



EFFECT OF VARIOUS DRYING METHODS ON THE VOLATILE OIL COMPOSITION OF BASIL LEAVES

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Abstract

This article presents the results pertaining to the drying behavior of basil leaves (*Ocimum basilicum* L.) in natural air drying (~25-30°C, 2 days), hot-air drying (50°C, 6h, 1m/s), and vacuum drying (50°C, 8kPa, 7h) conditions.

This study focused on the chemical composition characteristics of essential oils extracted from fresh and different dried basil leaves. The results showed that drying methods had a significant effect on essential oil content and composition of basil leaves. The volatile oil found in herbs is very sensitive to some drying parameters (e.g. pressure, temperature, weather, non-uniform drying, etc.).

The quality of the vacuum dried product was assessed – from a twelve major constituents – as being higher than that of a hot-air dried and natural air dried products. Taking into account all these considerations we recommend the drying of basil leaves by vacuum drying.

Keywords

vacuum drying, hot-air drying, natural air drying, essential oil content, basil.

1. Introduction

Medicinal herbs and their preparations are widely used by human beings in the whole world. Basil (*Ocimum basilicum* L., Lamiaceae) is an annual or perennial plant from southeast Asia and central Africa and nowadays cultivated world-wide. This plant is widely used for its therapeutic properties, as well as, for aromatic and culinary purposes (Morales and Simon, 1997). The essential oil may be used directly

in food or at the cosmetics industry for the production of shampoos, soaps, and perfumes. Basil essential oil contains mainly monoterpenes, sesquiterpenes, alcohols, aldehydes, ketones, esters and miscellaneous compounds (Lee et al, 2005).

One of the preservation methods ensuring microbial safety and extending shelf-life of foods is dehydration (Calín-Sánchez et al, 2012). However, drying must be performed carefully in order to preserve the aroma, appearance and nutritional characteristics of the raw herbs as much as possible (Crivelli et al., 2002). The drying may cause losses in volatilities or formation of new volatilities as a result of oxidation reactions, esterification reactions (Díaz-Maroto et al., 2002).

Due to economic reasons of natural drying is used in the developing countries, although it has the disadvantage of possible contamination by micro-organisms (Putievsky and Galambosi, 1999). The most common method of artificial dehydration is drying with hot-air. However, this method has several disadvantages and limitations. The color of the hot-air dried material changes, the product is shrinking, difficult to rehydrate and loss of essential oil content occurs (Calín et al, 2013). An alternative to a high temperature drying is the use of vacuum drying, using lower temperatures which can prevent some of the thermal damages in bioactive compounds and reduce the loss of essential compounds, because vacuum drying is a process in which moist materials are dried under a sub-atmospheric pressures (Uribe et al, 2016).

The aim of the research is examining the natural and artificial drying methods influence on the amount of the main components in the herb in comparison with the raw material.

2. Material and methods

Sample preparation

The basil samples were collected from an organic farm in Targu Mures (Romania), in 2017. The samples were obtained by cutting the plant manually. After that, the harvested samples were stored in plastic bags and kept in a refrigerator (Husqvarna, QT 4609 RW, Hungary) at temperature, frozen duration and relative humidity of 5°C, 4 h and 88-90%, respectively. Prior to drying process, basil leaves were separated from the stems. Later, the leaves were cut into 2-3 cm pieces.

Drying procedure

This article presents the results pertaining to the drying behaviour of basil leaves in natural air drying (~25-30°C, 2 days), hot-air drying (50°C, 6h, 1m/s), and vacuum drying (50°C, 8kPa, 7h) conditions.

The basil leaves are natural air dried on a mesh frame at ambient temperature in a well-ventilated room for 48 h (2 days) at average relative humidity of 63% - determined by a relative humidity meter (Testo). The air temperature is between 25-30°C, which was determined by a temperature gauge (Testo 4510 meter, Testo GmbH, Germany). The samples were spread in a single layer on a tray in the frame (50 g). The moisture losses of basil leaves were recorded at 1 hour intervals during the drying process by a digital balance (model JKH-500, Jadever Co., Taiwan) and an accuracy of 0.1 g.

Hot-air drying was carried out in a hot-air dryer (model LP306, LaborMIM, Hungary) at 50°C with an air flow rate of 1 m/s. Air humidity was regulated at ≈20%. The samples (50 g) were spread uniformly, in single layer on the trays of dryer. After 1h, the trays were taken out of the equipment, weighed, and then put back in the dryer. During the drying process, the weight of the basil leaves were recorded to construct a drying curve, and the temperature (material and air), air velocity, air humidity was measured using a Testo 4510 type meter (Testo GmbH, Germany). The mass was measured on an analytical balance (model JKH-500, Jadever Co., Taiwan) with a precision of ±0.1 g. The basil leaves were dehydrated until they reached the final moisture content (0,8%, w.b.).

Vacuum drying was performed in a laboratory-scale Kambic VS-50 vacuum dryer (Kambic Ltd., Slovenia). In the vacuum drying process, the basil leaves were spread uniformly in a single layer on a stainless steel tray. The leaves samples (50 g) were dried to a moisture content of 1,1% (w.b.) at an absolute pressure of 8kPa with a chamber temperature of 50°C. Thermocouples (two pieces) of vacuum drier

were inserted into the basil leaves. The mass was measured on an analytical balance (model JKH-500, Jadever Co., Taiwan) with a precision of ±0.1 g. After 1h, the trays were taken out of the equipment, weighed, and then put back in the dryer.

The samples were dried until it reached the equilibrium moisture content. All the experiments were repeated thrice and the average of three results for each treatment was used in this paper.

Moisture content

The moisture content of basil leaves was determined gravimetrically in triplicate by drying 3 g samples at 105°C until constant mass was achieved. The moisture content was determined by drying samples in a convective oven (LP306, Labor MIM, Budapest, Hungary). The moisture content (M) of the samples in the drying process was calculated from (1):

$$M = \frac{W_t - W_k}{W_k} \quad (1)$$

The dimensionless moisture content (MR) of the samples was calculated using the following equation (2):

$$MR = \frac{M - M_e}{M_0 - M_e} \quad (2)$$

Chromatography

The SPME (Solid Phase Micro Extraction) sample preparation was made with manual tool. The GC-MS measurements were executed on a 5890 Series II – 5971 mass spectrometer system. The components were identified with Wiley and NIST databases and retention indices from different manuals (Novák et al, 2011).

In terms of product quality, twelve (eucalyptol, linalool, camphor, estragole, beta-elemene, beta-caryophyllene, alpha-guaiene, alpha-humulene, germacrene-d, delta-guaiene, alpha-cadinene and delta-cadinene) major constituents of basil leaves essential oil were quantified by gas chromatography–mass spectrometry (GC-MS).

3. Results and discussion

Effect of various drying methods on chemical components of basil leaves

A total of 36 essential oil components were identified. A typical GC-MS chromatogram profile of fresh and dried basil extract is showed in Fig. 1. The principal

components of volatile oil of the basil leaves are eucalyptol, linalool, estragole, beta-elemene, germacrene-d, delta-guaiene and delta-cadinene (Yousif et al, 1999)

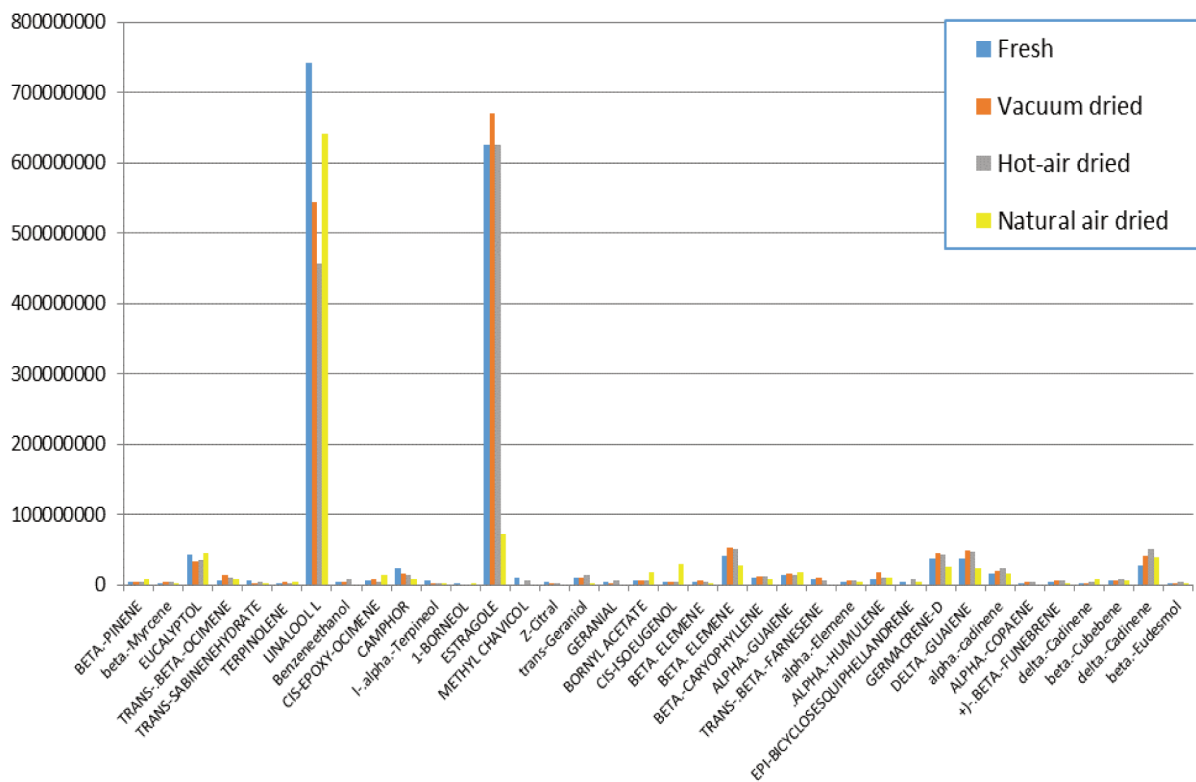


Figure 1. Comparison of basil based on the area value of total ion chromatograms (in bar graph)

Table 1. Concentration of the main essential oil components in basil

Components	Fresh (area)	Natural air drying (NAD)	Hot-air drying (HAD)	Vacuum drying (VD)
eucalyptol	43775484	+4,76% [1]	-19,46% [2]	-22,08% [3]
linalool	742065773	-13,46% [1]	-38,48% [3]	-26,58% [2]
camphor	24425461	-68,76% [3]	-43,01% [2]	-32,03% [1]
estragole	625315818	-88,56% [3]	+0,07 [2]	+7,08% [1]
beta-elemene	41861493	-33,39% [3]	+23,28% [2]	+26,55% [1]
beta-caryophyllene	9555398	-6,24% [3]	+15,47% [2]	+18,05% [1]
alpha-guaiene	12984727	+35,67% [1]	+10,99% [3]	+28,39% [2]
alpha-humulene	7166493	+29,85% [3]	+31,92% [2]	+136,66% [1]
germacrene-d	36272278	-32,05% [3]	+16,55% [2]	+25,94% [1]
delta-guaiene	37820670	-35,86% [3]	+25,11% [2]	+28,54% [1]
alpha-cadinene	15254299	+0,25% [3]	+51,06% [1]	+35,56% [2]
delta-cadinene	27993928	+36,72% [3]	+81% [1]	+48,3% [2]
Ranking	-	III.	II.	I.

Remark: The values in the chromatogram obtained with the GC-MS of basil refer to fresh plant matter.

Politeo et al. (2007) identified by GC-MS 33 essential oil components from basil leaves, most of

which are consistent with those in this scientific work. Di Cesare et al. (2003) found that eucalyptol, linalool, eugenol, and methyleugenol predominated in basil from Liguria (Italy). The volatile profile of fresh basil

was similar to those previously reported for Polish sweet basil, especially dominated by methyleugenol, eugenol, eucalyptol and linalool (Calín-Sánchez et al, 2012).

The concentration of the main constituents of basil leaves oil extracted from fresh and dehydrated samples are presented in Table 1.

Areas defined by the mass spectrum of essential oil components identified from the raw and dried basil leaves serve as a basis for ranking the drying methods. The area of the 12 main constituents found in the raw plant material was the control and the deviation – the effect of drying methods – was expressed as percentile form in Table 1. Differences due to drying were marked with a positive and negative sign in relation to the crude basil. In the brackets, we indicate the rank based on the values.

Table 1 shows the highest amount of essential oil in vacuum dried basil leaves (1) followed by hot-air (2) and natural air drying (3). The vacuum dried basil samples maintained their volatile composition much better when compared with the hot-air- and natural air dried ones.

Drying curve

The moisture loss was recorded at 1 hours intervals during the drying process in order to determine the drying curves. The experimental data sets from the different drying runs were expressed as moisture ratio (MR) versus drying time (t). The changes in the moisture ratio (MR) with time during natural air-, hot-air- and vacuum drying are given in Fig. 2. It can be observed that the moisture ratio decreases with drying time.

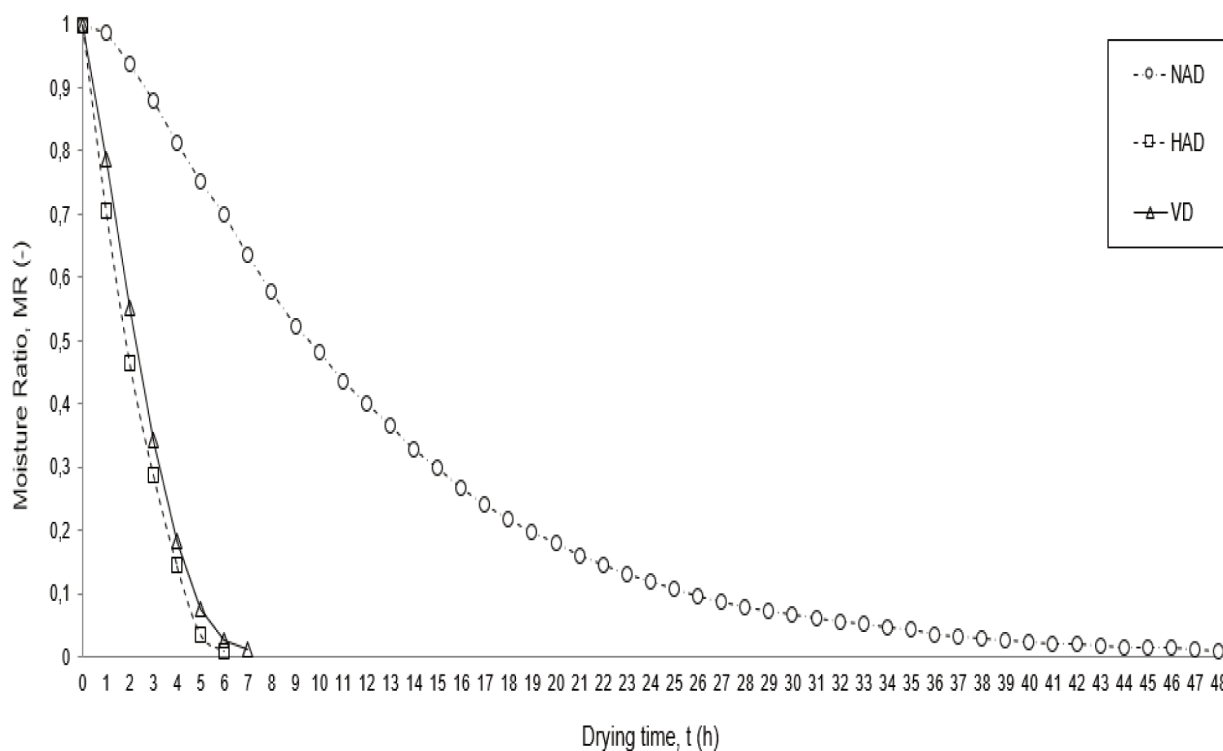


Figure 2. Drying curve of basil leaves dried by natural air-, hot-air- and vacuum drying
Remark: NAD – natural air drying, HAD – hot-air drying, VD – vacuum drying

The initial moisture content of the basil leaves was found to be 66,7% (wet basis: w.b.). The basil were dried by different drying methods until the final moisture content (0,8-1,4%, wet basis: w.b.).

The figure indicates that the drying period of the natural air drying process is longer than the hot-air dehydration, because of the minor drying rate. There is no significant difference in drying time between the two artificial drying. The artificial drying technique ended drying in 6-7 hours due to the faster drying rate

while the natural technique ended drying in 48 hours. Another research group found similar results (Hii et al, 2008).

Conclusions

This study focused on the chemical composition characteristics of essential oils extracted from fresh and different dried basil leaves. The results showed that drying methods had a significant effect on

essential oil content and composition of basil leaves. The volatile oil found in herbs is very sensitive to some drying parameters (e.g. pressure, temperature, weather, non-uniform drying, etc.), according to Parmar et al (2018), Tomaino et al (2005), Tsai et al (2013) and Díaz-Maroto et al (2007).

The quality of the vacuum dried (1) product was assessed – from a twelve major constituents (eucalyptol, linalool, camphor, estragole, beta-elemene, beta-caryophyllene, alpha-guaiene, alpha-humulene, germacrene-d, delta-guaiene, alpha-cadinene and delta-cadinene) – as being higher than that of a hot-air dried (2) and natural air dried (3) products (Calín-Sánchez et al, 2015). Losses in the content of essential oil in vacuum dried samples can also be observed. The amount oil losses is dependent on the pressure of vacuum drier. The applied vacuum (8000 Pa) at the vacuum drying probably split open the outer (exogenous) essential oil containers of the leaf.

A comparison between the vacuum drying and hot-air drying methods showed a difference in the quality of the dried basil leaves because hot-air drying uses relatively high temperatures and intensive ventilation, which causes undesirable alteration of the volatile compounds in the finished product (Abdollah et al, 2014) (Antal et al, 2011).

In the case of natural air drying, non-uniform drying and rewetting by the weather caused a loss of quality in plant material.

The three drying methods used greatly affected the drying characteristics basil leaves. Hot-air drying resulted in acceleration of the drying rate and water evaporation in the early stage of drying, however in the later stage the drying rate slowed down and approached the drying time of the vacuum drying. There is no significant difference between the drying times of the vacuum- and hot-air drying. Thanks to the low drying rate, the treatment time of natural drying is eight times that of artificial drying.

Taking into account all these considerations we recommend the drying of basil leaves by vacuum drying.

Nomenclature

db	dry basis	
m	mass	g
M	moisture content	kg/kg db
MR	moisture ratio	
Me	equilibrium moisture content	kg/kg db
M0	initial moisture content	kg/kg db
p	pressure	Pa
t	time	h
T	temperature	°C

wb	wet basis	%
Wt	sample weight at a specific time	kg
Wk	sample dry weight	kg

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