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Drying Characteristics and Color Analysis of Betel Leaves (*Piper betle* L.)

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ABSTRACT: *Piper betle* are deep green, heart-shaped leaves, commonly known as paan. Betel leaves are perishable in nature, and every year, the post-harvest losses are around 35 to 70%. To minimise spoilage, drying is the most commonly used preservation technique. The present study compares the effects of solar and cabinet drying on the physico-chemical properties of the pachaikodi and vellaikodi varieties belonging to Tamilnadu. The betel leaves are dried at 50°C in a cabinet tray dryer and also dried in solar tunnel drying. The dried leaves were grinded and packed in airtight LDPE pouches and stored at 4°C. The proximate analyses and Quality attributes like color and chlorophyll content were measured. In terms of proximate analysis and quality attributes, maximum nutrients were preserved in tray-dried betel leaves. The moisture content, carbohydrates, protein, fat, fiber and total ash of tray-dried pachaikodi variety are $3.49^{a}\pm0.13$, $46.58^{d}\pm0.06$, $16.10^{a}\pm0.01$, $13.25^{d}\pm0.03$, $8.9^{c}\pm0.02$ and $10^{a}\pm0.004$ respectively. The colour (L*, a*, b*, dE*) and chlorophyll (Total chlorophyll, chlorophyll a, chlorophyll b) values tray-dried pachaikodi variety are $47.88^{a}\pm0.02$, $1.33^{b}\pm0.05$, $14.22^{d}\pm0.03$ & $47.37^{d}\pm0.01$ and $26.80^{d}\pm0.04$, $20.11^{d}\pm0.02$ & $6.69^{d}\pm0.06$ respectively.

Keywords: Drying of betel leaves, Pachaikodi, Vellaikodi, Drying kinetics, Colour measurement, cabinet tray dryer, solar tunnel dryer.

INTRODUCTION

Piper Betel is a dioeciously shade-loving perennial root climber with deep green heart-shaped leaves, which are commonly known as paan in India. It belongs to the Piperaceae family and is scientifically named as *Piper betle* L. These leaves are grown in moist, tropical and subtropical regions of the world. In all, nearly 100 varieties of betel vine have been found in the world, of which 40 varieties are found in India (Saikat *et al*., 2015). The betel leaf varieties found in Tamil Nadu are Sirugamani, Kapoori, Vellaikodi and Pachaikodi (Sugumaran *et al.*, 2011). Betel leaf has a strong, pungent and sharp taste with a strong aromatic flavor. Betel leaves are generally used as a mouth freshener, stimulant and antiseptic. These leaves are perishable in nature, which is aromatic, carminative and expectorant (Rayaguru *et al*., 2011; Madan *et al*., 2014; Guha, 2006). Betel leaf possesses activities like antioxidant, antidiabetic, anti-inflammatory, antiulcer, antiplatelet aggregation, antimicrobial, antitumour, antimutagenic, antifertility, antihelminthic, anticarcinogenic due to the presence of phytochemicals like chevibetol, chavicol, saffrole, eugenol, estragole, hydroxycatechol, allyl pyrocatechol, carvacrol and caryophyllene (Vikash *et al*., 2012; Das *et al*., 2016; Fazal *et al*., 2014). The antiseptic property of betel leaf is due to the presence of chavicol which is four times more potent when compared to carbolic acid. Betel leaves also contain enzymes like diastase and catalasa (Shah *et al*., 2016). Betel leaves contain phytochemicals that can be used to treat cardiovascular disease and diabetes by preventing oxidative damage in the body (Mudhumita *et al*., 2020). Betel leaf is highly perishable in nature. Generally, the shelf life of betel leaf is around 3-5 days and 5-7 days in summer and winter respectively. Every year, the post harvest loss of betel leaf was around 35-70% which can be minimised by preservation methods like drying, extraction, blanching, curing and other packaging methods. This will delay the senescence process, preserve the quality attributes, and minimise postharvest losses (Saikat *et al*., 2015; Madan *et al*., 2014).

Drying is also known as dehydration, which removes the moisture from the product and thus avoids spoilage. Drying is a well-known preserving technique to enhance the shelf life of leaves and to prevent post-harvest losses (Pin *et al*., 2009; Madan *et al*., 2014). Drying implies many advantages, like longer shelf life, being easy to handle, and requiring a minimum space to store. To preserve the phytochemical compound, the rapid drying method is used (Wahida *et al*., 2012). Drying alters both physical and chemical properties of a product, thus the selection of a drying technique is an essential factor (Ali *et al*., 2019). Generally, drying methods like sun drying, shadow drying, vaccum drying, cabinat tray drying and oven drying were used for drying (Saikat *et al*., 2015; Rayaguru *et al*., 2007; Pandey *et al*., 2018). Researchers concluded that 50°C was found to be the optimum temperature for drying betel leaves in cabinet drying (Balasubramanium *et al*., 2011).

This study focuses on the drying of betel leaf in solar tunnel drying and cabinet tray. In the drying process, betel leaf varieties of Pachaikodi and Vellaikodi were used. Visually, Pachaikodi betel leaf variety is dark green in colour while the Vellaikodi betel leaf variety is light green in colour. The drying characteristics, proximity and colour of dried betel leaf were also investigated.

MATERIALS AND METHODS

A. Raw Material

Pachaikodi and vellaikodi varieties of betel leaf were collected from the local farmers of Sriperambuthur. The freshly collected betel leaves were sorted, depetiolized and washed before drying.

B. Preparation of betel leaves for drying

The fresh betel leaves were sorted by removing pest damaged leaves, and petioles were removed from the leaves. The petiole-removed leaves are washed to remove dirt particles. The water drained from the leaves. After removal of excess water, drying was carried out with two different techniques, such as solar tunnel drying and cabinet tray drying (Rayaguru *et al*., 2011).

C. Drying of betel leaves

150g of betel leaves were weighed accurately and the drying process was carried out in a sun tunnel dryer and a cabinet tray dryer.

(i) Solar tunnel drying. Betel leaves are sorted, washed, strained from excess water, and weighed. The weighed betel leaves are uniformly distributed on the filter papers and placed in the solar tunnel dryer for drying. The temperature of the solar tunnel dryer varies from 28°C to 38°C (Rayaguru *et al*., 2007). Drying was carried out until it reached a constant weight.

(ii) Cabinet Tray drying. Betel leaves are sorted, washed, strained from excess water, weighed and placed in a tray for drying. The betel leaves were dried at 50°C in a cabinet tray dryer. Drying continues until a constant weight is reached. After complete drying, the dried leaves were grinded and sieved in a vibratory sieve analyzer. The sieved powder was packed in airtight LDPE pouches and stored at 4ºC for further usage.

D. Drying characteristics of betel leaf

The moisture content was determined using moisture loss of betel leaf obtained during experiments (Okonkwo *et al*., 2019). The dimensionless moisture ratio and drying rate was calculated by the Eqn. (1), (2)

$$MR = \frac{M - M_e}{M_o - M_e} \quad (1)$$

$$DR = \frac{M_{t+dt} - M}{dt} \quad (2)$$

Where M is the moisture content at specific time, M_e is the equilibrium moisture content, M_o is the initial moisture content and M_{t+dt} is the moisture content at time t+dt (Saikat *et al*., 2015; Rayaguru *et al*., 2011). Due to continuos fluctuation of drying temperature and relative humidity in solar tunnel drier, the moisture ratio $MR = (M - M_e)/(M_o - M_e)$ was replaced by MR = M/M for mathematical modeling of drying (Sacilik *et al*., 2006; Gurlek *et al*., 2009).

E. Determination of Proximity Analysis

Protein, fat, fiber, total ash content was determined using Association of Official Analytical Chemists (AOAC) method. Protein was determined using kjeldhal method by following AOAC method 960.52 and conversion factor of 6.25 was used. Fat was determined using SoxTRON equipment according to AOAC methods 920.39. Fiber was determined using FibreTRON equipment by following AOAC method 962.09. Total ash content was estimated using muffle furnace by following AOAC method 923.03. Total Carbohydrate was estimated by Anthrone method. Total cholorophyll was evaluated using 80% Acetone Method.

F. Colour and chlorophyll measurement

Hunter lab colorimeter was used to determine colour value of betel leaf. Each sample is analyzed in triplicates randomly. L*, a*, b* measure the whiteness (black at 0 and white at 100), green (negative value) and red (positive value), blue (negative value) and yellow (positive value) respectively (Ali *et al*., 2014; Rayaguru *et al*., 2011).

G. Statistical analysis

The statistic analysis was performed using IBM-SPSS® software. All parameters were conducted in six trials and an analysis of variance was analyzed. The results were expressed as mean ± SE and least significant difference at $P < 0.05$ was calculated using Duncan's multiple range tests to determine significant differences in results.

RESULT AND DISCUSSION

A. Drying characteristics of Betel Leaf

Drying leads to a considerable amount of moisture loss, which further increases the shelf life of a product. Drying provides adverse effects like colour and textural changes and nutrient loss. The cabinet tray drying method leads to a reduction in drying time when compared with the solar tunnel drying method. This is due to the temperature fluctuation in the solar tunnel drier. Solar-dried betel leaves result in nutrient loss, colour and flavour degradation in comparison with tray-dried betel leaves. In solar tunnel drying, the betel leaf colour was leached, but in the cabinet tray drier, the colour retention was higher.

The graph between moisture content (%) Vs time (min) (Fig. 1, 4) shows that drying time varies with variety and drying condition. Tray drying and solar drying require 5 hrs and 10 hrs to dry betel leaf, respectively. This might be because of the controlled atmosphere in the cabinet tray drier. The graph between moisture ratio Vs time (min) (Fig. 2 & 5) shows that the moisture ratio decreases as the drying time increases. The graph between the drying rate (g/min) Vs time (min) (Fig. 3, 6) shows that the drying rate increases as the drying time increases. This shows that there was no constant rate drying period and the drying occurred in a falling rate drying period. This result correlates with the earlier observations (Rayaguru *et al*., 2011).

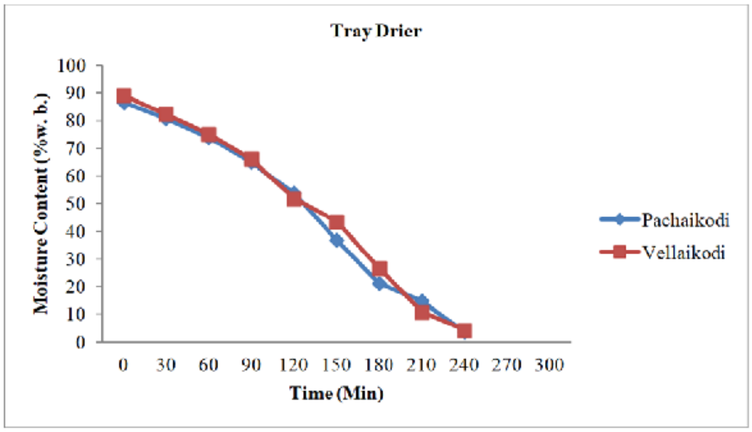

Fig. 1. Graph between moisture content (%) Vs time (min) for Tray Drier.

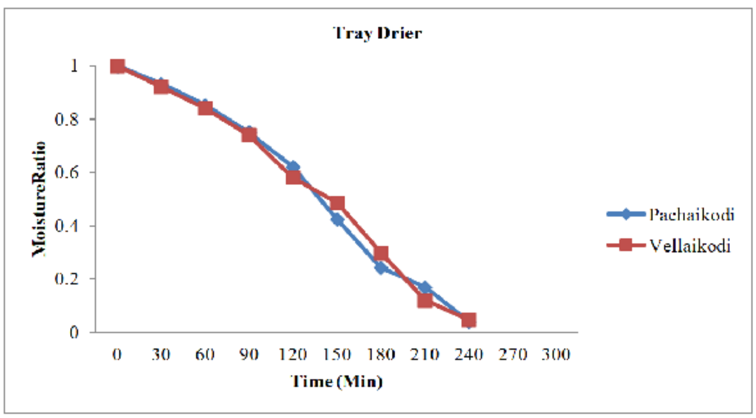

Fig. 2. Graph between moisture ratio Vs time (min) for Tray Drier.

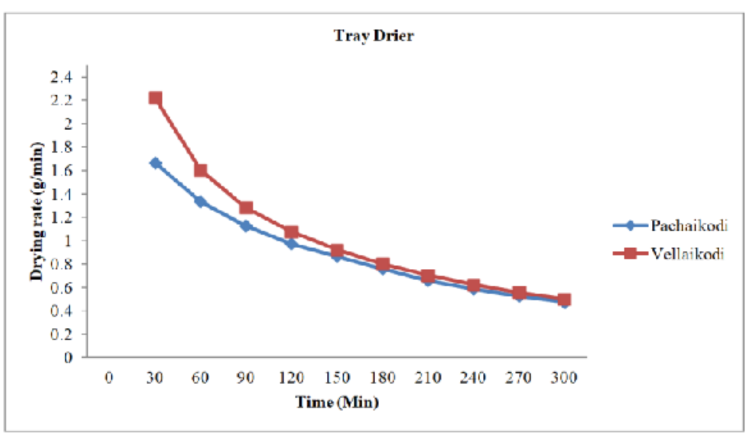

Fig. 3. Graph between drying rate (g/min) Vs time (min) for Tray Drier.

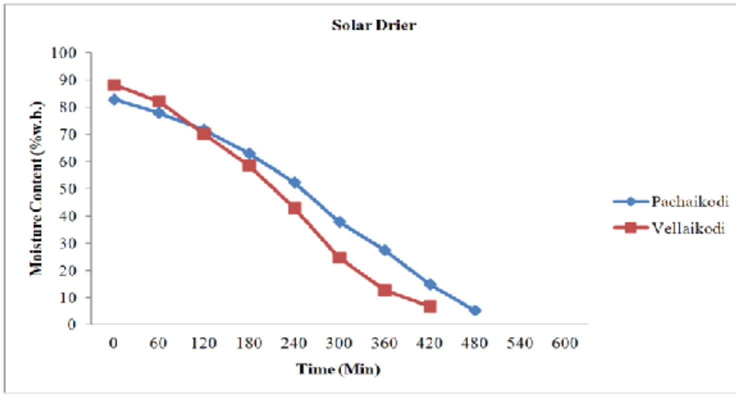

Fig. 4. Graph between moisture content (%) Vs time (min) for Solar Drier.

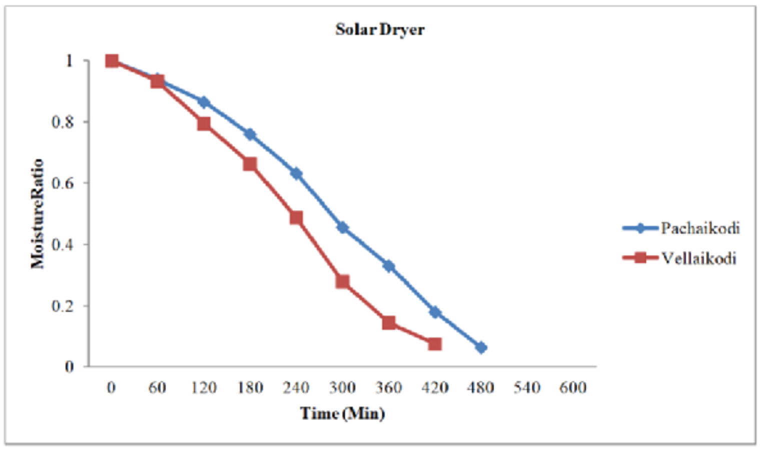

Fig. 5. graph between moisture ratio Vs time (min) for Solar Drier.

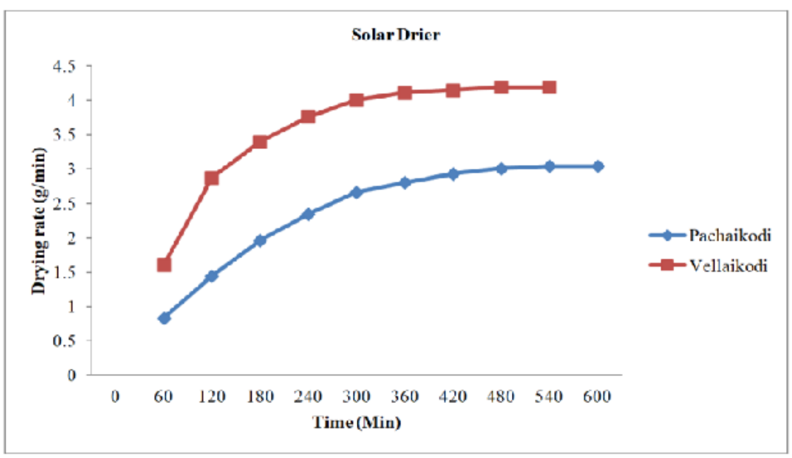

Fig. 6. Graph between drying rate (g/min) Vs time (min) for Solar Drier.

B. Proximate analysis

The moisture content of tray and solar dried samples was in the range of 3–6%. The tray dried sample had lower minimum moisture content than the solar-dried sample. This was due to drying temperature and their controlled atmosphere. The carbohydrate content of dried betel leaves was in the range of 39–46%. The protein content of tray and solar dried samples was in the range of 16–17%. The fat content of dried betel leaf was around 2–13%. The fibre content of the dried betel leaf was in the range of 7–9%. Generally, leaves are the richest source of fiber, which will increase the bulk for peristaltic action. The ash content of dried betel leaf was around 10–14%. The ash content will directly imply the mineral content of the product. Tray-dried samples show better nutrient retention than solar-dried samples because of the drying temperature and time. The proximity analysis of dried betel leaf indicates that the pachaikodi variety betel leaf had higher nutrients than the vellaikodi variety in both the drying methods, which is shown in Table 1.

Table 1: Proximate analysis (Mean±SE) @ of Betel leaf powder.

SAMPLE	Moisture content (% w.b.)	Crude protein (%)	Crude fat (%)	Carbohydrates (%)	Crude fibre (%)	Total ash (%)
Tray Dried Pachaikodi	3.49^{a}±0.13	16.10^{a}±0.01	13.25^{d}±0.03	46.58^{d}±0.06	8.9^{c}±0.02	10^{a}±0.004
Tray Dried Vellaikodi	4.23^{b}±0.05	17.32^{c}±0.07	4.84^{b}±0.04	40.53^{b}±0.09	7.89^{a}±0.04	14^{b}±0.005
Solar Dried Pachaikodi	5.26^{c}±0.06	16.45^{b}±0.09	7.40^{c}±0.07	43.14^{c}±0.04	9.58^{d}±0.1	10^{a}±0.004
Solar Dried Vellaikodi	6.65^{d}±0.05	17.85^{d}±0.04	2.36^{a}±0.05	39.06^{a}±0.04	8.17^{b}±0.05	14^{b}±0.004
F value	269.085**	171.266**	9152.692**	2883.132**	161.766**	292519.427**

C. Colour and chlorophyll measurement

The colour values of dried betel leaf powder are shown in Table 2. The lightness values (L*) of solar-dried betel leaf samples (pachaikodi and vellaikodi) are 48.27 and 51.28. The lightness values (L*) of tray dried betel leaf samples (pachaikodi and vellaikodi) are 47.88 and 49.93. The variety of betel leaf plays a significant role in drying. The results show that the vellaikodi variety is lighter than the pachaikodi. The changes in lightness value are due to cholorophyll degradation in vellaikodi, which is higher than in pachaikodi vareity. The drying temperature and time also affect the lightness values.

a* values of the solar-dried betel leaf samples (pachaikodi and vellaikodi) are 3.08 and 3.89. a* values of tray dried betel leaf samples (pachaikodi and vellaikodi) are 1.33 and -0.59. Visually, the dark green colour of the pachaikodi variety of betel leaf seems to be a dull green-yellow colour, and the light green colour of the vellaikodi variety of betel leaf seems to be a dull red-yellow colour.

b* values of the solar-dried betel leaf samples (pachaikodi and vellaikodi) are 14.22 and 14.07. b* values of tray dried betel leaf samples (pachaikodi and vellaikodi) are 12.62 and 14.48. The positive value implies that the dried betel leaf seems to be yellow in colour. The changes in b* were based on the variety of betel leaves, drying temperature, drying time and drying methods.

The cholorophyll values of dried betel leaf powder are shown in Table 3. The cholorophyll content of the tray-dried samples is higher than the solar-dried. The green colour of leaves is due to the cholorophyll molecule, which is related to magnesium. While drying, the magnesium may be converted into pyropheophytin and pheophytin (Ali *et al.*, 2014). During solar drying, the leaves are directly exposed to the sunlight, which may lead to the degradation of cholorophyll.

Table 2: Colour values (Mean±SE) @ of Betel leaf powder.

Sample	L*	a*	b*	dE*
Tray Dried Pachaikodi	47.88^{a}±0.02	1.33^{b}±0.05	14.22^{d}±0.03	47.37^{d}±0.01
Tray Dried Vellaikodi	49.93^{c}±0.02	-0.59^{a}±0.1	14.08^{b}±0.04	45.25^{b}±0.03
Solar Dried Pachaikodi	48.27^{b}±0.02	3.07^{c}±0.07	12.16^{a}0.06	46.81^{c}±0.01
Solar Dried Vellaikodi	51.28^{d}±0.02	3.89^{d}±0.03	14.48^{c}±0.04	44.40^{a}±0.01
F value	7278.232**	929.792**	346.836**	5803.022**

Table 3: Chlorophyll (Mean±SE) @ of Betel leaf powder.

Sample	Total Chlorophyll (µg/ml)	Chlorophyll a (µg/ml)	Chlorophyll b (µg/ml)
Tray Dried Pachaikodi	26.80^{d}±0.04	20.11^{d}±0.02	6.69^{d}±0.06
Tray Dried Vellaikodi	20.04^{c}±0.01	15.91^{c}±0.02	5.88^{c}±0.02
Solar Dried Pachaikodi	18.10^{b}±0.02	13.71^{b}±0.08	4.40^{b}±0.06
Solar Dried Vellaikodi	4.48^{a}±0.07	3.52^{a}±0.05	0.96^{a}±0.02
F value	51116.323**	20054.384**	2976.16**

CONCLUSION

Drying is the most popular preservation technique that produces a shelf-stable product for longer storage. Drying also minimises post-harvest losses and reduces the spoilage of perishable products. Cabinet tray drying and solar tunnel drying are the most popular methods of drying. The retention of nutrients like carbohydrates, protein, fat, fiber, ash and quality attributes like colour and flavour was good in cabinet tray drying as compared to solar tunnel drying. Solar drying also results in the degradation of cholorophyll content. It can be concluded that cabinet tray drying was a better method of dehydration when compared to solar tunnel drying.

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Conflict of Interest. None.

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