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*Review*

# Influence of drying process on the quality of medicinal plants: A review

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**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. The choice of the optimal drying air temperature is a central economic and ecological criterion. Most experimental studies focus on species with essential oils, revealing increasing essential oil losses with increasing temperature. However, there are differences in temperature sensitivity between species. Objective of this work was to develop a review of drying process, focusing in assisting research on aromatic and medicinal plants. This review compiles experimental studies in terms of effect of drying air temperature on active ingredients at different drying conditions.**

**Key words:** Active ingredient, essential oil, drying temperature.

## INTRODUCTION

The history of medicinal is associated with the development of civilizations. In all regions of the world, the history of peoples shows that these plants have always occupied an important place in medicine, the composition of perfumes, food and in cooking. China, birthplace of herbal medicine, India, the Middle East, especially the Arabo-Muslim world, Egypt, Greece and Rome represent civilizations in which aromatic and medicinal plants had an important place (Bowles, 2004). Brazil is one of the countries with large variations in climate from north to south, and presents a field of choice for the development of these cultures (Silva and Casali, 2000). These species contain essential oils and other substances that can be exploited as food (aromas), traditional medicine and for industrial purposes (food, perfume, cosmetics, pharmaceutical, etc.). Moreover, essential oils are proven to have various pharmacological effects, such as spasmolytic, carminative, hepatoprotective, antiviral and anticarcinogenic (Lahlou, 2004). The use of medicinal plants is part of a competitive market, which includes pharmaceuticals, food, cosmetics, and perfumery markets. In pharmaceuticals, plant extracts are especially relevant due to the use of their active substances for medicine development and as source to obtain adjuvant (Schenkel et al., 2003). The growing demand for medicinal species indicates the emergence of a market with high potential for consumption, requiring a consistent and readily available supply of high quality raw material. To supply this demand, the size and number of cultivation areas is growing in various regions of Brazil. The post-harvesting process of medicinal plants has great importance in the production chain, because of its direct influence on the quality and quantity of the active ingredients in the product sold (Silva and Casali, 2000).

Water is a significant component of biological materials. The physical and chemical properties of aromatic and medicinal plants are determined by their moisture content. The first step in many postharvest operations is removal of water that is, drying. Drying is basically defined as the decreasing of plant moisture content, aimed at preventing enzymatic and microbial activity, and consequently preserving the product for extend shelf life. For this reason, adequate dryers are needed, using temperature, velocity and humidity values for drying air that provides a rapid reduction in the moisture content without affecting the quality of the active ingredients of

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**Table 1.** Maximum final moisture content ($MC_f$) for various medicinal plant species as prescribed in the European Pharmacopoeia.

| Species | Drug | $MC_f$ % w.b |
|---|---|---|
| *Althaea officinalis* L. | Roots | 10 |
| *Arnica montana* L. | Flowers | 10 |
| *Calendula officinalis* L | Flowers | 12 |
| *Chamomilla recutita* [L.] Rauschert | Flowers | 12 |
| *Coriandrum sativum* L. | Seed | 10 |
| *Foeniculum vulgare* Mill. | Seed | 8 |
| *Hypericum perforatum* L. | Herb | 10 |
| *Levisticum officinale* Koch | Leaves | 12 |
| *Malva silvestris* L. | Leaves | 12 |
| *Melissa officinalis* L. | Leaves | 10 |
| *Mentha* x *piperita* L. | Leaves | 11 |
| *Plantago lanceolata* L. | Herb | 10 |
| *Valeriana officinalis* L. | Roots | 12 |
| *Verbascum phlomoides* L. | Herb | 12 |

Source: European Pharmacopoeia, 2005.

medicinal plants. Drying process may also contribute to a regular supply and facilitate the marketing of plants, because drying results in reduction of the weight and volume of the plant with positive consequences for transport and storage (Calixto, 2000).

For various medicinal plant species a maximum value of final moisture content is prescribed in different pharmacopoeias all over the world (Farias, 2003). Some examples are listed in Table 1, showing a range of final moisture content between 8 and 12% considerate adequate to preserve the product after dried. There is no obvious correlation between final moisture content and the used part of the plant such as root, herb, flower or seed.

Drying of aromatic and medicinal plants must meet the following requirements: (1) Moisture content has to be brought down to be at an equilibrium level that is defined for certain relative air humidity and temperature. This is defined as storage condition by standards; (2) minimum quality reduction in terms of active ingredients, color, flavor and aroma; and (3) microbial count must be below the prescribed limits. No chemical additives may be used (Oztekin and Martinov, 2007).

A literature search was undertaken on effects of different methods of drying on essential oil content and chemical composition of the essential oil plants. The results showed that drying method had a significant effect on oil content and composition of aromatic plants (Basver, 1993; Deans and Svoboda, 1992). The leaves of aromatic and medicinal plants are often dried before extraction to reduce moisture content. During this process, many compounds which are dragged to the leaf surface by the evaporating water are lost (Moyler, 1994). Natural drying is the simplest method to dry. This is usually achieved for manually collected spontaneous plants in the sunlight or in a well-ventilated space out of direct sunlight. The herbs are dried either in thin layers on trays or in branches. Traditional drying methods, such as drying in the shade or in the sun, have many drawbacks due to the inability to handle the large capacity of mechanical harvesters and to achieve the high quality standards required for medicinal plants. 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. Thus, traditional natural during in the sun or in the shade does not meet the required standards or consumers demands. To overcome these problems hot air-convective drying is widely used (Oztekin and Martinov, 2007). According to Gomes (2001), many farmers in Brazil still use drying in the sun and in the shade, but most Brazilian industries use dryers with forced hot air. After the drying process, the packing method is an important factor in the quality conservation of the product during storage (Martinazzo et al., 2009).

Approximately, 60% of the medicinal plants cultivated in Brazil fail to meet quality standards for the international market due to the lack of technical knowledge by the producers. Chemical changes are the most important in the post-harvest of medicinal plants and can be influenced by drying (Fennell et al., 2004). Moreover, drying can promote changes in product appearance (color) and smell, modifying the final quality. According to Lorenzi and Matos (2002), drying of medicinal species is a preparation process, carried out to meet the needs of the pharmaceutical industry, which does not have the adequate conditions to use fresh plants on the scale required by industry. Essential oils are odorous substances obtained from aromatic and medicinal plant by water vapor or hydrodistillation extraction. There are many types of essential oils registered in the world (approximately 3000), of which 300 are actually marketed mainly for industrial cosmetics and fragrances. The essential oils of medicinal plants are the constituents most sensitive in the drying process. The sensitivity of these substances determine the temperature of drying process, because the plant temperature is increased during the drying and high temperatures may promote loss by volatilization or degradation of the principles actives (Venskutonis et al., 1996).

Most essential oils are volatile and sensitive in the air conditions (humidity, temperature and velocity). Drying temperatures is the most important parameter to preserve the active ingredients of volatile oil in gland cells, which are very sensitive to temperature increase. Gland hairs are epidermal attachments called trichomes. Gland hairs are often formed by just one cell though sometimes several cells are involved. After harvest, the surface area of gland hairs reduces parallel to cell dying, where water could be lost drastically. Drying encourages moisture loss from the whole tissue, including gland hairs (Oztekin and Martinov, 2007). Generally, high temperatures influence essential oil quantity and quality in aromatic and medicinal plants not only during drying; reduction in active ingredients continues during storage period as well (Blazek and Kucera, 1952; Martinazzo et al., 2009).

The influence of drying on the quantity and quality of the essential oils was extensively studied. According to Müller and Mühlbauer (1990), the increase in the air temperature from 30 to 50°C in drying of chamomile (*Chamomilla recutita*) reduced drying time from 52 to 3.5 h, causing no significant reduction in oil content essential. It changes between 15 to 25%, independent of drying.

Baritaux et al. (1992) compared the chemical composition of essential oil of basil (*Ocimum basilicum* L.) submitted to drying with air heated to 45°C, with those obtained from fresh plant (control). The composition of essential oil of dried basil showed a chromatographic standard very different from that obtained in control. The contents of metilchavicol and eugenol decreased during drying, however, the levels of trans-bergamotene, linalool and 1,8-cineole significantly increased.

Hansen et al. (1993) conducted drying english yew (*Taxus baccata*) using four drying temperatures (30, 40, 50 and 60°C). To evaluate the yield of taxol (main constituent) in relation to the effect of drying air temperature, used the whole plant and separated into leaves and stalks, and then chopped into small pieces. They concluded that the production of taxol in the stalks was not affected by temperature of drying air, however, production in the leaves increased linearly with increase in temperature and the yield obtained in the whole plant has remained constant (0.014%) under drying temperatures of 40, 50 and 60ºC. However, the authors obtained a very low production when the temperature of drying air was 30ºC (0.008% of oil related to the mass of plant), because the drying time too long there was more enzymatic activity, causing degradation of taxol.

Koller and Raghavan (1995) studied the effects of oven drying, freeze drying and microwave drying on the composition of essential oil of thyme (*Thymus vulgaris* L.). They concluded that the chromatographic profile was shown to be unbalanced in relation to the constituents of the essential oil extracted from fresh plant, especially in relation to the major component, thymol.

Raina et al. (1996) employed various treatments on drying of saffron (*Crocus sativus* L.) to investigate the effect of drying on the composition and content of its active principle, which is crocin, a natural pigment and used in food industry. The authors concluded that the optimum temperature for drying was 45 ± 5°C using the solar dryer or oven, conditions that promoted the production of prime material of better quality.

Venskutonis (1997) observed reductions of 43 and 31% of the total amount of compounds isolated from thyme (*T. vulgaris* L.) and sage *(Salvia officinalis*), respectively, when submitted to oven drying at 60°C, compared to fresh plant. According to author, the reduction of volatile compounds during drying depends on the volatility and chemical structure of the constituents of the plant. In a study of drying air temperature of 60ºC, was found reductions of 3.4, 3 and 2 times on the quantaty of myrcene, limonene, β-pinene, respectively, compared with the results obtained with fresh plant.

Costa et al. (1998) found better visual quality in leaves of Guaco (*Mikania glomerata* Sprengel) when dried in an oven with forced air at 37ºC than in a chamber with desiccant at ambient temperature. Drying at ambient temperature, the leaves were dark spots, which may indicate the need of short time to dry this specie.

Buggle et al. (1999) carried out the drying of lemon grass (*Cymbopogon citratus*) in an oven heated to 30, 50, 70 and 90°C, until reaching constant weight, to evaluate the quantity and quality of essential oil. For the essential oil content, the best results were obtained when drying at 50°C (1.43%), although the treatment at 30°C (1.34%) showed little significant difference with the previous, but it was not indicated, because it favored fungus growth. Treatment at 70 and 90ºC (1.19 and 1.06%, respectively) showed significant reduction in the essential oil content compared to the others treatments. However, variations of the Citral contents (main component) were not evaluated statistically. The authors concluded that the changes were small: 95.2, 90.6, 91.8 and 94.6% for the drying treatments of 30, 50, 70 and 90°C, respectively.

Rocha et al. (2000) studied the temperatures of 30, 40, 50, 60 and 70ºC to dry citronella (*Cymbopogon winterianus* Jowitt) and concluded that the best results were obtained when the air temperature was 60ºC, because had the highest essential oil content, without affecting the chromatographic profile of the essential oil, in other words, without influencing its quality.

Martins (2000) dried lemongrass (*C. citratus* (DC.) Stapf) with air temperatures of 40, 50 and 60ºC. The author concluded that the temperature influenced the extraction of essential oil with increase of essential oil content, due to the increase in drying air temperature. This increase in essential oil content was 21% compared to that obtained with fresh plant (control) for drying at 60ºC, and 15% for drying at 60°C, compared to drying at 40°C. When the material was dried at 40°C, crital was increased in 5% than that obtained in fresh plant. Losses of 3.5 and 12% of citral were found in the dry plant at 50 and 60°C, respectively, compared to fresh produce.

Radünz et al. (2001) used five temperatures: ambient air and air heated to 40, 50, 60 and 70ºC for drying *Lippia sidoides* Cham, comparing with the fresh plant, to evaluate the essential oil content. The dry sample with ambient air was 8% lower in essential oil content, while in the drying treatments at 40, 50, 60 and 70°C, there were no significant differences in the essential oil contents compared with fresh plant.

Radünz et al. (2002a) used 5 temperatures (ambient air and heated air at 40, 50, 60 and 70ºC) for the drying of *L. sidoides* Cham, compared with the fresh plant, to evaluate the essential oil content. For the sample dried with environmental air a significant reduction of 8% in the essential oil content was observed, while drying at 40, 50, 60 and 70°C showed no significant differences between it and the fresh plant. According to Radünz et al. (2002b), for the chemical analysis of the same treatments described previously, no significant qualitative changes in the thymol percentage (main constituent) or to ρ-cymene compared to the fresh plant were found. However, significant increases in caryophyllene values were observed in which the drying air was heated to 50, 60 and 70°C.

Radünz et al. (2003) studied the influence of four temperatures of drying air (ambient air and air heated to 40, 55, 70°C) on the essential oil content of *Mikania glemerata* Sprengel. The authors found that the use of a temperature of 55°C for drying air, compared to fresh plant, did not influence statistically the essential oil content, however, produced higher yield compared to the treatments with ambient air and heated air at 40 and 70°C.

The oil content of shade-dried Roman chamomil flowers was found to be larger (1.9% w/w) than there of sun-dried (0.4%) and oven-dried at 40°C (0.9%). The drying method also had a significant effect on the proportion of the various components (Omidbaigi et al., 2004). Radünz (2004), after working with drying of mint-common (*Mentha x villosa* Huds), at temperatures between 50 and 70°C, concluded that the air temperature of 50°C is recommended for drying mint-common in order to obtain the highest essential oil content and higher concentration of the main active constituents.

Costa et al. (2005), studying two drying types (oven with forced ventilation at 40°C, and room temperature with dehumidifiers) of lemon grass, concluded that the most abundant component in the essential oil was citral, and had the highest concentrations in the leaves dried in the dehumidifiers. Mendes et al. (2006) investigated the effect of natural and artificial drying on the composition of the essential oil of *Cymbopogon nardus* and concluded that, especially for this plant, the drying operation did not influence the composition of the volatile compounds.

Braga et al. (2005) evaluated the effects of different drying air temperatures (35, 40, 45, 50, 55 and 60°C) on the yield and composition of essential oil from long pepper (*Piper hispidinervium* c. dc) leaves in a fixed-bed dryer. They observed that the essential oil yield increased twice after the drying process compared with the fresh plant. However, safrole content decreased about 20% when temperature was above 50°C.

Radünz et al. (2006) used common-mint (*M. x villosa* Huds), drying it on a fixed-bed dryer with ambient air and air heated to 40, 50, 60, 70 and 80°C and evaluated the essential oil content extracted after drying with that extracted from the fresh plant. Based on the results, it was concluded that the higher content was obtained when the drying process was done with drying air at 50°C.

Barbosa et al. (2006) submitted *Lippia alba* leaves to 6 drying treatments (ambient air and air heated to 40, 50, 60, 70 and 80°C), comparing with fresh leaves (control). They found that the citral level presented a significant increase when the leaves were submitted to drying, independent of treatment, compared to the fresh plant. The increase was attributed to the oxidation of geraniol during drying, converting it into geranial. It was also observed that the nerol content did not differ significantly between drying treatments, but statistically showed a significant decrease when compared with the fresh plant. This decrease was attributed to the oxidation of nerol during drying, which was transformed into neral. Considering that citral is the main chemical constituent of interest in the oil from this plant, it was concluded that drying for marketing purposes can be carried out using heated air from 40 to 80°C.

David et al. (2006) evaluated the influence of the drying air temperature on *Ocimum selloi* Benth essential oil composition. They observed that the main components of essential oil were elimicin (69.8%), trans-caryophyllene (6.0%), germacrene D (3.7%) and bicyclogermacrene (3.5%), and they found that increasing temperature above 40°C reduced the levels of the components.

Sefidkon et al. (2006) evaluated the influence of drying methods (sun-drying, shade-drying and oven-drying at 45°C) on yield and chemical composition of the essential oil of *Satureja hortensis.* It could be concluded that drying of aerial parts of *S. hortensis* in the oven at 45°C is most suitable and is recommended for fast drying, and high-oil yield, as well as, for a high-percentage of carvacrol.

The effect of tree methods of drying on the content and chemical quality of the essential oil of *Mentha longifolia* was studied by Asekun et al. (2007). The drying treatments were plants dried to constant weight in the sun; plants dried in the laboratory under normal air and at room temperature conditions; and plants dried in the oven at 40℃. They observed that the most prominent component in both the air-dried and sun-dried leaf oils was menthone (47.9 and 38.3%, respectively), while oven-dried leaf oil had limonene as the major compound (40.8%), whereas pulegone was the major compound from the original fresh leaf oil. Menthone and pulegone were not detected in the oven-dried leaf oil. The essential oil underwent significant chemical transformation in its monoterpenoids when the leaves were dried by the three different methods. Due to the significant reduction of the potentially harmful pulegone and menthone by oven-drying, the authors suggested that this herb should be oven-dried or cooked before consumption in order to reduce toxicity.

Soares et al. (2007) studied the influence of 4 drying air temperatures (40, 50, 60 and 70℃), in thin layers, and 2 air velocities (0.9 and 1.9 m $s^{-1}$) on the essential oil content of brazilian linalool (*O. basilicum* L). The higher essential oil contents were obtained in the drying process with an air temperature at 40℃ and air velocity of 1.9 m $s^{-1}$. The highest linalool contents were obtained with drying air temperature from 50 to 60℃ and an air velocity of 1.9 m $s^{-1}$. They concluded that the essential oil chemical composition of *O. basilicum* L was affected by both temperature and air velocity during drying. Martins et al. (2002) observed that drying lemon grass leaves with air velocities of 0.5 and 1.0 m $s^{-1}$ had no statistically significant effect on final product quality.

The influence of the drying air temperature (40, 50, 60, 70 and 80℃) on the essential oil content of *Melaleuca alternifólia* Cheel was studied by Lemos et al. (2008a). It was concluded that the essential oil content extracted from the dried plant was not affected by different drying temperatures, however, the drying caused reduction in the essential oil content compared to the fresh plant. According to Lemos et al. (2008b), for the chemical analysis of the same treatments described previously, the major essential oil components of *M. alternifólia* were within ISO 4730 quality standards.

Harbourne et al. (2009) evaluated the effect of drying at 30 and 70℃ on the chemical constituents of meadowsweet (*Filipendula ulmaria*) and willow (*Salix alba*). Although the drying at 70℃ resulted in shorter drying times it caused a reduction in the flavonoids and resulted in redder extracts. The decrease in flavonoids and corresponding increase in condensed tannins observed could be probably due to polymerisation during high temperature drying. Drying of both herbs at 30℃ yielded extracts high in phenols, active ingredients and had a desirable colour for incorporation into a beverage with potential anti-inflammatory properties. Borsato et al. (2009) studied the effect of drying process in a fixed layer at 80℃ on the yield and chemical composition of chamomile (*Chamomilla recutita* [L.] Rauschert) essential oil. They concluded that the drying process of chamomile showed reduction essential oil content and chemical composition.

Ennajar et al. (2010) used sun-drying, shade-drying and oven-drying at 45℃ to study the effects on yield and chemical composition of *Juniperus phoenicea* L. essential oils. The authors concluded that drying of berries of *J. phoenicea* in oven-drying is more suitable and is recommended for obtaining higher yield of essential oils; for higher percentages of some special components, however, such as α-pinene and δ-3-carene, shade-drying was more suitable.

The influence of the drying method on volatile compounds of *Origanum vulgare* and *Rosmarinus officinalis* were evaluated by Figiel et al. (2010) and Szumny et al (2010), respectively. The drying methods tested were convective (CD) at 60℃ and vacuum-microwave (VMD), as well as a combination of convective pre-drying and VM finish-drying (CPD–VMFD). The authors concluded that the drying method had significant effects on the quality of the final dried samples. The use of hot air in any part of the drying process of fresh oregano caused important losses of volatile compounds and consequently a significant reduction of the quality of dried product. The dried oregano samples with the highest content of volatile compounds were those obtained by VM without convective pre-drying followed by samples dried CPD–VMFD. The dried rosemary samples with the highest content of volatile compounds were those obtained by combination of convective pre-drying and vacuum-microwave finish-drying (CPD–VMFD) followed by samples dried using hot air at 60℃. Drying using exclusively VM is not recommended in rosemary due to significant reductions in both the volatile content and chemical quality.

Banout et al. (2010) studied two solar drying methods (direct cabinet solar dryer and indirect cabinet solar dryer) on the chemical composition of aerial parts of sacha culantro (*Eryngium foetidum).* (E)-2-dodecenal was determined as the main constituent of the sacha culantro essential oil, averaging 61.8 to 62.2%, followed by n-dodecanal (10.9 to 15.5%), (E)-2-tetradecenal (6.7 to 7.6%) and 1-tetradecene (3.6 to 5.7%). The authors concluded when comparing both solar drying methods, the indirect method was found as more suitable for drying *E. foetidum* since the dried product resembled the fresh herb more closely in its chemical composition and had better appearance.

Drying temperature usually has an influence on the temperature sensible components of essential oil (Tables 2 and 3). For example, the yield and chromatographic profile of the essential oil from *M. glomerata* presented changes due to the drying treatment, when compared with the fresh plant (Radünz et al., 2010).

**Table 2.** Essential oil content of *Mikania glomerata* leaves submitted to different drying air temperatures, compared with the fresh plant (control).

| Drying air temperatuire (°C) | Essentiol oil content (d.b) |
|---|---|
| 50 | 0.7367[a] |
| 70 | 0.6500[b] |
| 40 | 0.6400[bc] |
| 60 | 0.6000[bc] |
| 80 | 0.5600[cd] |
| Control | 0.4933[d] |
| Air ambient | 0.4133[e] |

CV = 7.44%.

**Table 3.** Statistical analysis results of *Mikania glomerata* essential oil constituents compared with the fresh plant (control), expressed as a percentage proportion of area.

| Treatment | Mean |
|---|---|
| **Germacrene D** | |
| 80°C | 42.69[a] |
| 60°C | 41.72[ab] |
| 70°C | 41.21[ab] |
| 50°C | 39.86[bc] |
| 40°C | 38.60[c] |
| Control | 32.51[d] |
| Air ambient | 15.34[e] |
| CV= 3.84. | |
| | |
| **Bicyclogermacrene** | |
| 80°C | 19.38[a] |
| 70°C | 18.90[a] |
| 60°C | 18.68[a] |
| 40°C | 18.39[a] |
| 50°C | 18.21[a] |
| Control | 17.85[a] |
| Ambient | 9.65[b] |
| CV = 7.15. | |
| | |
| **β- caryophyllene** | |
| 70°C | 10.74[a] |
| 80°C | 10.67[a] |
| 60°C | 10.11[ab] |
| Ambient | 9.50[ab] |
| 50°C | 9.47[ab] |
| 40°C | 9.44[ab] |
| Control | 8.75[b] |
| CV = 8.02. | |
| | |
| **α-pineno** | |
| Control | 5.23[a] |
| 40°C | 4.31[ab] |
| 50°C | 3.59[bc] |

**Table 3.** Contd.

| | |
|---|---|
| 60°C | 3.00[cd] |
| ambient | 2.67[cd] |
| 80°C | 2.23[d] |
| 70°C | 2.19[d] |
| CV = 17.64. | |
| | |
| **Mirceno** | |
| control | 3.80[a] |
| 50°C | 3.08[ab] |
| 40°C | 2.98[abc] |
| 60°C | 2.57[bc] |
| 80°C | 2.29[bc] |
| 70°C | 2.05[c] |
| ambient | 1.07[d] |
| CV = 19.88. | |
| | |
| **β-pineno** | |
| control | 3.54a |
| 40°C | 2.21b |
| 50°C | 1.90c |
| 60°C | 1.59d |
| ambient | 1.53de |
| 70°C | 1.34de |
| 80°C | 1.29e |
| CV= 7.50 | 3.54a |

Source: Radünz et al. (2010).

Many other authors found variations in the chemical composition of essential oil of different medicinal plants according to the drying air temperature (Khangholil and Rezaeinodehi, 2008; Baydar and Erbaş, 2009; Sellami et al., 2011).

## CONCLUSION

The drying method, velocity and temperature of drying air influence the quantity and quality of the active ingredients present in aromatic and medicinal plants. In spite of all technical developments, the choice of the correct drying temperature remains a central economic and ecological criterion in the drying of medicinal plants. The values recommended in literature and those used in practice are often far apart, confirming that there is an urgent need for research on this topic. However, drying air temperatures between 50 and 60°C appear to be feasible for drying large number of medicinal plants.

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