DIFFERENCES IN DRYING PROCESSES OF MORPHOLOGICAL PARTS OF PURPLE CONEFLOWER (*ECHINACEA PURPUREA* L. MOENCH)

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Abstract. As compared with synthetic pharmaceuticals, the pharmaceuticals originated from medicinal plant raw materials are characterised by wider therapeutic spectrum, their effect is smoother and side effects are less common. Currently in Lithuania traditional and folk medicine uses nearly 460 species of plants. Purple coneflower is one of the most popular medicinal plants. It is grown as a medicinal, as well as an ornamental, melliferous and fodder plant. It accumulates alkylamides, polysaccharides, proteins, lectins, chicoric acid and essential oils. Medicinal products from it are used for skin, gynaecological, urological, oncological diseases and colds treatment. Drying is used for preparation of herbal ingredients. The drying technology and parameters are chosen according to the raw material, its morphological structure, as well as to the chemical composition, stability of biologically active substances and according to other factors. Different parts of plants are used for the production of raw materials: leaves, flowers, stems, roots, etc. All these parts of the plant differ in their properties. These differences are highly significant in purple coneflower: big flower, medium thick stem and thin leaves. This paper analysis differences in intensity of the drying process of various morphological parts of *Echinacea purpurea* L. It was determined that rigid morphological parts of the plants lead to more stable and porous mound structure of the medicinal plant raw material. Therefore, conditions of flowers, grass and especially chopped stems drying with active ventilation are more favourable then in a mound of picked leaves.

Keywords: purple coneflower, drying, active ventilation, drying conditions, mound density.

Introduction

Nowadays, in a number of countries around the world and in Lithuania among them, growth of medicinal plant usage was noticed in various industries: pharmaceutical, medical, dental and food, chemical and in others. Medicinal products containing herbal ingredients, in comparison with synthetic pharmaceuticals, have a wider therapeutic spectrum and fewer side effects on human's body [1; 2].

Initial moisture content of medicinal plant raw material reaches to 70-85 % that results in high enzyme activity, relieved heat flow and it creates favourable conditions for microorganisms [3; 4]. All these factors have influence on losses of bio-active substances. Therefore, the raw material should be preserved immediately. The main method of herbal raw material preservation is drying. It has been used since ancient times, but the natural drying in the shade was applied only to small quantities [3-5]. With the increasing demand for medicinal plant raw materials, the importance of effective high-performance drying technologies, with applied additional energy for heating and creating air flow through the raw material, has increased.

Drying is one of the most widespread and the most energy-demanding technological processes. Chua et al. [6; 7] states that drying consumes on the average nearly 10-15 % of the total energy input in industry, while in herbal raw material preparation technologies – even 30-50 % of total energy consumption [5; 8]. Evaporation of 1 kg of water from medicinal plants requires nearly twice the amount of heat (approx. 10000 $kJ \cdot kg^{-1}$) than, for example, evaporation from grain [5]. Therefore, correct combination of drying conditions is necessary in order to reduce the drying costs and to preserve the quality of raw materials and active substances. Dryer design; optimal temperature and humidity of the drying agent, ventilation intensity and the height of a layer depend on herbal raw material, morphological characteristics and processing, on accumulated active substances, the selected drying method and other factors [5; 6; 9]. Publication review showed that there is a lack of knowledge in setting optimal combination of different medicinal plant raw material drying conditions, especially in preserving large amounts of it.

Currently in Lithuania traditional and folk medicine uses nearly 460 species of plants. Purple coneflower (*Echinacea purpurea* L. Moench) with its healing properties is one of the most popular medicinal plants [10; 11]. It originates from North America and up to now it was normally grown as an ornamental plant in Lithuania. The roots or the above-ground part of purple coneflower, i.e., grass can be used as a pharmaceutical plant material. The above-ground part of the plant can grow up to 60-100 cm, rarely up to 180 cm height. The grass growth is more intensive in the second year of cultivation, and its highest yields are obtained in the fourth and fifth year of cultivation [1; 11], where: in the second year of growth – 44.2 $t \cdot ha^{-1}$, in the third year – 56.7 $t \cdot ha^{-1}$ and in the fourth year – 73.1 $t \cdot ha^{-1}$ [11]. The above-ground part of a plant consists of stems, leaves and flowers and their biometric characteristics differ from each other: the stems are round in the lower part, and at the top one-third they are branched, hollow and slightly ribbed; the leaves are thin, with wrinkled surface, 17-24 cm long and 6-10 cm wide, they have a heart-shaped base and a pointed notched tip; the flowers are big with receptacle 1.5-3.5 cm in diameter [1]. Due to different physical properties, each part of purple coneflower is characterised by a unique drying process.

The objective of the study is to compare drying processes of different parts of purple coneflower (*Echinacea purpurea* L. Moench) – stems, leaves, flowers and grass in a thick still mound and to determine their characteristics.

Materials and methods

The research was carried out on the above-ground part of purple coneflower in the third year of growth, cultivated in Kaunas Botanical Garden, Vytautas Magnus University. The moisture content of the herbal raw material was determined by drying specially prepared samples up to constant weight in a drying cabinet SFP 600 (Memmert GmbH, Germany) at temperature of 105 ± 2 ºC. The drying experiments were carried out by drying harvested and prepared raw purple coneflower, i.e., grass, stems, leaves and flowers, in a still thick layer. Grass and the stems of purple coneflower were chopped additionally before drying, to 40 ± 6.4 mm length of fraction with a cutting machine ALKO Silent Power 4000 (AL-KO Kober AG, Germany).

The drying study was carried out at the Institute of Energy and Biotechnology Engineering, Aleksandras Stulginskis University. The prepared raw material of purple coneflower was dried with heated ambient air; the air temperature was 44.8 ± 1.5 ºC and relative humidity 65.2 ± 3.8 %. Average comparative intensity of ventilation was 4120 $m^3 \cdot (t \cdot h)^{-1}$. The raw material was dried in a special test-bench with four drying containers (Fig. 1), i.e., with ventilated cylinders, 180 mm in diameter and 1050 mm height.

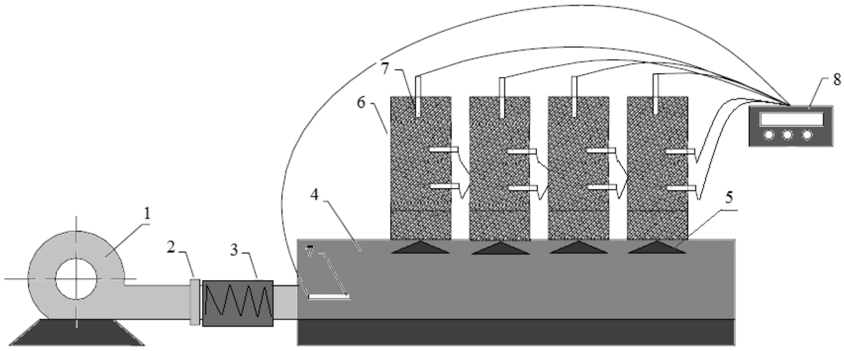

Fig. 1. **Basic scheme of a test- bench for material drying in a still thick layer:** 1 – fan; 2 – flexible flange; 3 – electric heater; 4 – air flow distribution manifold; 5 – hatches; 6 – ventilated containers; filled with herbal raw material; 7 – temperature and relative humidity sensors; 8 – data logger Almemo

Temperature and relative humidity sensors, for recording the parameters of the drying conditions and the drying process, were positioned in the air manifold and in four ventilated containers: at the bottom of a container (5-10 cm above the bottom of a herbal raw material layer) and at the top (5 cm below the top of the herbal raw material). The flowers of purple coneflower were dried in the first container; chopped stems in the second, leaves in the third and chopped grass in the fourth container. The measurement results were recorded with the data logging device Almemo 3290 (Ahlborn Mess- und Regelungstechnik GmbH, Germany).

The drying containers were weighed periodically, every 6-8 hours, 4 times a day using the scales VB 150K20 DLM (Kern&Sohn GmbH, Germany). The weight and moisture content changes of the medicinal plant raw material were monitored during the drying process. The intensity of ventilation was controlled and the velocity of air flow through the medicinal plants was measured with the thermo-anemometer OMEGAFLO HH – 600 Series, model 615 M (Omega, USA).

Results and discussion

The stems amounted to the largest above-ground part of the total weight of purple coneflower – 48.7 ± 3.39 %. They grew up to 813 ± 117.1 mm and the diameter ranged from 6.95 ± 1.1 mm at the thickest part of a stem to 4.79 ± 0.5 mm at the thinnest part of a stem. The leaves were relatively small (111 ± 32 mm long and 56 ± 10 mm wide on average) and amounted to 32.5 ± 2.46 % of total weight of an above-ground part. The flowers made up the smallest part of grass weight – 18.82 ± 3.23 %. The flowers showed high dispersions of the measurement results: the diameter of their receptacles ranged from 14 mm to 36 mm.

The initial moisture content of the purple coneflower stems, flowers, leaves and grass was 77.1 ± 0.98 %, 81.6 ± 1.32 %, 79.1 ± 0.38 % and 80.4 ± 0.61 % respectively. Decrease of the moisture content in the stems and in grass was the most intensive during drying (Fig. 2). After evaporation of 6,36 kg of water, the ventilated chopped stems dried up to 13.2 ± 0.43 % within 33 hours. It was 2 times faster than for the flowers, that reached 13.6 ± 0.5 % of the moisture content after 66 hours of drying. The grass dried up within 42 hours with 4.48 kg of moisture loss. The drying time for the leaves was 66 hours. However, since a mound sagged down, the moisture content decreased very slowly and the leaves dried up to 22.7 ± 1.37 % of the moisture content only. It was foreseen that the leaves would have to dry up to the recommended moisture content 13.5 to 14 % within 95 hours.

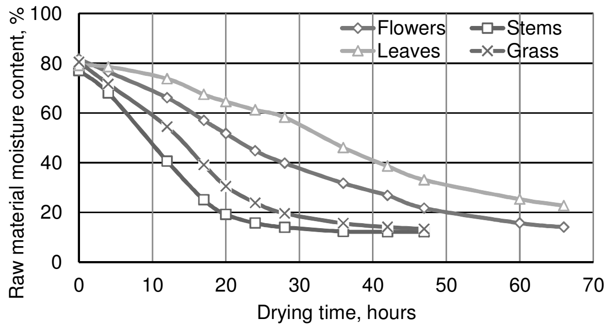

Fig. 2. **Dynamics of herbal raw material (*Echinacea purpurea* L. Moench) drying in a thick still mound**

Heated ambient air (air temperature was 44.8 ± 1.5 ºC and relative humidity – 65.2 ± 3.8 %) was blown through a layer of the medicinal plant raw material during drying. Fig. 3, a and b below show variations of the drying agent temperature.

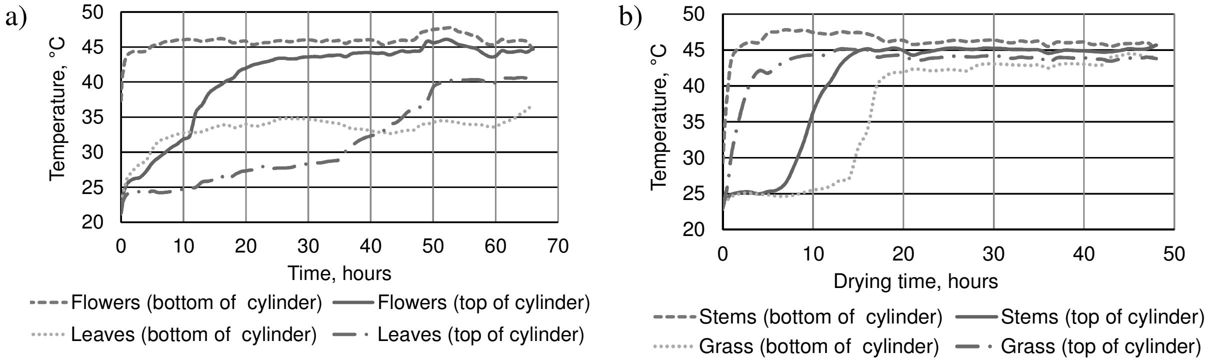

Fig. 3. Changes of drying agent temperature: a – in a mound of dried flowers and leaves; b – in a mound of dried stems and grass

Drying of stems and grass is characterised by a pronounced layer-by-layer drying principle. Intensive drying in the upper layers of a mound had started later than at the bottom: drying of stems at the top of a mound had started after 6 hours, whilst that of grass in a mound – after 13 hours. The drying process of flowers and leaves in mounds had started almost at the same time both in the lower and in the upper layers then, however, at the top of a mound, the drying process of the medicinal plant raw material was slower and longer: in the leaves mound – by 2.5 times and in the mound with flowers – by 3.1 times.

A similar situation was observed in the analysis of the relative humidity changes of a drying agent. The equilibrium moisture content of the dried chopped stems at the bottom of a layer reached its steady state after 6 hours and at the top of a layer – after 12 hours. Accordingly, in the flower mound it occurred after 10 and 20 hours, in the grass mound – after 9 and 18 hours and in the leaves mound – after 8 and 18 hours.

The height of the mound of the dried product decreased due to the moisture losses and same processes in the mound [12; 13]. It was determined that the most intensive decline of the height of the raw material mound occurred within the first 12 hours of drying (Fig. 4). Later on there was a slight change of the height, but the trend remained the same: the maximum variation of a mound height was determined in dried leaves and flowers. Thus, when drying was finished, the height of the mound with stems decreased by 30 % (83 ± 1.2 cm to 59 ± 1.2 cm), in the grass mound – by 35 % (77 ± 1.5 cm to 51 ± 0.5 cm), in the flower mound – by 55 % (73 ± 1.0 cm to 34 ± 1.0 cm) and the height of the mound with leaves – by 57 % (from 63 ± 1.0 cm to 28 ± 0.5 cm).

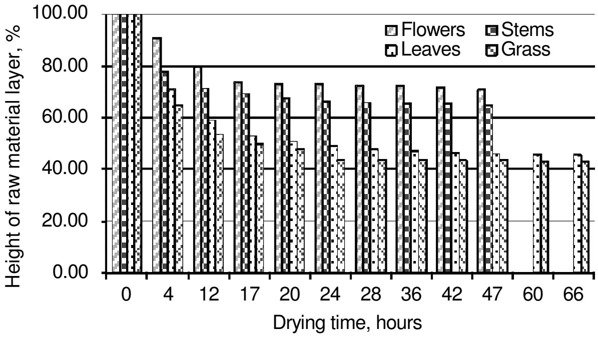

Fig. 4. **Height variation in a mound of dried herbal raw material (*Echinacea Purpurea L.* Moench)**

At the same time the density of a mound of the dried medicinal plant raw material had changed as well (Table 1). Variation of the stem mound density was the most intensive, but it had stabilised shortly, after 17 hours since drying was started. The porous and stable layer was formed, favourable for drying with active ventilation.

Table 1

Density variation in a mound of dried herbal raw material (purple coneflower)

Drying time, hours	Density of raw material							
	Grass		Steams		Flowers		Leaves	
	$kg \cdot m^{-3}$	%	$kg \cdot m^{-3}$	%	$kg \cdot m^{-3}$	%	$kg \cdot m^{-3}$	%
0	221.0	100.0	409.7	100.0	315.1	100.0	127.7	100.0
17	141.4	64.0	153.7	37.5	243.2	77.2	126.3	98.9
24	122.1	53.1	148.1	35.8	215.9	66.7	120.5	87.5
36	117.3	53.0	146.6	35.5	210.0	54.1	111.8	76.7
47	116.9	52.9	155.1	37.9	159.5	50.6	93.2	72.95
66	-	-	-	-	145.3	46.1	82.5	64.57

A similar process took place in the mound of purple coneflower grass. After 24-28 hours of drying, a stable layer had been formed. Stems played the role of structural elements that prevented compacting of the dried material layer. Variation of the density of the leaves mound was the least. It had decreased by 35 % only. At the same time variation of the mound height was the highest. The layer was compacted and distribution of the drying agent in the layer was disrupted. More intensive ventilation and drying of layers close to the walls were observed. The density of the flower layer had changed sufficiently intensive during the entire drying. However, the round shape of receptacles supported the mound structure that was favourable for drying, although the drying process was slow due to the coarse flowers.

Conclusions

During purple coneflower drying with active ventilation at air temperature of 44.8 ± 1.5 ºC, relative humidity 65.2 ± 3.8 % and at intensity of ventilation 4120 $m^3 \cdot (t \cdot h)^{-1}$, chopped stems were dried to 13.5-14 % moisture content over 33 hours, i.e., 1.3 times faster than grass (42 hrs.), 2 times faster than flowers (66 hrs.) and 2.9 times faster than leaves (95 hrs.).

Unlike in a mound with chopped stems and grass, a more even drying process was observed in purple coneflower leaves and flowers mound, thus avoiding the layered pattern of raw medicinal plant drying; the drying zone immediately covered the whole volume of leaves and flowers within the thick still mound.

It was found that the height of the mounds of purple coneflower flowers and leaves decreased by 55 % and 57 % respectively, i.e., by almost twice as much as for the mounds of grass (35 %) and chopped stems (30 %).

The density of the dried medicinal plant raw material (*Echinacea purpurea* L.) had decreased: density of chopped stems – from 409 $kg \cdot m^{-3}$ to 155 $kg \cdot m^{-3}$, flower density – from 315 $kg \cdot m^{-3}$ to 145 $kg \cdot m^{-3}$, chopped grass density – from 221 kg m^{-3} to 116.8 $kg \cdot m^{-3}$, leaves density – from 127.7 $kg \cdot m^{-3}$ to 82.5 $kg \cdot m^{-3}$, and density variation was the most intensive within 20 hours since the beginning of drying.

Rigid morphological parts of the plant lead to a more stable and porous mound structure of the herbal raw material, therefore, conditions of drying with active ventilation are more favourable for drying flowers and especially chopped stems and grass of purple coneflower.

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