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The Impact of Drying Methods on Product Quality of *Rosmarinus officinalis* L.

Abstract

This study was conducted to evaluate the effects of different drying methods (shade drying, sun drying and oven drying at 40°C) on essential oil content, composition and color quality of rosemary (*Rosmarinus officinalis* L.). The essential oil content was obtained by hydro-distillation of dried plants, and were analyzed by GC-MS. The results showed that different drying methods had no significant effects on essential oil content, but essential oil constituents and percentage affected by drying methods as well. Camphor, (between 27.57 and 29.15%), 1.8 cineol (between 17.62 and 9.39%), borneol (11.25-12.37%) and linalool (between 7.30 and 8.18%) were the major essential oil compounds of different drying methods. In total regarding the essential oil composition, oven drying method can be recommended as the appropriate procedure for major constituents of rosemary essential oil. In this study, Lightness (L*), greenness (a*), and yellowness (b*) of dried leaves were also evaluated. Drying methods affected the color quality of the herb.

INTRODUCTION

Rosmarinus officinalis L., commonly known as rosemary (biberiye, kuşdili, hasalban are the common names for rosemary in Turkish), of the family Lamiaceae, is an aromatic plant naturally distributed in the Mediterranean region. The plant is also an important medicinal and aromatic plant species native to Turkey (Gulbaba et al., 2002; Szumny et al., 2010). Rosemary is cultivated in France and Spain, is collected from nature in Turkey. The rosemary plant is 50-100 cm high, the bush is a perennial herb in appearance, all green, flowers are pale blue (Baytop, 1984). Rosemary has a kind of bioactive compounds in its composition. The major families found in rosemary are phenolic diterpenes including: carnosic acid, carnosol or rosmanol; flavonoids such as genkwanin, cirsimaritin or homoplantagin; and triterpenes such as ursolic acid (Borrás-Linares et al., 2014). Rosemary essential oil is also used as an antibacterial, antifungal and anticancer agent. Major constituents described for the oil are α -pinene, 1, 8-cineole and camphor (Khorshidi et al., 2009).

The yield and chemical composition of essential oils from medicinal plants are related to a variety of internal and external factors, for example, the drying process. Drying is the most common way to preserve quality of aromatic and medicinal plants (Rocha et al., 2011). Khorshidi et al. (2009) showed that effect of drying methods, extraction time, and organ type on the essential oil percentage were significant for rosemary. The maximum essential oil percentage of the plant (1.8%) was obtained from the leaf part, 3hrs of extraction, and shade drying. Szumny et al. (2010) stated that the drying method had significant effects on the aroma quality of the final dried samples. The dried samples with the highest content of volatile compounds were also those obtained by combination of convective pre-drying and vacuum-microwave finish-drying followed by samples dried using hot air at 60 °C.

Researchers do not recommend drying using exclusively vacuum microwave due to significant reductions in both the volatile content and sensory quality. In another study, Rao et al. (1998) fresh rosemary volatiles contained 75-80% oxygenated terpenes which included, a character-impact compound, verbenone, in a high concentration of 5.7%. They were subjected to convection (45 °C) and microwave drying and the attended effect on flavor components is reported for fresh rosemary leaves. Despite faster drying and good color retention, the microwave drying was not useful to dry and preserve the herb due to heavy loss of volatile oil during drying. Mohammed et al. (2020) recommend a one-week natural, shade-based drying of the rosemary herbs for higher yields of the volatile oil at both industrial and small scales. Their results revealed that the best volatile oil yield and the majority of oil constituents present and comprising the 1,8-cineole, camphor, and camphene ingredients in higher ratios could be obtained after the first week of rosemary herbs' shade-drying under natural conditions.

Rosemary is a potential essential oil plant that can be grown in the Southeastern Anatolia Region. Drying, which is one of the most important post-harvest processes in the cultivation of essential oil plants, is of great importance in terms of product quality. In this study, the effects of different drying methods on quality of the rosemary plant for postharvest technology in semi-arid ecological conditions (Diyarbakir province/Turkey).

MATERIAL and METHODS

Plant material and extraction of essential oil

The aerial parts of *Rosmarinus officinalis* were harvested randomly from plants cultivating in the Collection Garden of Medicinal and Aromatic Plants at Faculty of Agriculture, Department of Field Crops, Diyarbakir, Turkey in July, 2018. Three portions (100 g each) of the plant material

were dried to constant weights by air drying in shade drying, sun drying and oven drying at 40 °C respectively.

Color analysis

Color of the samples was measured in three repetitions using Hunter Lab D25LT. The results were obtained in reference to International Commission on Illumination (CIE) L*, a* and b* color space, where L* stands for lightness, varies between 0 and 100, with 0 being black and 100 representing white, a* values vary between negative (green) and positive (red), and b* values vary between negative values indicated as blue and positive values indicated as yellow color.

Distillation of essential oil

After drying of the fresh material, the dried aerial parts were separately subjected to hydro distillation for 3 hrs using a Clevenger apparatus according to the British Pharmacopoeia12.

Gas chromatography–mass spectrometry (GC–MS) analysis

GC–MS analyses were done at the laboratory of Plant Physiology, the Department of Biology, Sutcu Imam University, Kahramanmaras, Turkey. GC/MS analyses were done with Agilent GC – 6890 II series coupled with Agilent 5975C Mass Spectrometer. Column: HP – 88, 100 m × 250 µm × 0.20 µm film thickness. The GC/MS temperature was adjusted from 70 °C (1 min) to 230 °C (20 min) with rate of change of 10 °C/min. The injection temperature remained 250 °C. Injection volume was 1.0 µL. Carrier gas

was He. Injection mode was split (20:1). MS interface temperature was 250 °C; MS mode remained EI; detector voltage: 70 eV; mass range of 35–400 m/z with scan speed (amu s⁻¹). The components of the oil were detected by mass spectra and compared with reference compounds of pure authentic samples, available in our laboratories, and with those stored in HPCH1607, Willey7n.1 and NIST08 libraries. Retention indices (RI) were computed from gas chromatograms by logarithmic interpolation between n–alkanes. The homologous series of n–alkanes C7 – C40, Supelco, USA were used as standard. Retention indices were calculated as HP – 88 capillary column. The analyses of all samples were replicated thrice for GC/MS analysis (Kizil et al., 2019).

Statistical analysis

Data are expressed as mean ± standard error of the mean. The mean between major components of GC-FID (flame ionization detector) data was measured by one-way analysis of variance (ANOVA) followed by the Least Significant Difference (LSD) test at 0.05 probability level.

RESULTS and DISCUSSION

Color is an important quality characters of food for consumers. It is a natural indicator of the quality of a food and there is a relationship between food acceptability and color (Doymaz, 2006). Moreover, drying can affect changes in product appearance (color) and odor by altering the final quality. Color analysis of rosemary is presented in the Table 1.

Table 1. Color parameters of rosemary (*Rosmarinus officinalis* L.) subjected to drying using different methods

Drying Method	L*	a*	b*
Shade	52.19	-4.18	12.74
Sun	50.89	-4.70	20.56
Oven	44.03	-0.21	20.79

The highest value is obtained from the shade drying application with 52.19 and the lowest value is obtained from the application of drying in the oven with 44.03 for values of parameters L*. While the L *

value was closer to white in shade-dried plants, a value indicating the brightness of the color of the sample, it was darker in the oven-drying application. When a * values were examined, it was seen that shade (-

4.18) and sun (-4.70) drying applications with values (-) in all three drying forms showed similar values, while oven drying application (-0.21) had the lowest value. When the b^* values are examined, it is seen that drying in the sun and oven has higher values than drying in the shade and their yellowness tone increases even more. The highest b^* value was obtained from oven drying application with 20.79 and shadow drying application with the lowest 12.74 (Table 1). Kocabiyik and Demirturk (2008) in their study of mint, all of the applications caused a decrease in the b^* values of dried

mint leaves during drying in *Mentha spicata* they emphasized that the color properties of dried mint in general are affected by the process variables. Rahimmaleka and Goli (2013) reported that oven drying at higher temperature in thyme resulted in a considerable decrease in the color quality of the leaves, air drying and oven 50 °C and 70 °C had the highest yellowness in comparison to other treatments.

The essential oil content and its components (%) of the plant (*Rosmarinus officinalis* L.) are given in Table 2.

Table 2. Essential oil components of *Rosmarinus officinalis* L as affected by different drying methods (%)

Compound (%)*	RT (min)	Sun-drying	Shade-drying	Oven-drying
α -pinene	12.23	2.16±0.10	1.65±0.007	1.96±0.007
Myrcene	12.35	1.00±0.03	-	-
Limonene	12.85	4.97±0.02	4.31±0.04	4.74±0.02
1.8 cineol	13.94	17.84±0.24	17.62±0.02	19.39±0.05
p-cymene	14.35	4.45±0.02	3.61±0.02	3.83±0.01
Linalool	17.70	7.55±0.06	7.30±0.05	8.18±0.01
Bornyl acetate	19.42	2.18±0.02	2.80±0	1.89±0.01
Transpinocamphone	19.99	1.85±0.02	1.90±0.02	1.35±0.01
Camphor	20.41	28.38±0.61	29.15±0.12	27.57±0.19
Borneol	20.98	12.37±0.07	11.25±0.08	12.07±0.12
α -campholenol	21.53	1.93±0.10	2.14±0.04	1.94±0
β -pinene	22.72	2.24±0.29	1.29±0.06	1.80±0.02
Bicyclo[4.3.0] heptane	22.84	2.67±0.007	2.43±0.07	2.66±0.03
Verbenone	23.72	5.35±0.01	9.24±0.08	5.08±0.07
Piperitone	25.64	-	-	1.08±0.04
Carvacrol	26.26	-	-	1.75±0.04
Total		94.94	94.69	95.29
Essential oil content (%)		0.25	0.25	0.25
Grouped Components				
Monoterpene hydrocarbons		16.67	12.76	13.68
Oxygenated monoterpenes		75.60	79.50	78.95
Oxygenated sesquiterpenes		2.67	2.43	2.66

* Components with 1% or more in total essential oil were recorded

The essential oil rate (0.25%) was not affected by drying methods (Table 2). Blanco et al. (2002) found that higher drying temperature decreased the essential oil content (% w/w) and the highest one was obtained from 40 °C as 2.13%. Khorshidi et al. (2009) reported that the maximum essential oil research (1.8%) was obtained from leaf sample and shade drying. Verma and Chauhan (2011) found that essential oil varied from 0.18 to 1.1% under different

methods of drying. Mohammed et al. (2020) obtained the highest amount of essential oil (327 mg^l) from one-week dried rosemary herbs.

As a result of the GC / MS analysis of the essential oil obtained from sun drying samples, several constituents (15) were found in rosemary herbs' oil as compared to the sun, shade, and oven drying oil samples, which consisted of 14, 13, and 15 constituents and these components

comprising 94.94%, 94.69%, 95.29% of the total oil, respectively. It has been determined that the main components of rosemary essential oil are camphor, (between 27.57 and 29.15%), 1.8 cineol (between 17.62 and 9.39%), borneol (11.25-12.37%) and linalool (between 7.30 and 8.18%). The other component such as verbenone varied from 5.08% to 9.24% its higher percentages at shade drying method.

Other minor common constituents were limonene (4.31-4.97 %) and p-cymene (3.61-4.45 %), they were high in sun drying method. The results of a study from Turkey demonstrate that camphor, and 1.8-cineole were the major essential oil components (Bagci et al., 2017). Verma and Chauhan (2011) has identified the major components of the oils as 1.8 cineol, camphor, α -pinene and verbenone.

Table 3. Mean of FID values obtained from different drying methods in rosemary (*Rosmarinus officinalis*) (%)

Drying methods	Camphor	1.8 cineol	Borneol	Linalool
Shade-drying	27.67 B	17.32 B	11.52 A	7.87 B
Sun-drying	28.83 A	17.56 B	10.31 B	7.58 C
Oven-drying	28.35 AB	20.78 A	10.59 B	8.74 A
Mean	28.28	18.55	10.80	8.06
LSD%	0.70	0.18	0.33	0.194

* The differences between the mean shown in the same letters are not statistically significant.

In the study, it can be seen that the effect of drying applications on the main components rate are statistically significant according to FID results ($p < 0.01$) (Table 3). The highest camphor rate was obtained from sun drying method (28.83%) and lowest obtained from shade drying application (27.67%). The highest rate of 1.8 cineol was obtained from oven drying method with 20.78% and shade drying methods gave the lowest data (17.32%). The highest borneol content was obtained from shade drying method with 11.52%, while the lowest borneol content was obtained from sun drying method with 10.31%. The highest linalool rate was obtained from oven drying method with 8.74%, and sun drying method with the lowest rate (7.58%).

There are different studies about drying method of rosemary essential oil content and composition. Rao et al. (1998) reported oven-drying of rosemary at 45 °C resulted in 7.25% loss in volatile components, while microwave-drying produced losses of 61.5%. Researches also reported that the reduction of camphor, one of the main components, in the traditional drying

method may due to the sublimation of camphor and due to longer duration of exposure of the herb during convection drying. Verma and Chauhan (2011) stated that the shade and sun drying did not cause major variation in the essential oil yield and chemical composition whereas hot air and oven drying methods moderately changed the composition of essential oil. However, they reported that microwave drying significantly reduced the oil yield, monoterpenes and 1.8-cineole concentration. Hence, they advise shade drying method for most suitable followed by sun and hot air drying for rosemary leaves. De Pasquale et. al. (2019) used five types of drying methods for the tests, and they observed the results highlight qualitative and quantitative differences with regards to the dry methods and essential oils. Mohammed et al. (2020) revealed that the 1,8-cineole, camphor, and camphene in higher ratios could be obtained after the first week of rosemary herbs' shade-drying under natural conditions.

In some other Lamiaceae family plants, researches has also been shown that drying methods were significantly affected on the

essential oil content and components (Ebadi et al., 2015; Pasa et al., 2019; Mirjalili et al., 2019). Changes in essential oil during the drying process depend on the type of plant tissue, temperature, time and the drying method used (Lewicki and Pawlak, 2003). Therefore, determining a suitable drying method to achieve higher secondary metabolites in medicinal plants is very important. In our study, while the essential oil content were not affected by different drying methods, but changes were observed especially in the main components. Oven-drying and sun-drying methods have been determined as suitable drying methods in terms of camphor, 1,8 cineol and linalool, except for borneol.

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