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Effect of Drying on Oil Yield, Antioxidant Capacity and Bioactive Compounds of *Pogostemon heyneanus* Benth. (Lamiacea)

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ABSTRACT

The study was conducted to find out the effect of different drying temperatures; room temperature, 40, 45, 50, 55 and 60 °C on drying herbage of *Pogostemon heyneanus* in terms of drying time, drying curves, oil yield, antioxidant capacity and composition of bioactive compounds (phenolics and flavonoids). Initial moisture contents of freshly harvested stems and leaves of *Pogostemon heyneanus* were determined using microwave oven method and separately dried under different temperatures until the moisture contents were reduced less than twenty percent. Moisture loss was recorded three hourly intervals in order to plot drying curves under different drying temperatures. The dried herbages were tested for oil content, total antioxidant capacity (TAC), total phenolic content (TPC) and total flavonoid content (TFC). For both stems and leaves oil recovery was significantly increased with the temperature. The highest leaf and stem oil contents respectively 2.5% and 0.51% were found under 55 °C while those of the lowest respectively 1.95% and 0.35% were found under room temperature. However, significant losses were found in TAC, TPC and TFC of dried leaves of *Pogostemon heyneanus* with the increasing temperatures. The findings of the study necessitates further studies on drying behavior of this crop in terms of oil quality under different drying temperatures even beyond 60 °C before recommendations.

KEYWORDS: Antioxidant capacity, Drying temperatures, Oil content, Phenolics, *Pogostemon heyneanus*

INTRODUCTION

Pogostemon heyneanus is an aromatic crop, belonging to the family Lamiaceae and is commonly known as *Kollankola*. It is cultivated extensively in Indonesia, Malaysia, China and Brazil for the essential oil namely Patchouli Oil. Since there is no any synthetic substitute for patchouli oil, it has a great demand in food, beverage, pharmaceutical and perfumery industries (Akhila and Tewari, 1984).

Pogostemon heyneanus leaves and stems have to be dried for removing excess moisture prior to the distillation step. This would be very important to improve the yield and quality of the oil. For higher recovery of the oil, the moisture content of patchouli herbage should be between 2.5 and 8.3 per cent (Prabu, 2006). At present, shade drying is commonly practiced in the commercial level processing of patchouli oil. In this method, the herbage is dried in ventilated rooms. High ambient air temperature and relative air humidity during the harvesting season promote insect and mold development in harvested crops. Furthermore, intensive solar radiation adversely affects quality, causing losses in essential oils or color changes in dried plants (Ambrose *et al.*, 2013).

Modern studies have found that oil recovery of medicinal plants increases with the drying temperature (Blazek and Kucera, 1952). High temperatures influence essential oil quantity and quality in aromatic and medicinal plants and reduction in active ingredients continues during storage period as well (Martinazzo *et al.*, 2009).

The temperature of drying air influences the quantity and quality of the active ingredients present in herbage. In spite of all technical developments, the choice of the correct drying temperature remains a central economic criterion, confirming that there is an urgent need for research on this topic. Therefore, finding of a drying temperature that had a higher amount of oil content while keeping its aromatic and active ingredients for a satisfactory level is timely required. This study aims were to investigate how stem and leaf oil contents vary with the increase of drying temperature, their respective drying periods and active ingredient contents.

MATERIALS AND METHODS

Experimental Location

The study was carried out at the Department of Plantation Management, Faculty of Agriculture and Plantation Management, Wayamba University of Sri Lanka with the collaborations of Industrial Technology Institute (ITI), Colombo.

Sample Preparation

Freshly harvested *P. heyneanus* herbage was collected from experimental plots. Leaves

and stems were separated from 1 kg of herbage sample and used for each drying trial.

Drying Studies

Initial moisture contents of the samples were determined by micro wave oven method (Rocha *et al.*, 2010). Samples were then dried at room temperature in a well-ventilated room and temperatures of 40, 45, 50, 55 and 60 °C in an oven. The oven (Model; POL-EKO APPERTURA SL 115) had internal dimensions 460, 540 and 450 mm respectively width, height and depth and nominal power of 2,400 W operated under 240 V at 50 Hz. The weights of the samples were recorded at three hourly intervals, and the drying was stopped once consecutive readings on the weight were achieved to be constant.

Estimation of Volatile Oil Content

The volatile oil content of the dried patchouli herbage was estimated using a clevenger arm apperatus. Well-grounded 100 g of leaves and stems were used for the distillation.

Determination of Total Antioxidant Capacity (TAC)

Total antioxidant capacity was determined using Ferric Reducing Antioxidant Power (FRAP) assay as described by (Benzie and Strain, 1996).

Determination of Total Phenolic Content (TPC)

The total phenolic contents were determined by modified Folin–Ciocalteu method (Abeysinghe *et al.*, 2007).

Determination of Total Flavonoid Content (TFC)

Total flavonoid contents of the samples were determined by colorimetric method (Liu *et al.*, 2002).

RESULTS AND DISCUSSION

Drying Behavior of Leaves and Stems

The moisture content of patchouli herbage decreased with drying time. The average initial leaf moisture content of *P. hayneanus* herbage was estimated to be about 356% dry basis (d.b), and that of the stem is about 372% (d.b). However, the total time required to reach the final moisture content less than 20%, varied among the different drying temperatures of leaves and stem samples. As showed in Figure 1 the total time requirement of drying leaves under room temperature, 40, 45, 50, 55 and 60 °C were respectively 18, 33, 21, 18, 12, 9 hours and that of stems were respectively 36, 36, 21, 21, 15 and 12 hours (Figure 2).

The time taken for drying at room temperature (18 h) was less than samples dried at 40 °C (33 h) and 45 °C (21 h). Also it had taken an equal time duration as the samples dried at 50 °C in an oven. This was due to the well ventilation found at room temperature as the samples were totally opened for the action of a ceiling fan (Model KDK M56RG; 75W, 275 R.P.M) placed 12 ft above it. Similarly drying stems of *P. heyneanus* under room temperature seemed more efficient than drying at 40 °C in an oven. The moisture reduction verses time relationship was found to be nonlinear. Under different temperatures, the decrease in moisture being larger initially as compared to the latter part of drying. Similar results were reported by Ambrose *et al.* (2013) on drying herbage of *P. cablin.*

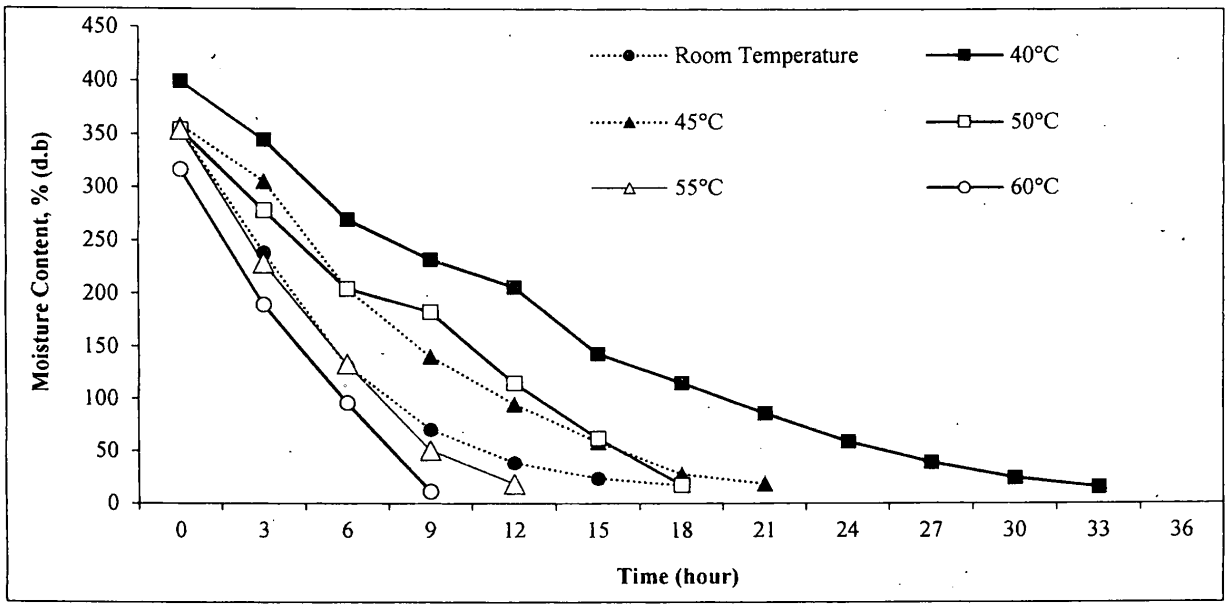

Figure 1. Moisture reduction in leaves of *P. heyneanus* under different drying temperatures

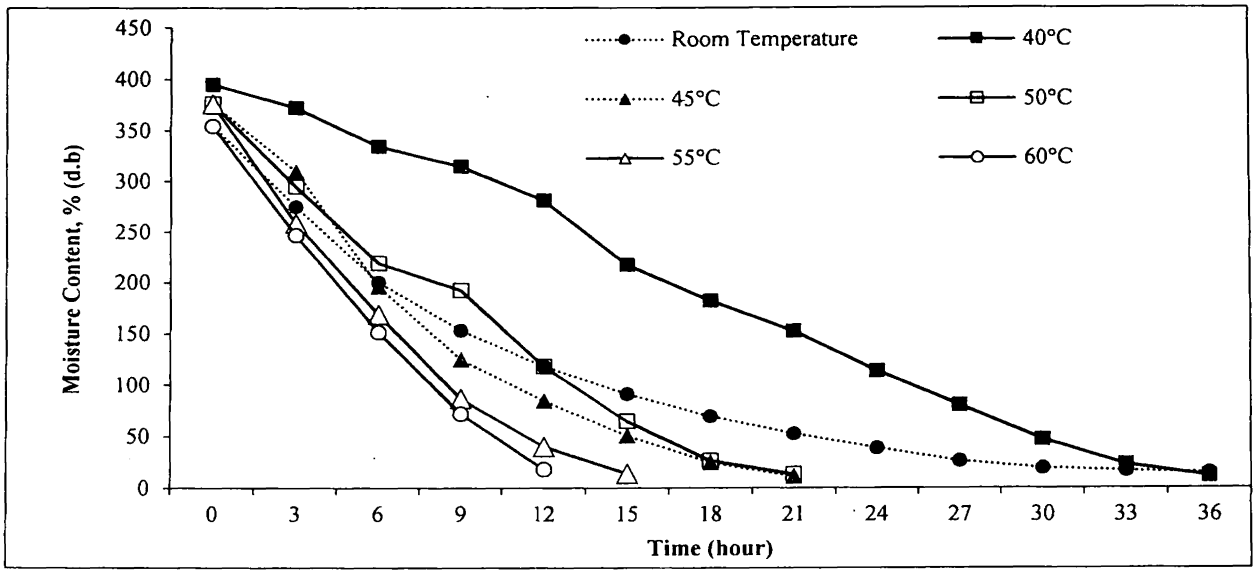

Figure 2. Moisture reduction in stems of *P. heyneanus* under different drying temperatures

Effect of Different Temperatures on Leaf Oil Content

The highest oil content was found in leaves dried at 55 °C (2.5%). This was followed by drying temperatures of 50 °C (2.41%), 45 °C (2.13%), 60 °C (2.06%), 40 °C (2.01%) and under the room temperature (1.95%) (Figure 3). Up to 55 °C oil content increased with the temperature. Reduction in oil yield was found at 60 °C by 17.6% compared to the oil yield in 55 °C. This reduction may be due to volatilization which occurred at high-temperature conditions (Buggle *et al.*, 1999). However, the plants dried at 55 °C recorded the highest oil content, statistically, it was not significantly different with the leaves dried at 45 °C and 50 °C however significantly differed from room temperature, 40 °C and 60 °C. Further, the leaves dried at room temperature yielded the least oil content and it was not statistically significant from the oil contents of leaves dried at 40, 45 and 60 °C. This result was in conformity with the findings of Radünz *et al.* (2003) where the highest oil yield was found at 55 °C among the temperatures of ambient air, 40 and 70 °C in drying the leaves of *Mikania glemerata* Sprengel. Extended periods of drying times found under lower drying temperatures which promote enhanced enzymatic activity and the oxidative process would be a reason for the decrease in oil content with the decrease in drying temperature (Radünz *et al.*, 2010).

Effect of Different Temperatures on Stem Oil Content

Different temperatures had a significant effect on stem oil content. As similar in leaf oil content, the highest stem oil content was recorded in stems dried at 55 °C (0.51%) whereas the lowest was found in stems dried under the room temperature. From room temperature up to the drying temperature 55 °C, the stem oil content increased with the temperature. However, a slight reduction was observed in oil content at 60 °C (0.47%) compared to that of 55 °C. Though the drying temperature of 55 °C recorded the highest stem oil content, statistically it was not significant from stem oil contents of drying temperature at 50 and 60 °C. The stem oil content at 40 °C was not significantly different from oil contents at room temperature and 45 °C.

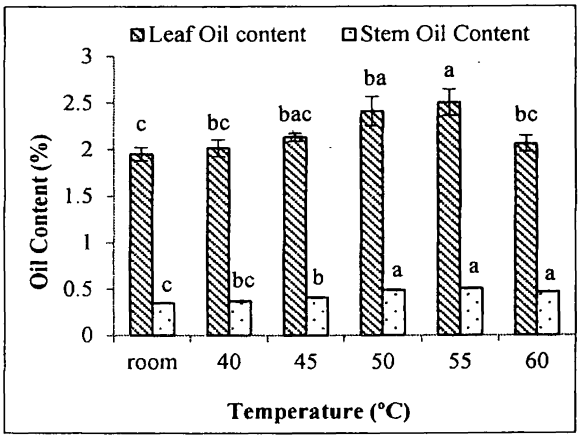

Figure 3. Leaf and stem oil contents under different drying temperatures

Effect of Different Drying Temperatures on Total Antioxidant Capacity, Total Phenolic, and Total Flavonoid Contents

Total Antioxidant Capacity (TAC)

The highest antioxidant capacity was recorded in leaves dried at ambient air (52.77 mg TE/g DW). This was followed by leaves dried at 40, 45, 50, 55 and 60 °C. Total Antioxidant Capacity of room temperature was significantly different from all other treatments (Table 1). However, the TAC of leaves dried at 40 °C and 45 °C were not significantly different.

Table 1. Total antioxidant capacity (TAC), total flavonoid content (TFC) and total phenolic content (TPC) of dried leaves *P. heyneanus* under different temperatures

Temperature °C	TAC (mg TE/g DW)	TFC (mg RE/g DW)	TPC (mg GAE/g DW)
Room Temperature	52.77±4.69a	99.66±3.10a	15.88±0.22a
40	43.39±3.26b	82.81±0.54b	13.25±0.16b
45	40.44±1.20b	76.81±3.99b	12.86±0.12c
50	30.73±0.60c	52.28±1.71c	12.64±0.06c
55	27.74±0.43c	32.38±1.29d	12.14±0.03d
60	14.76±1.67d	23.76±1.93e	9.57±0.08e

Means with the same letters in a column are not significantly different at 0.05 level; TE - Trolox Equivalents; GAE - Galic Acid Equivalents; RE - Rutin Equivalents; DW - Dry Weight.

Further, the results clearly explain a decrease in TAC with increasing temperature. Similar results were obtained by Pokorney, (1986) where further stated that decrease in antioxidant capacity with increasing temperature was typical. Further, the decrease in antioxidant activity with the increasing temperature was caused mainly due to the decrease in the ability of antioxidants to react with free radicals at a higher temperature.

Total Phenolic Content (TPC)

The highest total phenolic content (15.88 mg GAE/g DW) was observed in leaves dried at room temperature whereas the lowest (9.54 mg GAE/g DW) was found in leaves dried at 60 °C (Table 1). Different drying temperatures had a significant effect on the TPC of leaves in *P. hayneanus*. Except 45 and 50 °C the TPC of different drying temperatures were significantly different from each other.

Total Flavonoid Content (TFC)

As similar in TAC and TPC the highest total flavonoid content was found under leaves dried at room temperature (99.66 mg RE/g DW) and it was significantly different from all (Table 1). The least TFC was found in leaves dried at 60 °C where a 76.2% loss of TFC was found with compared to leaves dried under room temperature. As similar in TAC and TPC, a decrease was found in TFC with the increasing temperature.

CONCLUSIONS

Results indicated that better yield of patchouli oil can be recovered at higher drying temperatures in a shorter time. Among the selected drying temperatures, it was found that drying at 55 °C temperature would be ideal for drying, with an oil recovery of 2.5%. However when it compared to drying at room temperature, there were considerable losses in bioactive compounds (TPC, and TFC) and antioxidant activity. Since there is no significant difference between oil content at 45, 50 and 55 °C, 45 °C could be recommended as the best as it was able to conserve more bioactive compounds and antioxidants than the higher temperature levels studied.

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