionally, leaves of tejpat have been collected from the wild in the Himalayan regions of India and Nepal, which are the natural habitats of the species (Gwari *et al*. 2016; Phondani *et al*. 2016). In recent past, cultivation of tejpat is being extended in warm and humid parts of India including the Andaman and Nicobar Islands (Rani *et al*. 2017; Waman and Bohra 2021; Waman 2022).

The leaves have traditionally been utilized for imparting flavours as well as in the home remedies for treating various ailments. Tejpat possesses several active ingredients, and exhibit significant medicinal properties (Sharma and Rao 2014). It has been an important constituent of several Ayurvedic medicinal formulations (Gaur 2008; Kotteswari *et al*. 2018; Waman 2022). Further, leaves are being used as clarifiers in dyeing procedures, as green dye, shade provider, food, fodder and timber in the Himalayan regions of India and Nepal (Gaur 2008).

Tejpat naturally grows in the Himalayan hill regions, where its leaves are harvested during the dry and mild months of the year- typically from October to December, and sometimes extending until March (Sharma and Rao 2014). Lamichhane and Karna (2009) have suggested shade drying as the routine practice in the Nepal Himalayas. The rainy season is known to induce new flushes at higher frequency (Saha and Mitra 2024) and thus, these times are generally avoided for harvesting purposes. These traditional drying practices may not be suitable for other agro-climatic regions due to significant variations in temperature, rainfall, relative humidity, sunshine hours, and microclimatic conditions across different areas. Recently, some studies have been conducted in tejpat, which have suggested role of drying method on quality parameters in *C. tamala* under West Bengal and Uttarakhand conditions (Attri *et al.* 2024; Saha *et al.* 2024). Similarly, the growing conditions/ pre-harvest factors are known to affect the biochemical parameters of tejpat (Tansura *et al*. 2024), which could result in variations in the quality of dried produce even under mechanical drying method. Hence, the present study was conducted to identify a suitable method of drying for warm and humid climatic regions of the Bay Islands rather than extending the general recommendations from other tejpat growing regions having completely different.

Materials and methods

Collection of samples and pre-experimental observations

The present investigation was carried out at the Division of Horticulture and Crop Improvement, Indian Council of Agricultural Research - Central Island Agricultural Research Institute (ICAR-CIARI), Sri Vijaya Puram, Andaman and Nicobar Islands during 2022-23. Mature leaves of *Cinnamomum tamala* (Buch.-Ham.) T. Nees & Eberm. (Lauraceae) accession IC653501 were harvested from the Germplasm Conservation Block of the Institute. Twenty leaves were taken for recording morphological observations as detailed in Waman *et al*. (2020). Leaf colour was determined by using Royal Horticultural Society (RHS) Colour Chart cards (Sixth Edition 2015; 2019 Reprint) by matching the leaf shade with the available shades on the cards.

Drying treatments

Freshly harvested, mature, healthy leaves that were free from any damage were selected for imposing treatments. Leaves were wiped with tissue paper, accurately weighed and placed in heavy walled glass drying trays (Borosil, India) before subjecting to drying using different methods *viz*., sun drying (SD), air drying (AD), vacuum drying (VD), and oven drying (OD45 and OD55) as indicated below.

Table 1. Details of drying treatments used in the present study

Method	Description	Conditions
SD	Sun drying	Mean temperature: 34.7 °C, mean light intensity: 86,267 lux and relative humidity: 82%
AD	Air drying with dehumidifier (Sharp, DW-J20) for reducing the relative humidity in the drying area	Mean temperature: 28 °C and relative humidity: 70%
VD	Vacuum tray dryer (Ruchi Enterprises, India. (SS inner body, heater: 0.5 kilowatt, three trays of 35 cm × 35 cm × 35 cm, placed 10 cm apart), 2 stage vacuum pump of 0.5 HP (Value, China).	Temperature: 45 °C with -580 mm Hg vacuum
OD45 and OD55	Hot air oven with air circulation (Deep Vision, India) heater: 3.0 kilowatt, three trays of 58 cm × 58 cm × 58 cm, placed 15 cm apart)	Temperature: 45 °C and 55 °C, as per treatment

Determination of moisture content (%) and dry recovery (%)

Moisture content was determined in the freshly harvested as well as dried leaves obtained from various treatments. For this, leaves were made into pieces and transferred to Petri dishes, which were pre-weighed using analytical balance (Citizen, India) in three replications. Samples along with Petri dishes were kept at 105 °C in a hot air oven till constant weight was obtained. Samples were cooled to room temperature, and weight of samples along with Petri dishes was recorded. Moisture content (%) was calculated using the formula :

$$\text{Moisture content (\%)} = \frac{(W2\text{-}W3)}{(W2\text{-}W1)} \times 100$$

Where, W1 = weight of empty Petri dish (g), W2 = weight of empty Petri dish (g) and fresh sample (g), W3 = weight of empty Petri dish (g) and dried sample (g)

For determining the dry recovery, leaves were accurately weighed to 150 g and placed in the heavy walled glass drying trays (Borosil, India). Drying was carried out in five replications and dry recovery (%) was determined by the formula :

$$\text{Dry ecovery (\%)} = \frac{\text{Dry Weight}}{\text{Fresh Weight}} \times 100$$

Estimation of chlorophyll and carotenoid content (µg/g) and recording of colour

Fresh leaf samples and dried samples obtained from various treatments were cut into small pieces and accurately weighed to 0.125 g and transferred into test tubes (Borosil, India) in three replications. Using a micropipette, 6.25

ml of dimethyl sulfoxide (Sigma Aldrich) was added into the test tubes, which were then placed on a test tube stand and covered using aluminum foil. It was then incubated for 72 h in the dark at room temperature. After 72 h, the supernatant was used to read the absorption at 665, 649 and 480 nm using Biospectrometer (Eppendorf). Concentrations of chlorophyll a, b and total carotenoids were calculated using the formulas (Wellburn 1994) given below and values were converted to μg/g.

$$\text{Chlorophyll a } (\mu g/ml) = (12.19 \times A_{665}) - (3.45 \times A_{649})$$

$$\text{Chlorophyll b } (\mu g/ml) = (21.99 \times A_{649}) - (5.32 \times A_{665})$$

$$\text{Total Chlorophyll Content} = \text{Chlorophyll a} + \text{Chlorophyll b } (\mu g/ml)$$

Dried powdered samples from each treatment were used for recording colour shade using RHS colour chart as mentioned above.

Determination of essential oil (%) and oleoresin (%)

Dried samples in each treatment were ground using electric grinder and used for determining essential oil and oleoresins. Known quantity of sample was extracted using Clevenger type apparatus (Borosil, India) till the consecutive readings for essential oil content in the trap remained unchanged (AOAC, 2005). The analysis was carried out in duplicate and essential oil content was calculated as followed.

Known quantity of fine powder from each treatment was extracted using acetone as a solvent on a Soxhlet apparatus (Borosil, India) that was heated with heating mantle (LabQuest, Borosil, India). Condensation was carried out using closed water circulatory system- Dweep Aqua Saver (ICAR-CIARI, India). The analysis was carried out in duplicate. After extraction, the solvent was removed using a vacuum rotary evaporator and final drying was done in the hot air oven to remove the residual solvent. Final weight of the flask was measured for calculation of oleoresin yield (Garusinghe *et al*., 2023) using the formula :

$$\text{Total carotenoids } (\mu g/ml) = \frac{((1000 \times A_{480}) - (2.14 \times \text{Chl.a}) - (70.16 \times \text{Chl.b}))}{220}$$

Statistical analysis

The experiment was laid in completely randomized design and data collected for various parameters was subjected to Analysis of Variance (ANOVA) using Web Agri Statistical Package (WASP 2.0, ICAR-CCARI, Goa, India) following least significant difference. In other cases, data was presented as mean ± standard error of mean.

Results and discussion

Various methods are used for drying and preservation of herbs and spices *viz.* sun drying, air/ shade drying, oven drying, vacuum drying, microwave drying, freeze drying *etc*., of which natural drying methods have been considered the most preferred conventional means (Orphanides *et al*. 2016). Drying processes are commonly used for the structural preservation of produce, but they may cause discoloration, loss of aroma, and changes in texture and physical properties. Each drying method has its own advantages and disadvantages (Ghasem *et al*. 2020), and selection of method should be based on the plant species, size of tissues, type of produce (leaf, whole herb, rhizome, seeds etc.) to be dried, technique's efficiency, cost involved, active ingredients of interest, maintenance of quality, region of cultivation, and scale/ purpose of operation (Diaz-Maroto *et al*. 2002; Jayashree *et al*. 2014; Orphanides *et al*. 2016; Ghasem *et al*. 2020; Waman *et al*. 2024a).

In the present paper, five drying methods were compared to identify optimum method for drying of tejpat under warm and humid conditions of the Bay Islands, India. In the optimization of drying process, understanding the morphological characteristics is also important (Jayashree *et al*. 2014; Orphanides *et al*. 2016) as morphology of material is known to influence the drying kinetics. The morphological features of the experimental material used in the present study have been presented in the Table 1. Leaves were 17.9 cm long, 5.2 cm wide, 0.3 mm thick, weighed 1.4 g each and had petioles of 1.2 cm length. Leaves of tejpat are rather thick and shiny unlike many herbs, which are known to have softer leaves that facilitates easier and quicker drying.

Table 1. Leaf morphological parameters of the experimental material

Parameter	Range	Mean ± SEm
Leaf length (cm)	14.2-21.1	17.9 ± 0.38
Leaf width (cm)	3.6-7.2	5.2 ± 0.17
Leaf thickness (mm)	0.20-0.48	0.3 ± 0.02
Weight of leaf (g)	0.44-1.60	1.4 ± 0.07
Length of petiole (cm)	1.09-2.35	1.2 ± 0.07

Moisture content, dry recovery and drying time

Moisture content in the food can have a big impact on taste, texture, appearance, shape, and weight. However, higher levels of moisture than optimum may lead to rapid deterioration of the quality apart from predisposing the produce to microbial spoilage (Hamrouni-Sellami *et al*. 2013). Moisture content thus has implications on legal and labelling requirements, and hence, its determination is considered as an essential component in the food industry. In the present study, moisture content in the fresh leaves was found to be 49.89%, which was reduced considerably in all the treatments upon drying (Table 2). The moisture content in the fresh produce varies with the type of plant tissues and species. For example, in spear mint (*Mentha spicata*), which is a soft leaved herb, the initial moisture content was 79.03% (Ghasem *et al*. 2020); whereas in rhizomatous crop ginger, the moisture content was 81.3% (Jayashree *et al*. 2014). The moisture content of 46.2 to 58.6% and 53.61% have been reported in closely related *C. verum* (Waman *et al.* 2020) and *C. burmanii* (Fiana *et al*. 2024), respectively, suggesting similar ranges of moisture in these *Cinnamomum* species.

All the drying treatments tested could reduce the moisture content to safer limits of below 10% as per the 2.9.33 tejpat standards of Food Safety and Standards Authority of India (www.fssai.gov.in). Samples dried under the sun and in oven had the lowest levels of moisture i.e. 4.54% (SD), 4.69% (OD55), and 4.93% (OD45). Air dried leaves showed the highest moisture content of 6.78%, while it was 5.29% in VD. In general, the temperature during air drying during the present study was 28 °C, which was the lowest among all the treatments of drying. Higher temperature provided in other than AD treatment might have facilitated efficient removal of moisture from the produce (Orphanides *et al*. 2016). These results are in accordance with an earlier study on lemongrass leaves under warm and humid conditions, wherein highest moisture was recorded in air dried samples, while sun and oven dried samples had significantly lower moisture (Priyanka *et al*. 2022).

The drying recovery, that is the quantity of produce obtained upon drying, is an important parameter that is directly related to the saleable produce. In the present study, significantly highest drying recovery of 50.47% was observed in AD samples, followed by VD samples with 49.76% recovery. Sun drying and OD treatments showed significantly lowest drying recovery in the samples. Earlier study on *C. verum* leaves suggested dry recovery of 46.5 to 66.7% in air dried samples (Waman *et al.* 2020). The drying process has been reported to be dependent on temperature as well as humidity (Sefidkon *et al*. 2006) and these conditions varied distinctly among the treatments (Table 2), causing variations in the moisture contents as well as drying recovery.

The method of drying had influence on drying time as well (Table 2). Sun drying was found to be the fastest method with mean drying time of 5 h 14 min, which was followed by OD55 (5 h 25 min), while air drying treatment took the longest time of 93 h 54 min. The low temperature involved in drying during AD might have contributed in slower drying of

Table 2. Moisture content and drying recovery of tejpat as influenced by drying method

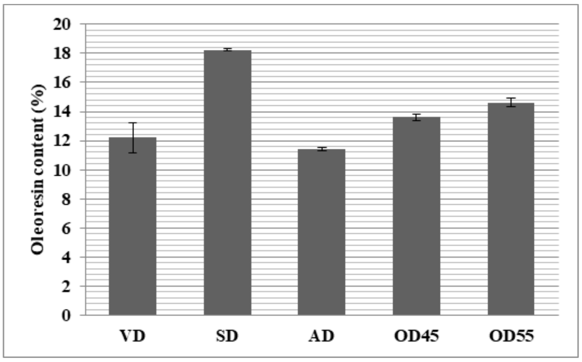
Drying method	Moisture content (%)	Dry recovery (%)	Drying time (h:min)
Fresh	49.89 ± 0.485	-	-
Vacuum dried (VD)	5.29 ± 0.278	49.76b	21:20
Sun dried (SD)	4.54 ± 0.462	47.33c	05:14
Air dried (AD)	6.78 ± 0.127	50.47a	93:54
OD @ 45°C (OD45)	4.93 ± 0.140	47.73c	12:00
OD @ 55°C (OD55)	4.69 ± 0.128	47.86c	05:25

the produce in this treatment. Interestingly, *C. tamala* leaves took 3 days in sun drying and 19 days in shade drying treatments under West Bengal conditions (Saha *et al.* 2024); whereas time taken under present study was much lower than these. This scenario clearly demonstrates the role of local weather conditions on the efficiency of natural drying methods. Oven drying treatments in their study were faster (Saha *et al.* 2024) as observed in the present study; thereby emphasizing the fact that mechanical drying could help in reducing the dependence on external weather conditions, which is highly inconstant in the island ecosystem. Ghasem *et al*. (2020) have also reported similar results in spearmint wherein sun drying took 7 h for drying, while the longest time of 28 h was required in shade drying method.

Oleoresin and essential oil content

Spices are typically high value commodities and hence, the end-users expect the product to be of high quality (Schaarschmidt 2016). Although present in small quantities, essential oils and oleoresins are the main contributors to spice aroma (Rao *et al*. 1998). Oleoresins are highly concentrated viscous resin-like materials obtained upon extraction of spices (Sowbhagya 2019) using a suitable solvent such as acetone, ethyl acetate, ethylene dichloride, methanol etc., which are evaporated after the extraction is over. Spice oils only impart the aroma to the spice, whereas spice oleoresins can provide the whole flavour of the spice as they constitute volatile and non-volatile constituents, fixed oils, pigments, and antioxidants (Procopio *et al*. 2022). Oleoresin content has been considered a quality determinant in various spices (Waman *et al*. 2024b). In general, drying reduces the flavouring/ volatile compounds, and some drying methods could preserve the compounds better than the other methods (Choe and Min 2006). In the present study, acetone based oleoresin content was determined in the samples (Fig. 1). It was observed that the sun dried sample of tejpat had the highest oleoresin content of 18.24%, which was followed by OD55 sample with 14.61% content. Quicker drying process in these two treatments might have helped in preserving the oleoresins content. These findings are in conformity with the earlier study in ginger in which the highest oleoresin content was obtained in the sun-dried samples (Jayashree *et al*. 2014).

Essential oil content in the present study varied between 0.3 and 0.4% among different treatments. Though there were variations in the oil content among the treatments, the values did not differ significantly among each other (Fig. 1b). On the contrary, considerable influence of drying method on essential oil content of dried produce has been reported in other herbs (Ghasem *et al.* 2020) and in tejpat



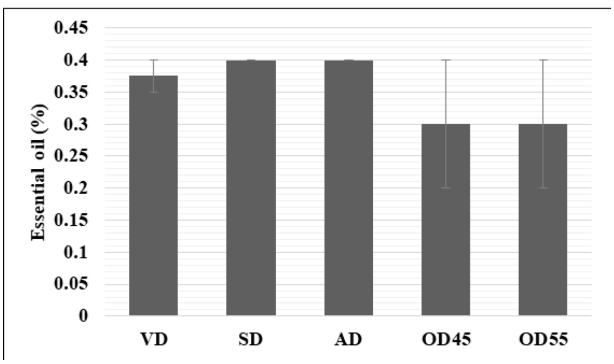


Fig. 1. Oleoresin content (a) and essential oil content (b) in tejpat as influenced by the drying method.

(Saha *et al.*, 2024). Saha *et al.* (2024) have reported essential oil contents of 0.13 to 0.25% in tejpat among the drying methods studied, while 0.11% essential oil was reported in the market samples. Essential oil content obtained from all the treatments of present study were much higher than this report. Probably, the genotype, microclimate, growing conditions, biotic and abiotic stresses etc. could be responsible for these variations. Variations in the essential oil content in *Cinnamomum* spp. due to genotype, weather and area of cultivation have been reported earlier (Waman *et al*. 2020; Tansura *et al*. 2024), possibly indicating their role in the present case as well.

Pigments and colour values

It is understood that the customers are generally reluctant to purchase spices that are either too dull or too bright in colour. Dull-coloured spices are perceived to have poor flavour, while brightly coloured spices, on the other hand, raise suspicions of adulteration in the minds of consumers. It is critical to sort and grade the spices based on physical properties such as colour and appearance. The colour of fresh and dried tejpat leaves was determined by comparing them to various Royal Horticultural Society (RHS) Colour Chart cards as presented in Table 3. Freshly harvested leaves showed 139C Moderate Yellow Greenish values in Fan 3 of Green Group. The colours were faded in all the treatments, although with varied degrees. In order to understand the degree of retention of pigments upon drying, quantification of chlorophylls and carotenoids was done (Table 3).

In the fresh leaves, 912.0, 353.7, 1265.7 and 172.8 μg/g of chlorophyll a, chlorophyll b, total chlorophylls and total carotenoids, respectively were observed. After drying, AD samples showed the highest values of chlorophyll a (2456.70 μg/g), chlorophyll b (1185.90 μg/g) and total chlorophylls (3642.60 μg/g), which remained on par with VD samples. Effect of drying method on the appearance of both ventral and dorsal surfaces of leaves has been presented in Fig. 2. For total carotenoids, highest value of 479.30 μg/g was recorded in VD samples. The sun-dried samples and samples dried at higher temperature *i.e.* 55 °C showed the lowest concentration of chlorophylls, while the latter method also had lowest total carotenoids.

Change of leaf colour due to degradation of chlorophylls and carotenoids could be contributed by the thermal treatment or oxidation caused during the drying process (Saha *et al.* 2024). Earlier studies have reported total chlorophyll content of 0.646 to 1.183 mg/g in tejpat samples processed during different harvesting seasons (Tansura *et al*. 2024). Variations in total chlorophyll content in the leaves of improved varieties of *C. verum* was found to be 0.67 to 1.08 mg/g, when dried using air (Waman *et al.* 2020). The higher values obtained for AD and VD treatment than these

Table 3. Photosynthetic pigments and RHS colour codes in tejpat leaves as influenced by drying methods

Sample	Concentration (μg/g)				RHS colour code
	Chlorophyll a	Chlorophyll b	Total chlorophyll	Total carotenoids	
Fresh	912.0 ± 29.60	353.7 ± 31.48	1265.7 ± 55.88	172.8 ± 5.24	139C Moderate Yellow Greenish (Green Group, Fan 3)
VD	2361.67a	1111.30ab	3472.97a	479.30 a	146D Moderate Yellow Green (Yellow Green Group, Fan 3)
SD	778.63d	176.70d	955.37d	202.50 c	143C Strong Yellow Green (Green Group, Fan 3)
AD	2456.70a	1185.90a	3642.60a	435.93 b	143B Strong Yellow Green (Green Group, Fan 3)
OD45	1863.27c	425.43c	2288.70b	446.67 b	147C Moderate Yellow Green (Yellow Green Group, Fan 3)
OD55	773.37d	380.80c	1154.13c	171.20 d	N148A Moderate Yellow Green (Yellow Green Group, Fan 3)

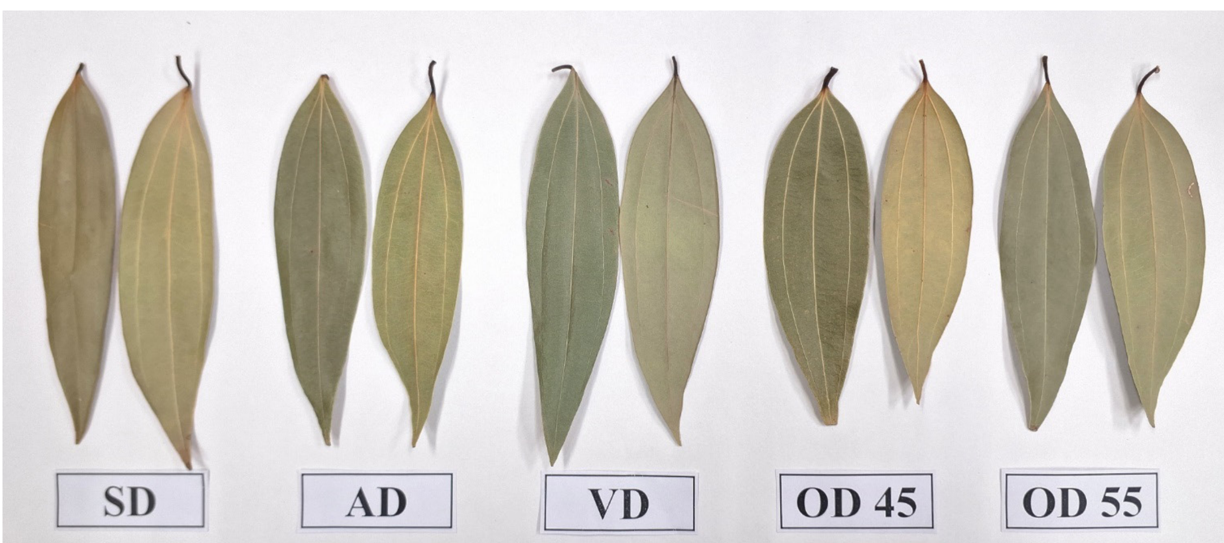


Fig. 2. Ventral and dorsal surface view of tejpat dried using different methods

reports indicate the efficiency of these methods in retention of pigments upon drying. Sun drying, though was faster and had the highest oleoresins, the colour was greatly impacted by this method.

Thus, in general, air drying was found to be a practical (although slow) method of drying in the present study. However, during the process of drying, heat is generally utilized by the produce, which causes evaporation of the moisture either as surface moisture or as water vapor that is evaporated from the internal tissues and subsequently lost via surface of the produce (Okos *et al*. 2007). It is a known fact that the atmospheric humidity determines the rate of evaporation in shade and sun drying techniques, thereby altering the drying rate as well as quality of the produce. In tropical parts of Bangladesh, early monsoon period has been recommended for harvesting of tejpat leaves based on biochemical richness (Tansura *et al*. 2024). However, under high humidity conditions in warm and tropical regions, traditional drying may encounter difficulties. Hence, adoption of vacuum drying or oven drying at 45 °C would be pragmatic to facilitate better drying of produce. Based on the outcome of the drying process and intended use of the product, more than one drying methods could be recommended e.g. shade drying and oven drying at 40 and 60°C have been recommended for *Mentha spicata* processing (Ghasem *et al*. 2020). Similarly, in the present study, air drying during favourable weather conditions and vacuum drying or oven drying at 45 °C during other times is recommended for tejpat under warm and humid regions.

Acknowledgements

Authors are thankful to the ICAR, New Delhi for financial assistance and Director, ICAR-CIARI, Sri Vijaya Puram for providing necessary facilities for conducting this study.

References

AOAC 2005 Official Methods of Analysis, 18th Ed., AOAC International, Rockville, MD.

Attri D C, Bahukhandi A, Trivedi V, Chauhan RS, Nautiyal MC & Nautiyal BP 2024 Variation in the essential oil composition in leaves (fresh & dried) of *Cinnamomum tamala* (Indian bay leaf) cultivated in Western Himalaya. Natl. Acad. Sci. Lett. 47(6):701–704. https://doi.org/10.1007/s40009-024-01416-1.

Calin-Sanchez A, Szumny A, Figiel A, Jaloszynski K, Adamski M & Carbonell-Barrachina A A 2011 Effects of vacuum level and microwave power on rosemary volatile composition during vacuum-microwave drying. J. Food Eng. 103(2): 219-227.

Choe E & Min D B 2006 Mechanisms and factors for edible oil oxidation. Compr. Rev. Food Sci. Food Saf. 5(4): 169–186.

Diaz-Maroto M C, Perez-Coello M S & Cabezudo M D 2002 Effect of drying method on the volatiles in bay leaf (*Laurus nobilis* L.). J. Agric. Food Chem. 50: 4520-4524.

Fiana R M, Ningsih W S, Abdi, Syukri D & Indeswari N S 2024 Characteristics of chemical components and organoleptic tests of Cinnamon leaf tea against differences in time and temperatures. Food Sci. Technol. 12(1): 94-104.

Garusinghe D M P M, Lee F S & Thoo Y Y 2023 Efficacy of green solvents in pungent, aroma and colour extractions of spice oleoresins and impact on phytochemical and antioxidant capacities. Food Biosci. 56: 103171.

Gaur R D 2008 Traditional dye yielding plants of Uttarakhand, India. Nat. Prod. Res. 7(2): 154-165.

Ghasem M, Ebadi M T & Ayyari M 2020 Qualitative changes of spearmint essential oil as affected by drying methods. Ind. Crop. Prod. 153: 112492. https://doi.org/10.1016/j.indcrop.2020.112492.

Gwari G, Bhandari U, Naik G, Haider S Z & Chauhan N 2016 Genetic diversity in *Cinnamomum tamala* Nees. accessions through DNA fingerprinting using molecular markers. Ind. J. Agric. Res. 50(5): 446-450.

Hamrouni-Sellami I, Rahali F Z, Rebey I B, Bourgou S, Limam F & Marzouk B 2013 Total phenolics, flavonoids, and antioxidant activity of sage (*Salvia officinalis* L.) plants as affected by different drying methods. Food Bioprocess Technol. 6(3): 806-817.

Jayashree E, Visvanathan R & Zachariah T J 2014 Quality of dry ginger (*Zingiber officinale*) by different drying methods. J. Food Sci. Technol. 51(11): 3190–3198. https://doi.org/10.1007/s13197-012-0823-8.

Kotteswari M, Rao M R K, Kumar S, Prabhu K, Sundaram R L & Dinakar S 2018 GCMS analysis of one ayurvedic preparation 'Aswagandharishtam'. Biomed. Pharmacol. J. 11(2): 1061-1072.

Lamichhane D & Karna N K 2009 Harvesting methods of *Cinnamomum tamala* leaves in private land: a case study from Udayapur district, Nepal. Banko Janakari 19(2): 20-24.

Okos M, Campanella O, Narsimhan G, Singh R K & Weitnauer A C 2007 Food dehydration. In: Heldman DR, Lund DB (eds) Handbook of food engineering, 2nd edn. CRC Press, Boca Raton, pp 601-744.

Orphanides A, Vlasios G & Gekas V 2016 Drying technologies: vehicle to high-quality herbs. Food Eng. Rev. https://doi.org/10.1007/s12393-015-9128-9

Phondani P C, Bhatt I D, Negi V S, Kothyari B P, Bhatt A & Maikhuri R K 2016 Promoting medicinal plants cultivation as a tool for biodiversity conservation and livelihood enhancement in Indian Himalaya. J. Asia-Pacific Biodiv. 9: 39-46.

Priyanka G D, Ghosh S, Devi R K & Waman A A 2022 Effect of Drying Methods on Quality Parameters of Lemon Grass (*Cymbopogon flexuosus*) Var. OD-19. J. Andaman Sci. Assoc. 27(2): 204-209.

Procopio F R, Ferraz M C, Paulino B N, Sobral T J A & Hubinger M D 2022 Spice oleoresins as value added ingredient for food industry: recent advances and perspectives. Trends Food Sci. Technol. 122: 123-139.

Rahimmalek M & Goli S H 2013 Evaluation of six drying treatments with respect to essential oil yield, composition and color characteristics of *Thymys daenensis* sub. sp. *daenensis*. Celak leaves. Ind. Crop. Prod. 42: 613-619. https://doi.org/10.1016/j.indcrop.2012.06.012

Rani A, Pande C, Tewari G & Patni K 2017 A review on aroma profile of *Cinnamomum* species in North and North East India. World J. Pharm. Res. 6: 200-221.

Rao L J, Singh M, Raghavan B & Abraham K O 1998 Rosemary (*Rosmarinus officinalis* L.): Impact of drying on its flavour quality. J. Food Qual. 21(2): 107–215. https://doi.org/10.1111/j.1745-4557.1998.tb00508

Saha S & Mitra A 2024 Seasonal and diurnal variations in leaf aroma volatiles of *Cinnamomum tamala* (Buch.—Ham.) T. Nees & Eberm as evidenced from metabolite profiling, histochemical and ultrastructural analyses. Tree Physiol. 44: tpae138 https://doi.org/10.1093/treephys/tpae138

Saha S, Bhattacharya R, Dey P K & Mitra A 2024 Comparative assessment of essential oil composition and yield in *Cinnamomum tamala* leaves upon application of different drying practices. J. Essen. Oil Res. 36(4): 395-406. https://doi.org/10.1080/10412905.2024.2350409

Schaarschmidt S 2016 Public and private standards for dried culinary herbs and spices—part I: Standards defining the physical and chemical product quality and safety. Food Control 70: 339–349. https://doi.org/10.1016/j.foodcont.2016.06.004

Sefidkon F, Abbasi K & Khaniki G B 2006 Influence of drying and extraction methods on yield and chemical composition of the essential oil of *Satureja hortensis*. Food Chem. 99(1): 19–23.

Sharma V & Rao L J M 2014 An overview on chemical composition, bioactivity and processing of leaves of *Cinnamomum tamala.* Crit. Rev. Food Sci. Nutr. 54: 433-448, https://doi.org/10.1080/10408398.2011.587615

Sowbhagya H. 2019 Value-added processing of by-products from spice industry. Food Qual. Saf. 3(2): 73-80.

Tansura M, Tabassum F, Alam K M M & Uddin M A 2024 Seasonal dynamics of phytochemicals in *Cinnamomum tamala* (Buch.-Ham.) Nees and Eberm. (Tejpata). Int. J. Med. Plants Nat. Prod. 10(1): 31-45. https://doi.org/10.20431/2454-7999.1001004

Waman A A & Bohra P 2021 A novel approach for round the year propagation of *Cinnamomum tamala* (Buch.-Ham.) T. Nees. &Eberm. through air layering. J Plant. Crops 49(3): 222-224. https://doi.org/10.25081/jpc.2021.v49.i3.7457

Waman A A 2022 Promoting Indian Bay Leaf in the Andaman Islands through Quality Planting Material. Indian J. Arecanut Spices Med. Plants 24(3): 16-18.

Waman A A, Bohra P & Devi K R 2024b Biochemical studies in woody pepper (*Piper pendulispicum* C.DC.): A spice with edible stem from Andaman Islands, India. Ann. Phytomed., 13(1): 1141-1148. http://dx.doi.org/10.54085/ap.2024.13.1.122.

Waman A A, Bohra P & Devi R K 2020 Performance of improved varieties of true Cinnamon (*Cinnamomum verum* J. Presl.) in Andaman Islands, India. Pantnagar J. Res. 18(3): 243-248.

Waman A A, Bohra P, Devi K R, Lokesha A N & Shivashankara K S 2024a Stem of Woody Pepper (*Piper pendulispicum* C. DC) as a Source of Phenolic Acids and Piperine. Indian J. Plant Genet. Resour. 37(2): 294-300. DOI: 10.61949/0976-1926.2024.v37i02.12.

Wellburn A R 1994 The spectral determination of chlorophylls a and b, as well as total carotenoids, using various solvents with spectrophotometers of different resolutions. J. Plant Physiol. 144: 307-31.