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Effect of Drying on Quality and Sensory Attributes of Lemongrass (*Cymbopogon citratus*) Tea

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Abstract

The aim of this study was to investigate the effect of drying on quality and sensory attributes of lemon grass (*Cymbopogon citratus*) tea. Lemongrass (*C. citratus*) leaves were dried using four different drying methods: sun, solar, oven (40, 50, and 60 ℃), and microwave (50 W). Teas made from the grass were analyzed for colour, pH and sensory attribute. Data obtained were statistically analyzed using SPSS Version 23 one way analysis of variance and means were compared using Duncan multiple comparison test ($p < 0.05$). Results obtained indicate that after drying the moisture content were significantly reduced. Ash content results showed no significant difference amongst lemongrass samples dried under difference drying methods. However, there was a significant difference ($p < 0.05$) in the pH of tea made from the lemongrass dried under different drying methods. Results indicate that drying temperature and time are the main factors affecting the colour of dried lemongrass leaves for tea. There was a significant difference ($p < 0.05$) in the colour profile of the dried leaves. Sensory evaluation results showed that the colour, aroma, taste, and overall acceptability scores of tea from lemongrass dried with oven at 40 ℃ was highest. The study revealed that oven drying at 40 ℃ for 15 hours was found to be most suitable for drying of lemongrass leaves for tea production in order to retain appreciable sensory attributes.

Keywords: lemongrass, drying methods, tea, organoleptic properties, chemical properties, sensory evaluation

1. Introduction

It is generally accepted that tea is one of the most popular beverages in the world. The demand for high-quality dried food products is permanently increasing all over the world. The main purpose of drying is to extend product shelf life, minimize packaging requirements and reduce shipping weights (Hamrouni-Sellami et al., 2012). Drying process increases the shelf life by slowing microbial growth and thus preventing certain biochemical reactions that might alter the organoleptic characteristics (Díaz-Maroto et al., 2003; Hamrouni-Sellami et al., 2012). Lemongrass (*Cymbopogon citratus*) is an herb that belongs to the genus *Cymbopogon* of aromatic grasses and contains essential oil with fine lemon flavour (Nur Ain et al., 2011). It is a tallperennial grass widely cultivated in Brazil for medicinal purposes, especially as tea and its essential oil (Martinazzo et al., 2009); grows up to 90 cm in height and 5 mm wide (Nur Ain et al., 2013); is highly sought after in the nutritional, pharmaceutical and flavouring industries (Lonkar et al., 2013). Cultivated on a large scale, especially in tropics and subtropics (Akhila, 2010), lemongrass is commonly used in folk medicine for treatment of nervous and gastrointestinal disturbances, and as an antispasmodic, analgesic, anti-inflammatory, anti-pyretic, a diuretic and a sedative (Brian & Ikhlas, 2002; Santin et al., 2009; Lodhi et al., 2014). It contains active ingredients like myrcene, an anti-bacterial and the pain relievers, citronella, and geraniol (Blanco et al., 2009). India is the largest producer of lemongrass of which about 80% is exported. Leite et al. (2000) also reported that lemongrass tea can be used to treat fevers, colds, coughs and stomach upset. With its wide use as an ingredient for cooking, Berry (2004), describes lemongrass as the rising star in the herbal world, having both floral and fragrant characteristics that add an instant exotic appeal to food and beverages.

Teas from various sources are available in popular flavours (spicy, smoky, cinnammon-like, sweet ether-like, weak sulfurous) and are consumed for amongst other benefits, their antioxidant properties (Hara, 1994; Hengel and Shibamoto 2013). Lemongrass tea has a flavour very true to the flavour of the herb itself, a characteristic lemon flavour due to its composition, rich in volatile oils that present chemical components of great importance to the industry (Barata et al 1998). This study investigated the effect of drying on quality and sensory attributes

of freshly harvested lemongrass (*Cymbopogon citratus*) tea.

2. Materials and Methods

2.1 Sample Collection and Preparation

Fresh leaves of lemongrass were collected with permission from a farmer in Matangari Village in Limpopo province, South Africa. The samples were selected on the basis of fresh green leaves. The leaves were washed with water and cut into small pieces with a clean scissors/stainless steel knife (Lonkar et al., 2013). All procedures including tests were performed in triplicate.

2.2 Drying Experiments

Fifty (50) g of fresh chopped green lemongrass were dried using sun, solar dryer (Janjai et al., 2002),microwave (model P70B17L-T8)at 50 W, and oven (Prolab Instrument - model OTE 80) at 40 ℃, 50 ℃, 60 ℃ (Lonkar et al., 2013; Nur Ain et al., 2013). During the drying process, the weight of the sample were monitored at regular intervals (hourly) using weighing balance (ADAM AAA 300L/PW 254) and the process was stopped at a point where the weight of the sample remained constant (Lonkar et al. 2013). The dried lemongrass was stored in an airtight bag plastic bag until further analysis (Lonkar et al., 2013 & Nur Ain et al., 2013).

2.3 Quality Analysis

2.3.1 pH of Dried Lemongrass Leaves

A pH meter (Crison instrument, 042030, S.A) was used to assess the pH of each sample. Fresh standardization solutions of pH 4.01, 7.00, and 9.21 were used to standardize the instrument before using and after every five or six reading (Vargas et al., 2008).

2.3.2 Colour of Lemongrass Tea

A colorimeter (Hunter Lab s/n: cx2540) was used to measure the *L** (Lightness), *a** (Redness), and *b** (Yellowness) colour parameters of each tea sample. The colorimeter was calibrated with a standard white (L* = 93.71, a* = –0.84 and b* = 1.83) and black plate prior to each colour measurement.

2.3.3 Moisture Content of Dried Lemongrass Leaves

Dried lemongrass cuts (3 g) were dried in pre-weighed crucibles in an oven at 105 ℃ for 3 hours, and cooled in desiccator for 30 min. Moisture content was calculated from difference in weight according to A0AC, 2007 method number 945.32. The following formula was used to calculate the moisture content (MC) of dried lemongrass:

$$MC\ \% = W_2 - W_3 / W_2 - W_1 * 100$$

where:

W_1 = Initial weight of empty crucible

W_2 = Weight of crucible + samples prior drying

W_3 = Final weight of crucible + sample after drying

2.3.4 Ash Content of Dried Lemongrass Leaves

Dried samples (3 g) in pre-weighed crucibles were transferred and kept in a muffle furnace at 550 ℃ overnight and left until a light grey ash resulted, and cooled in a desiccator for 30 min before weighing (Aftab et al., 2011). The following formula was used to calculate ash content (AC) of lemongrass samples.

$$AC\ \% = W_3 – W_1 / W_2 - W_1 * 100$$

where:

W_1 = Weight of empty crucible

W_2 = Weight of crucible + samples prior drying

W_3 = Final weight of crucible + ash

2.4 Preparation of Tea from Dried Lemongrass Leaves

The unsweetened lemongrass teas were prepared using each of the dried samples as follows: sample (18 g) was weighed and put into a flask (1.8 L) to which boiling water (99.7^{o}C) was added. The teas were left to brew for 5 min and then passed through a 106 μm sieve. The tea was not sweetened.

2.5 Sensory Evaluation of Tea

Sensory evaluations of the teas brewed as described above were conducted in the Department of Food Science and Technology using 50 untrained panellists. The lemongrass tea were evaluated with respect to colour, aroma, taste, and overall acceptability using the 5-point hedonic scale where 1 represents dislike extremely and 5 like extremely respectively. Tea samples were coded and served randomly to panellists to avoid bias (Hashin et al., 2009). About 30 ml of each tea samples was served in a 120 ml paper cup. The tea samples were approximately 67.2 ℃ at the time of tasting. The panellist were served and instructed to rinse their mouth with warm water (45.7 ℃) in between evaluating each tea sample to minimize the lingering tastes (Meilgaard et al., 1999).

2.6 Statistical Analysis

The statistical software package SPSS Version 23 program was used to analyse all experimental data collected. All comparisons were subjected to a one-way analysis of variance (ANOVA), and significant differences between treatments means were determined using Duncan's multiple range test (Duncan, 1955) at $p < 0.05$.

3. Results and Discussion

3.1 Moisture Content of Fresh Lemongrass Leaves

The initial moisture content of the freshly harvested lemongrass samples was found to be 73 %. It could be observed from Table 1 that the final moisture content of lemongrass samples varied with respect to the different drying methods.

Table 1. Effect of drying methods on moisture content of dried lemongrass

Drying methods	Temperature (℃)	Time (h)	Final moisture content (%)
Sun	34.7	10	3.33 ±2.89
Solar	50.6	8	5.00 ±0.00
Oven	40	15	5.00 ±0.00
	50	8	5.00 ±0.00
	60	6	2.10 ±0.00
Microwave	**Power (W)**		
	50	0.9	3.33 ±2.89

The final moisture contents of lemongrass samples ranged from 3.33 to 5.00%. The moisture content was in the range of 0% - 5% for different drying conditions. Products dried using sun and microwave at 50 W had similar (3.3%) amount of moisture content, however the highest (5%) amount of moisture were in solar, oven at 40 ℃, and 50 ℃ while the lowest (0%) was oven at 60 ℃ (Table 1). The shelf stability of a food product depends on the moisture content i.e. the higher the moisture content, the lower the shelf stability and vice versa (Fennema, 1996).The moisture content of dried lemongrass tea leaf samples were within the recommended moisture content range (3-12% (w/w) (Barbosa et al., 2008). This is an indication that all the dried samples are likely to stay longer before use or processing due to their low moisture content since the low moisture content of the leaves coupled with drying could hinder growth of microorganisms, hence storage life would be longer (Awogbemi & Ogunleye 2009).

3.2 Ash Content of Dried Lemongrass Leaves

The ash contents of lemongrass samples dried under the different drying conditions is as shown in Figure 1. The ash content of lemon grass samples varies with respect to the drying conditions. The ash contents of lemongrass samples ranged from 6.67 to 7.78, with oven dried at (60 ℃) samples having the highest ash content (7.78%) while sun, solar, oven (40 ℃, 50 ℃) and microwave (50 W) had the same (6.67%) ash content. Ash content is as a measure of the total amount of minerals present within a food. According to Kirk & Sawyer (1997), the range of the ash content of dried samples is 5.2% to 7.2% for teas. Product dried by sun, solar, oven at 40 ℃, 50 ℃, and microwave were within the recommended range of 5.2% to 7.2%. This is an indication that lemongrass leaves has a considerable amount of minerals. However, oven at 60 ℃ exceeded the recommended range of 5.2% to 7.2% since it has the highest (7.78%) amount of ash, this could be attributed to the reduction in moisture content during drying that resulted in corresponding increases in dry mater content due to concentration of soluble solids (Tetteh, 2009). There was no significant difference amongst the ash content of lemongrass samples dried under difference drying methods (Table 2).

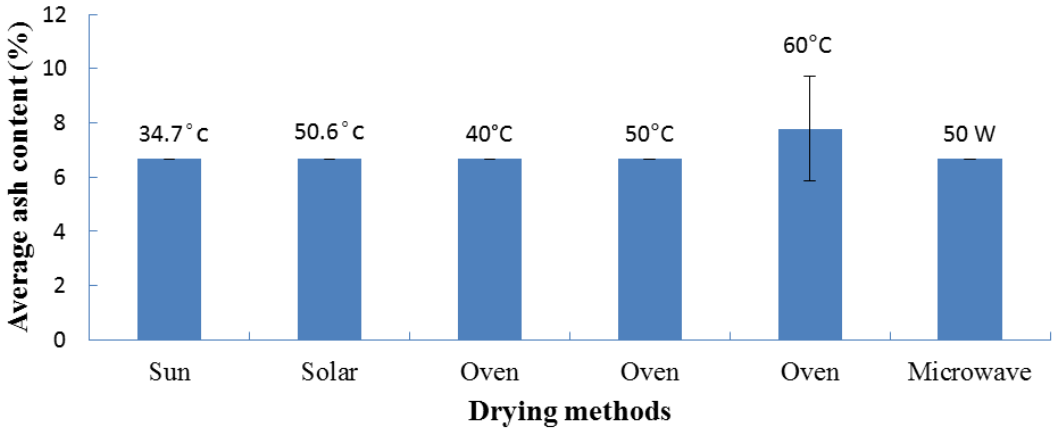

Figure 1. Average ash content of dried lemongrass under different drying methods

3.3 pH Measurement of Lemongrass Leaves

The lemongrass tea samples from different drying conditions gave pH readings as shown in Figure 2.It shows variation of ash contents of lemongrass samples with respect to the drying conditions. The pH contents of lemongrass samples ranged from 5.8 to 6.3.Variation in pH might be attributed due to delay in drying, wherein the leaves started to ferment even though they were stored in the cold room before analysis. The variation in pH values could further be explained by factors such as exposure times to drying air, drying air temperature, relative humidity in the drying site, nature of drying air flow as previously indicated by Franke et al., (2008). Almost similar pH readings were obtained from the analysis of lemongrass in Ghana (De-heer, 2011). There was a significant difference amongst the pH of the samples dried under different drying methods (Table 3). De-heer (2011) conducted a study in Ghana on formulation and sensory evaluation of herb tea from *Moringa oleifra, Hibscus scibdariffa* and *Cymbopogon citratrus* and obtained a pH of 4.53. The pH found in this study was higher than that reported by De-heer (2011). This could possibly be due to variation in climatic condition and the soil types.

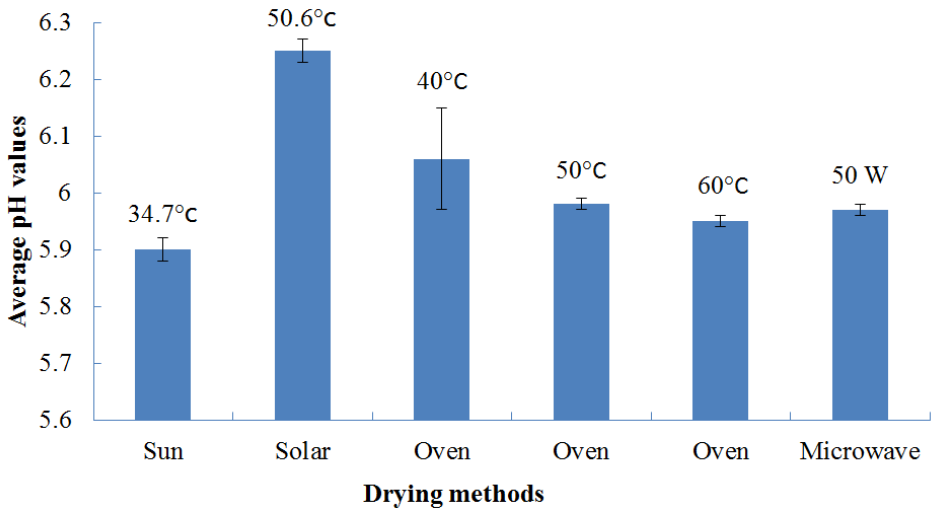

Figure 2. Average pH of dried lemongrass dried under different drying methods

3.4 Instrumental Colour Analysis of Lemongrass Tea

Colour is an important attribute of dried product from the consumer's acceptability view (Inchuen et al., 2010). It is also considered as an important quality indicator for acceptance of the final product in the market (Soysal, 2004).The results shows that drying temperature and time are the main factors affecting the colour of dried lemongrass leaves for tea. Similar observation was made by Somkiat et al., 2004. Oven at 40 ℃, 50 ℃, and 60 ℃ (Table 2), shows the reduction in brightness value L* of the dried lemongrass leaves as the drying temperature increases. These results agreed with the observation of Hoque et al., 2013. They reported that lightness L*

decrease with an increase in drying temperature. These results again agreed with the observation of Sanmeema (2012). He reported that the colour parameters for L* values were high at 40 ℃ when compared with 50 ℃ and 60 ℃, this indicate that the dried products were darkened when the temperature increases. The highest L* value was obtained in products dried by sun and oven at 40 ℃, indicating the drying methods which are useful in maintaining the colour of the dried products. There was a significance difference ($p < 0.05$) between the L* values of lemongrass leaves dried under the difference drying methods. Negative a* values obtained for samples dried under sun, solar, oven at 40 ℃, 50 ℃, and 60 ℃, indicated that all lemongrass leaves dried under the different drying conditions were green. The lowest a* values were obtained from solar drying with decreased greenness followed by oven at 40 ℃, oven at 60 ℃, oven at 50 ℃ and sun respectively. However, microwave at 50 W was having a positive a* value, indicating that the green colour was negatively affected and destroyed during drying. This was expected since the previous studies reported (Drouzas et al., 1999) that undesirable browning and reduced green colour of the microwave-dried product occurred in samples because of the high temperature generated by the microwaves. The b* values indicating the yellowness of the samples varied from 12.98 to 18.74. There was a significant difference ($p < 0.05$) of yellowness from all drying methods.

3.5 Sensory Evaluation of Lemongrass Tea Samples

3.5.1 Colour Acceptability

Colour of a food surface is the first quality parameter evaluated by consumers and is critical in product acceptance, even before it is tasted (Youssef and Mokhtar 2014). Consumers expect food to look appetizing and the colour of food is usually associated with expected the flavour of food (Downham & Collins 2000). Consumer responses on colour acceptability showed that, tea from microwave at 50 W, oven 60 ℃, and sun were least acceptable while the colour of oven 50 ℃, solar, and oven 40 ℃ were the most acceptable. Similar observation was made by Cuervo-Andrade (2011). Colour acceptability of the tea samples increased in order as follow: microwave at 50 W < oven at 60 ℃ < sun < oven at 50 ℃ < solar < oven at 40 ℃ (Table 3). This indicates that samples from microwave at 50 W, oven at 60 ℃ and sun were negatively affected during drying. This agreed with the observation of Rahimmalek & Goli (2013). They reported that oven drying at higher temperature resulted in a considerable decrease in the colour quality of celak leaves. Shaw et al. (2007) reported a significant colour change in coriander foliage under microwave drying process. Ozkan et al. (2007) also reported that the colour of spinach was adversely affected under microwave drying process at very high microwave powers. Rahman et al. (2013) reported that direct exposure to sunlight reduces the quality of lemongrass such as colour, flavour leading to the production of low and variable quality of products. There was a significant difference amongst the colour acceptability of the samples dried under different drying methods (Table 3). The colour acceptability was in a range of 2.58 to 3.56. A possible explanation for this low colour acceptability range could possibly be that consumers in the study area expect the colour of the tea to be black. Lemongrass tea is not known or consumed in the study area, and assessors used for evaluation of the tea acceptability are not familiar with the lemongrass tea unlike other commercial tea found in shopping malls in the study area. These are possibly the reason for low colour acceptability range observed in the study.

3.5.2 Aroma Acceptability

Lemongrass tea is expected to have a strong aroma (Baratta et al., 1998; Kasali et al., 2001; Nur Ain et al., 2011). This is due to its high concentration of aromatic oils. Results show variation in aroma acceptability of tea samples obtained using different drying condition in the range of 2.66 to 3.52. A possible explanation for the variation in aroma (2.66 to 3.52) might be that aroma producing compounds are generally volatiles or they get combined with other biomolecules when grinding samples for preparation of powder (Lonkar et al., 2013). There was a significant difference amongst the aroma acceptability of the samples dried under different drying conditions (Table 3). Consumer responses on aroma acceptability showed that, tea from microwave at 50 W (2.66), oven at 60 ℃ (2.74), and sun (2.98) were least acceptable while the aroma of oven at 50 ℃ (3.20), solar (3.24), and oven at 40 ℃ (3.52) were most acceptable.

3.5.3 Taste Acceptability

Lemongrass tea has a flavour very true to the flavour of the herb itself. As the name suggests, the tea tastes lemon (Leite et al., 2000). Taste is one of the sensory properties which form the component of flavour of a product (Meilgaard et al., 1999). The result shows variation in taste acceptability of lemongrass tea samples obtained from different drying condition. There was a significant difference amongst the taste acceptability of the samples dried under different drying conditions (Table 3).Consumer responses on taste acceptability showed that, tea from oven at 40 ℃, solar, and sun were the most acceptable while those dried by oven at 60 ℃, microwave 50 W, and oven at 50 ℃ were least acceptable as shown in Table 3. Low taste acceptability scores

which were in a range of 2.62 to 3.40 could be due to the observed elements in the tea.

3.5.4 Overall Acceptability

Results show that product dried using oven at 40 ℃ had the highest mean score in overall acceptability (3.50) as shown in Table 3. This was expected as it was the most preferred product in colour (3.56), aroma (3.52), and in taste (3.40). The overall acceptability of the tea is based on the organoleptic properties such as colour of tea, aroma of tea and taste of the tea (Lonkar et al., 2013). Low scores on colour, aroma and taste acceptability due to the fact that consumers were not familiar with lemongrass tea. Consumers expect the colour of the tea to be black. They also expect the taste of the tea to be sweetened. Exposure of aroma forming compounds to the natural environment due to the use of various treatments of cutting and powder making (Lonkar et al., 2013) could be possibly have caused a lesser overall acceptance by panellists which was in a range of 2.56 to 3.50 despite the fact that the highest score was 3.50.There was no significant difference amongst the overall acceptability of the samples with high scores which are dried by sun, solar, oven at 40 ℃, and oven at 50 ℃ (Table 3). This indicate that these are the product which were most accepted by the panellist with respect to their colour, aroma, and taste. However, samples dried by oven at 60 ℃ and microwave at 50 W were significantly different to samples dried by sun, solar, oven at 40 ℃, and at 50 ℃. This also indicate that products dried by oven at 60 ℃ and microwave at 50 W were least accepted by the panellist with respect to their colour, aroma, and taste. These agreed with the observation of Rahimmalek & Goli, 2013. They reported that oven drying at higher temperature resulted in a considerable decrease in the colour quality of the leaves. Shaw et al. (2007), reported about the colour changes occurring during drying of most of the leaves using microwave drying process. There is increasing need for methods and tools for determining the characteristics of tea varieties (Buyukgoz et al., 2016).

Table 2. Physicochemical analysis for lemongrass dried under different conditions

			Oven (℃)			
Properties	**Sun**	**Solar**	**40**	**50**	**60**	**Microwave at 50 W**
L*	50.29 ±1.15^{a}	47.13 ±0.48^{b}	50.22 ±1.96^{a}	43.74 ±1.13^{c}	39.62 ±1.21^{d}	40.09 ±1.16^{d}
a*	-0.86 ±0.49^{b}	-3.94 ±0.55^{d}	-2.15 ±0.19^{c}	-1.03 ±0.13^{b}	-2.11 ±0.58^{c}	1.44 ±0.14^{a}
b*	12.98 ±1.05^{d}	13.21 ±0.76^{d}	15.23 ±0.67^{c}	13.55 ±0.70^{d}	18.74 ±0.90^{a}	16.81 ±0.33^{b}
Ash	6.67 ±0.00^{a}	6.67 ±0.01^{a}	6.67 ±0.02^{a}	6.67 ±0.03^{a}	7.78 ±1.92^{a}	6.67 ±0.03^{a}
pH	5.89 ±0.02^{d}	6.25 ±0.02^{a}	6.06 ±0.09^{b}	5.98 ±0.01^{c}	5.96 ±0.03^{cd}	5.97 ±0.01^{cd}

Mean scores in the same row with different superscripts are significantly different ($p < 0.05$). L* = Lightness, a* = Redness, b* = Yellowness.

Table 3. Sensory analysis for lemongrass tea dried under different drying conditions

			Oven (℃)			
Sensory properties	**Sun**	**Solar**	**40**	**50**	**60**	**Microwave at 50 W**
Colour	2.98 ±1.27^{bc}	3.46 ±1.27^{ab}	3.56±1.23^{a}	3.24±1.25^{ab}	2.94±1.32^{bc}	2.58±1.21^{c}
Aroma	2.98 ±1.15^{bc}	3.24 ±1.22^{ab}	3.52±1.13^{a}	3.20±1.14^{ab}	2.74±1.34^{bc}	2.66±1.32^{c}
Taste	3.02 ±1.15^{abc}	3.30 ±1.27^{ab}	3.40 ±1.12^{a}	2.84±1.29^{bc}	2.62±1.24^{c}	2.74±1.26^{c}
Overall acceptability	3.34±0.98^{a}	3.40 ±1.23^{a}	3.50 ±0.91^{a}	3.16±1.17^{ab}	2.78±1.22^{bc}	2.56±1.31^{c}

Mean scores in the same row with different superscripts are significantly different ($p < 0.05$).

4. Conclusion

The study investigated the effect of drying on quality and sensory attributes of lemon grass (*Cymbopogon citratus*) tea. Results showed that the sensory properties, moisture content, ash content, pH and colour of lemongrass samples differ with respect to the drying methods used. Lemongrass tea from samples dried by oven at 40 ℃ was the most preferred in colour, aroma, taste and overall acceptability. Oven drying at 40 ℃ was found to be most suitable for drying of lemongrass leaves for tea production in order to retain appreciable sensory attributes.

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