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Hot-Air Drying of Purslane (*Portulaca Oleracea* L.) As A Medicinal Material: Blanching Effect, Drying Characteristics and Mathematic Modelling

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Abstract:- **The drying characteristics of untreated and blanched purslane used as a medicinal herb were investigated in this study. It was found that (1) blanching for 60s could save the drying time by 75.5%, 40.3%, 36.8%, 29.0% at 50, 60, 70 and 80°C, respectively; (2) Two stage could be distinguished by plotting Ln*MR* versus drying time, and the apparent activation energy of the first stage were 61.23 and 46.84 KJ/mol for untreated and blanched purslane, respectively; (3) Logarithmic model could mathematically fit to the drying data. The finding provides some reference for industrial drying of purslane and analysis of other products' drying.**

Keywords: Purslane, drying, blanching, activation energy, modelling

1. INTRODUCTION

Purslane (*Portulaca oleracea* L.) is a succulent plant of the family Portulacaceae. It contains high amounts of omega-3 fatty acids, vitamins, carotenoids, essential amino acids and minerals, which make purslane an important health food and widely consumed as a vegetable in many regions of Europe, Mediterranean countries, Asia, Africa and Australia.[1, 2]. As the fresh purslane is highly perishable, it was also dried for use out of season and for export to meet the requirements of the other population. The drying characteristics of purslane leaves or seedlings have been investigated by different drying methods including microwave, vacuum, infrared, hot-air drying or open-air sun drying with salted or blanched pretreatments or in its natural state [3-8].

Purslane is also one of the mostly used herbs and it has been given the term 'Global Panacea' by World Health Organization [9]. In China, it is used to clear away heat and toxic materials, and cool the blood according to the theory of traditional Chinese medicine [10]. Modern researches have confirmed that it has many other constituents including alkaloids, phenolic acids, organic acids, flavonoids etc. and possess neuroprotective, antimicrobial, antidiabetic, antioxidant, anti-inflammatory, antiulcerogenic, and anticancer activities.[1, 2, 11-14].

As recorded in the Chinese Pharmacopoeia, purslane should be collected in summer or autumn, and sun-dried after being steamed or blanched. Sun drying is the most traditional drying method. The advantage of this method is simple operation and full use of natural energy, however the drying efficiency is low, it is dependent on the weather and space, and the product quality is difficult to control [14, 15]. During the period of purslane collection, it always rains, and it is usually a tough job to dry by sun in the open air, especially for purslane drying, as it contains a large amount of mucus. Comparing with sun drying, hot air drying can effectively avoid these problems, so it will be an alternative choice for industrial drying of purslane. A deep knowledge of drying process and characteristics of raw material is needed for optimization of the drying operation [3]. Therefore, in this study, the drying characteristics of blanched purslane was investigated in comparison with the untreated one to lay the foundation of industrial drying of purslane used as a herbal medicine.

2. MATERIALS AND METHODS

2.1 Materials

Fully developed purslane with stem, leaves, flowers and fruits were collected at the end of July from the same field in a village located in the Linyi County, China, and stored in a refrigerator at 4°C prior to the experiments. The average initial moisture content of the fresh purslane was 88.91% (wet basis, w.b.) determined by drying at 105°C for about 12 hour until a constant weight obtained.

2.2 Experimental dryer

The dryer consists of a heating chamber, a drying chamber, an axial fan and a weighing system as shown in Figure 1. A sample basket (25 cm ×25 cm) made of stainless steel mesh was suspended in the drying chamber from an electronic balance (0.01 g). The air was heated to the required temperature in the heating chamber by a 2000w tubular electric heating element connected with a proportional-integral-derivative (PID) controller, and forced circulation by the the fan within the drier. During the drying process, the sample weight was automatically recorded by a computer through communicating with the balance at an interval of 10 min. Air velocity was measured using an anemometer and adjusted to 0.5 m/s by changing the revolving speed of the axial fan by an electric speed regulator.

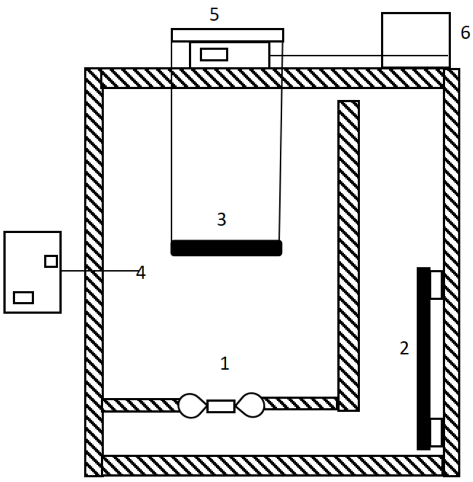

Figure 1. Schematic diagram of the experimental dryer (1. Axial fan; 2. Heating chamber; 3. Sample basket; 4. Temperature senor; 5. Electronic balance; 6. Computer)

2.3 Experimental procedure

The fresh purslane was taken out of refrigerator and acclimated to room temperature for 1 h, and then 400 g sample was blanched in 2L of boiling water, during which the water was heated by a 2000W electromagnetic oven to control the water temperature over 90°C. To obtain the drying characteristics of purslane, both blanched and untreated samples were dried at the temperatures of 50, 60, 70 or 80°C until the weight unchanged.

2.4 Data analysis

The moisture change of the purslane sample during the drying process was expressed by moisture ratio (*MR*), which was calculated as follows [16-18]:

$$MR = \frac{M_t - M_e}{M_0 - M_e} \quad \text{........(1)}$$

Where M_t, M_0 *and* M_e are moisture content (kg water/kg dry matter) at a specific time, initial and equilibrium moisture content, respectively. The value of M_e is relatively small compared to M_t or M_0 after a long time drying so it can be ignored; therefore, the *MR* is simplified to M_t/M_0.

The drying rate of purslane was calculated based on the following equation:

$$\text{Drying } rate = \frac{M_{t+dt} - M_t}{dt} \quad \text{........(2)}$$

Where M_t is the moisture content at time *t*, M_{t+dt} is the moisture content at *t+dt*.

The stems, leaves, flowers and fruits of purslane are inconsistent in shape and structure, it is difficult to calculate the activation energy of purslane according to commonly used method as literatures. In this study, the dehydration of purslane was considered as a chemical reaction: decomposition of water with the dry matter, water concentration was indirectly expressed by *MR*, accordingly the apparent activation energy was estimated by Arrhenius plotting:

$$A = A_0 \exp\left(-\frac{Ea}{RT}\right) \quad \text{........(3)}$$

Where, *A* is the reaction rate constant, which is obtained by plotting Ln*MR* versus drying time; A_0 is the pre-exponential factor; *Ea* is the apparent activation energy (J/mol); T is the temperature in Kelvin and R is the gas constant (J/(mol·K)).

To explore the drying characteristics of purslane, Logarithmic model was chosen to fit the data of purslane dried at different temperatures using non-linear regression solved by a Levenberg-Marquardt numerical algorithm [16, 19, 20].

$$MR = a \cdot \exp(-kt) + c \quad \text{........(4)}$$

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Where, a, c in the model are drying constants and k is the drying rate constant.

3. RESULTS AND DISCUSSION

3.1 Drying behaviour of purslane

The untreated purslane samples were dried at different temperatures. The drying curves are shown in Figure 2. The drying time required to reach the same level of moisture ratio became significantly shorter when dried at a higher temperature, for example, when the moisture ratio of the samples reached to 0.1, the required drying times were 81.5, 16.8, 9.9 and 5.2 hours when dried at 50, 60,70 and 80°C respectively.The result indicates that the higher the drying temperature, the more energy the material gets, and the faster the rate of water migration, which agrees with the finding of Doymaz for purslane [6], and the reports on the other products such as rosehip [21], garlic slices [22] and rupturewort [23].

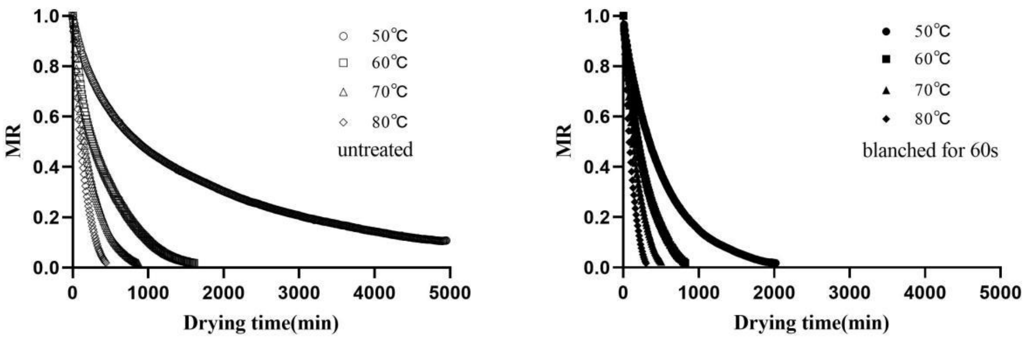

Figure 2. The moisture ratios of untreated and blanched purslane versus drying time.

The drying times of the blanched samples were much shorter than those of the untreated controls, when the drying reached to MR = 0.1 and the drying times saved by 75.5%, 40.3%, 36.8%, 29.0% at 50, 60, 70 and 80°C, respectively, which agrees with the result of İsmail O for purslane drying [7]. It can be seen that the effect of blanching seems to be more pronounced at a lower temperature drying like 50°C. What's more, it is worth noting that drying could affect the retention of bioactive molecules and antioxidant activity [1], and blanching could inactivate the quality-deterioration enzymes [24] and cause loss of water-soluble components, therefore, further investigations should be conducted to optimize the blanching technique.

The drying times in this study are much longer than previous reports. The primary reason may lie in the samples used in different studies. The fully developed purslane was used in this study, it might have a thicker cuticle, and contain a higher mount of mucus, while the other studies only used leaves, or segments of younger samples with stems and leaves [4, 5, 7]. In addition, the size, shape and thickness of the sample may also affect the drying time. Therefore, follow-up experiments will explore the specific impacts of these factors on the drying of purslane.

3.2 Drying rate of purslane

Consistent with the expected effect, the drying rate of purslane is not a constant process, instead a falling rate period as shown in Figure 3. It is speculated that it may be due to the relatively high water content of the sample in the earlier period, and free water continuously spreads from the sample surface to maintain the early rapid water loss. As the drying continued, the free water became less, and the rate of water loss declined gradually, during which drying rate may largely depend on water diffusion from the inside to the surface of the material.

The drying rates of blanched samples are distinctly higher than those of the untreated ones in all the drying processes. The reason may be that both cuticle and cell membrane were damaged by the blanching pretreatment. As showed in Figure 3, the initial drying rates of the samples are relatively low, which may be a false appearance as the power of the experimental dryer is relatively low, and the samples could not be instantaneously heated to the set temperatures.

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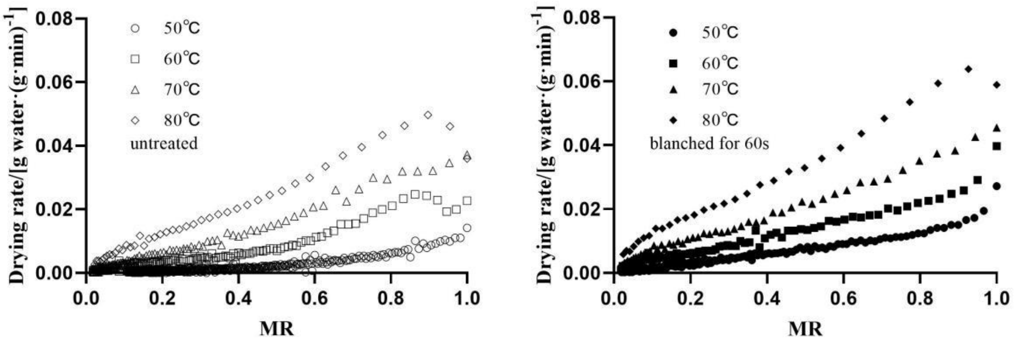

Figure 3. The drying rate of untreated and blanched purslane

3.3 Identification of drying stages and calculation of apparent activation energy

By plotting Ln*MR* versus drying time, two near-linear stages can be identified with exception of untreated purslane dried at 50°C, it seems that the second stage of which did not come yet by the time of 5000 hours (Figure 4). Most of the turning points locate in the range of -2 > Ln*MR* > -2.5, therefore, this is a transition. Accordingly, the earlier period before this transition is artificially termed as the first stage, and the later as the second stage.

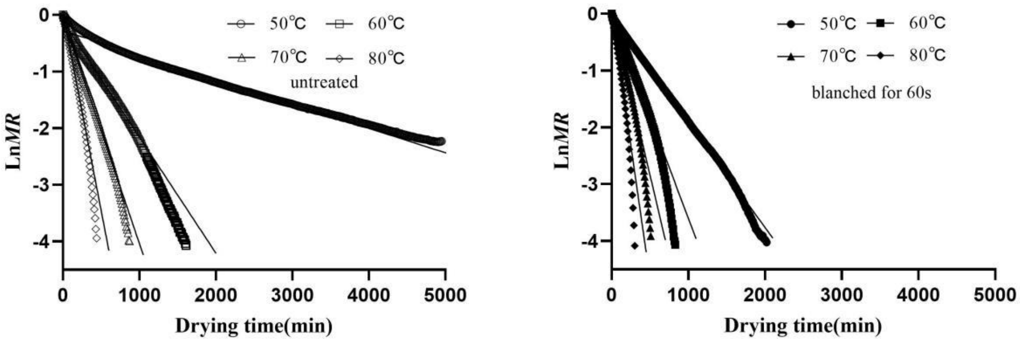

Figure 4. Identification of two near-linear stages by plotting Ln*MR* versus drying time
(The lines are the trend line of the first drying stage)

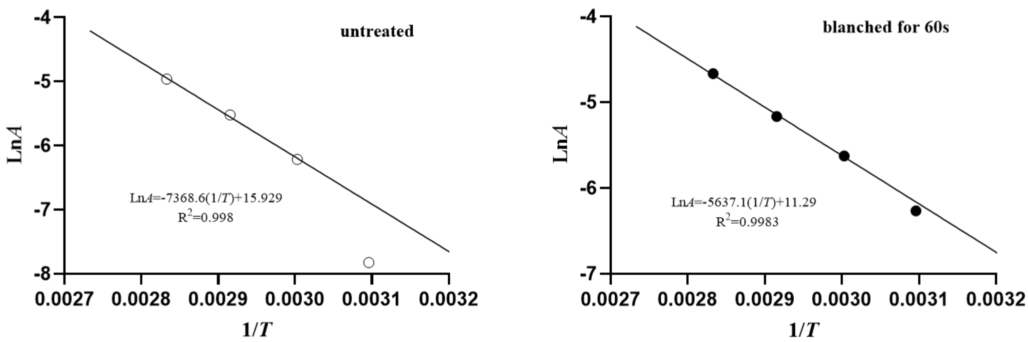

Figure 5. Arrhenius plotting of the first stage of purslane drying

Due to most moisture removed in the first stage, the apparent activation energy of this stage was calculated based on Arrhenius plotting as Figure 5. It can be found that the drying at 50°C clearly deviate from the drying at the other temperatures, the reason may be those discussed in section 3.2. Accordingly, the data of the first stage of drying at 60, 70 and 80°C were selected to calculate the apparent activation energy, which are 61.23 KJ/mol, 46.84 KJ/mol for untreated and blanched purslane, respectively. It can be seen that the apparent activation energy was significantly reduced by blanching pretreatment.

3.4 Mathematic modelling of hot-air drying of purslane

In this study, Logarithmic model as the equation (4) was chosen to fit the experimental data of the first stage. By the method of plotting, the experimental dimensionless moisture ratios are compared with those predicted by Logarithmic model as shown in Figure 6. It can be seen that the two types of values nearly overlap, which indicates that the model could well describe the drying behaviour of purslane at the drying temperature ranged from 60℃ - 80℃, especially for the first stage. In addition, we found that there is a good linear relationship between the model constant of the Logarithmic model with drying temperature. Therefore, the moisture ratios (*MR*) at a given drying time (*t*) and drying temperature (*T*) could be predicted by the following equations for the untreated or blanched purslane drying:

$$MR_{\text{untreated}} = (0.0085T-1.9543)\exp[(-0.0002T+0.0636)t]-0.0057T+1.9998$$

$$MR_{\text{blanched}} = (0.0036T-0.2015)\exp[(-0.0003T+0.0804)t]-0.0026T+0.8327$$

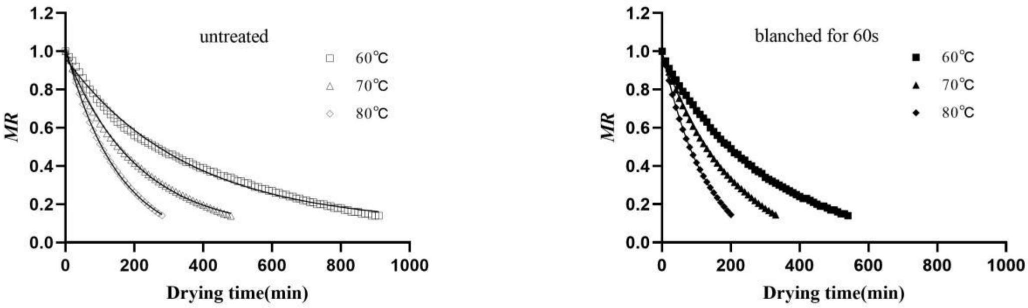

Figure 6. Comparison of experimental data (scatter plot) with Logarithmic model-predicted data (line plot)

4. CONCLUSION

Drying characteristics of untreated and blanched purslane were investigated. It was found that blanching pretreatment and increasing drying temperature could increase the drying rate of purslane. Two stage could be distinguished by plotting Ln*MR* versus drying time, and the apparent activation energy of the first stage was reduced by blanching pretreatment. Logarithmic model could fit the data of the first stage of the drying processes at 60, 70 or 80°C. Our finding partly confirmed the rationality of the traditional technique for purslane drying and provided some reference for industrial drying of purslane used as a herbal medicine and analysis of other products' drying.

REFERENCE

[1] Shanker N and Debnath S. Impact of dehydration of purslane on retention of bioactive molecules and antioxidant activity. Journal of Food Science and Technology, 2015, 52(10): 6631-6638.
[2] Nemzer B, Al-Taher F, Abshiru N. Phytochemical composition and nutritional value of different plant parts in two cultivated and wild purslane (*Portulaca oleracea* L.) genotypes. Food Chemistry, 2020, 320: 126621.
[3] Kashaninejad M, Tabil LG. Drying characteristics of Purslane (*Portulaca oleraceae* L.). Drying Technology, 2004, 22(9): 2183-2200.
[4] Demirhan E, Özbek B. Drying kinetics and effective moisture diffusivity of purslane undergoing microwave heat treatment. Korean Journal of Chemical Engineering, 2010, 27(5):1377-1383.
[5] Karaaslan S, Erdem T, Oztekin S. Mathematical modelling and color characteristics of Purslane (*Portulaca oleraceae* L.) leaves using different drying methods. The Philippine Agricultural Scientist, 2013, 96(3): 267-274.
[6] Doymaz İ. Hot-air drying of purslane (*Portulaca oleracea* L.) Heat and Mass Transfer, 2013, 49(6): 835-841.
[7] İsmail O, Figen AK, Pişkin S. Effects of open-air sun drying and pre-treatment on drying characteristics of purslane (*Portulaca oleracea* L.). Heat and Mass Transfer, 2015, 51(6): 807-813.
[8] Reddy DK, Waghray K, Sathyanarayana SV. Infrared heating - A new green technology for process intensification in drying of purslane leaves to reduce the thermal losses. ICETE 2019, Lais 2: 466-475.
[9] Lim YY, Quah EPL. Antioxidant properties of different cultivars of *Portulaca oleracea*. Food Chemistry, 2006, 103(3): 734-740.
[10] The state commission of chinese pharmacopoeia. Pharmacopoeia of people's republic of China, Part I. Beijing: Chemical Industry Press, 2020: 51-52.
[11] Farag MA, Shakour ZTA. Metabolomics driven analysis of 11 Portulaca leaf taxa as analysed via UPLC-ESI-MS/MS and chemometrics. Phytochemistry, 2019, 161: 117-129.
[12] Jiao ZZ, Yue S, Sun HX, Jin TY, Wang HN, Zhu RX, Xiang L. Indoline amide glucosides from *Portulaca oleracea*: Isolation, structure, and DPPH radical scavenging activity. Journal of natural products, 2015, 78(11): 2588-2597.
[13] Yang ZJ, Liu CJ, Xiang L, Zheng YN. Phenolic alkaloids as a new class of antioxidants in Portulaca oleracea. Phytotherapy Research, 2009, 23(7):1032-1035.
[14] Huang D, Men KY, Li DP, Wen T, Gong ZL, Sunden B, Wu Z. Application of ultrasound technology in the drying of food products. Ultrasonics

Sonochemistry, 2020, 63: 104950.

[15] Pochont NP, Mohammad MN, Pradeep BT, Kumar PV. A comparative study of drying kinetics and quality of Indian red chilli in solar hybrid greenhouse drying and open sun drying. Materials Today: Proceedings, 2020, 21(1): 286-290.

[16] Qin S, Wen XS, Shen T, Xiang L. Thin layer drying characteristics and quality evaluation of steam blanched chrysanthemum. Transactions of the Chinese Society of Agricultural Engineering, 2011, 27(6): 357-364.

[17] Doymaz İ. Convective drying kinetics of strawberry. Chemical Engineering and Processing: Process Intensification, 2007, 47(5): 914-919.

[18] Doymaz İ. Convective air drying characteristics of thin layer carrots. Journal of Food Engineering, 2004, 61(3): 359-364.

[19] Zhu BM, Wen XS, Wei GD. Effect of pre-treatments on drying characteristics of Chinese jujube (*Zizyphus jujuba* Miller). International Journal of Agricultural and Biological Engineering, 2014, 7(1): 94-102.

[20] Özdemir M, Devres YO. The thin layer drying characteristics of hazelnuts during roasting. Journal of Food Engineering, 1999, 42(4): 225-233.

[21] Erenturk S, Gulaboglu MS, Gultekin S. The thin-layer drying characteristics of rosehip. Biosystems Engineering, 2004, 89(2): 159-166.

[22] Madamba PS, Driscoll RH, Buckle KA. The thin-layer drying characteristics of garlic slices. Journal of Food Engineering, 1996, 29(1): 75-97.

[23] Bahammou Y, Moussaoui H, Lamsyehe H. Tagnamas Z, Kouhila M, Ouaabou R, Lamharrar A, Idlimam A. Water sorption isotherms and drying characteristics of rupturewort (*Herniaria hirsuta*) during a convective solar drying for a better conservation. Solar Energy, 2020, 201: 916-926.

[24] Xiao HW, Pan ZL, Deng LZ, El-Mashad HM, Yang XH, Mujumdar AS, Gao ZJ, Zhang Q. Recent developments and trends in thermal blanching-A comprehensive review. Information Processing in Agriculture, 2017, 4(2): 101-127.