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Ashok K Senapati
Centre of Excellence on Post-Harvest Technology, Navsari Agricultural University, Navsari, Gujarat, India

SS Mahanand
Dept. of Fisheries Engineering College of Fisheries Central Agricultural University Lembucherra, Tripura, India

Harish G Suthar
Centre of Excellence on Post-Harvest Technology, Navsari Agricultural University, Navsari, Gujarat, India

Dev Raj
Centre of Excellence on Post-Harvest Technology, Navsari Agricultural University, Navsari, Gujarat, India

Vineet K Sharma
Department of Agricultural Engg. NM College of Agriculture, NAU, Navsari, Gujarat, India

Correspondence
Ashok K Senapati
Centre of Excellence on Post-Harvest Technology, Navsari Agricultural University, Navsari, Gujarat, India

Drying of Ashwagandha (*Withiania somnifera*) root a review

Ashok K Senapati, SS Mahanand, Harish G Suthar, Dev Raj and Vineet K Sharma

Abstract
Ashwagandha (Withania somnifera) is an important medicinal plant cultivated in India as well as other parts of the world. The characteristics of Ashwagandha roots have also been reviewed. The reviewers suggested the various drying methods like shed drying, sun drying, cabinet drying, convective drying and microwave- convective drying used for drying of fresh Ashwagandha roots. These techniques are mainly used for preservation and value addition of Ashwagandha roots. Several researchers have attempted for evaluation of quality parameters of Ashwagandha roots and model of drying kinetics which are also compiled here briefly.

Keywords: Ashwagandha roots, drying methods, quality evaluation, mathematical modeling

Introduction
Ashwagandha (*Withania somnifera* Dunal) (family Solanaceae) is highly reputed as “Indian ginseng” in Ayurvedic medicine (Schliebs *et al*., 1997) [24]. The worldwide interest in medicinal plant products has increased significantly in recent years. A medicinal plant consists of plant materials in the form of crude or processed state as active ingredient. In medicinal plants like Ashwagandha the root parts contains more active ingredients, volatile oil, flavour and alkaloids and withanaloids as compared to the other parts of the plants. This herb is used for 4000 years plus in India and a very important herb in ayurveda, the traditional Indian medicine (Senapati *et al*., 2017) [22]. Withania somnifera is well known as a folk medicine and to afford withanolides, which are steroidal derivatives having a characteristic partial structure in the A, B-ring part and the side chain of d -lactone. To date more than 40 withanolides have been isolated from W. somnifera (Kirson *et al*., 1971; Nittala *et al*., 1981; Bessalle and Lavie., 1992) [8, 13, 5]. They commonly contain high level of moisture and microorganisms (Senapati *et al*., 2014). The study revealed that total accumulation of alkaloid content in roots increased up to 135 days after sowing of Ashwagandha (Baraiya, 2004) [3]. It contains nicotine and group of alkaloids and also contains the ingredients i.e. foreign matter (Not more than 2%), total ash (7%), acid soluble ash (1%), alkaloids (2.5%) and water (80%) (Baraiya, 2004) [3]. In Ashwagandha, the root parts contain more active ingredients, volatile oil, flavour and alkaloids as compared to the other parts of the plants (Prasad *et al*. 1986) [14]. Ashwagandha root has a short shelf life. In order to extend its shelf life, preservation is needed in some form. Drying is one of the oldest and most widely used methods of food preservations. Longer shelf life, product diversity and substantial volume reduction are the reasons for the popularity of dried medicinal roots (Agrawal *et al*. 2014; Senapati *et al*., 2017) [1, 22]. The natural drying, usually on the field can be replaced by artificial drying such as convective drying, Tray drying, cabinet drying and microwave drying due to reduced drying time and more aseptic conditions. The mould and bacteria growth as well as losses of active ingredients can be significantly reduced and post-harvest infection could be avoided (Senapati *et al*., 2014) [23]. Microwaves drying is relatively a new addition in the existing drying technique viz. hot air, cabinet, spray, vacuum and freeze drying (Prabhanjan *et al*. 1995) [16]; Ren and Chen (1998) [18]. Microwaves are rarely used alone but rather in combination with hot air, steam, vacuum conditions or the conventional methods have more synergistic effect. Two narrow band of microwave allotted for use in industrial food processing application are 915 and 2450 MHz which can be absorbed by water containing materials and converted to heat (Khraisheh *et al*., 1997) [9]. Waves can penetrate directly into the material; heating is volumetric (from the inside to

outside) and provides fast and uniform heating throughout the product (Schiffman, 1987; Anantheswaran *et al.*, 1994; Prabhanjan *et al.*, 1995; Rynanen,1995; Khraisheh *et al.*, 1997 and Saltiel and Datta, 1999) [2, 16, 19, 9, 21]. Mathematical modeling can play an important role in the design and control of the process parameters during drying. The developed model is then used to recalculate the dependent parameters at drying process parameters. The models are tested for statistical viability at the 1% level of significance (Khraisheh *et al.*, 1999) [10].

Methodology

The vacuum oven method was used to determine the moisture content of fresh Ashwagandha root (Young & Mason, 2002) [2].

1.1 Process flow chart for drying of Ashwagandha root

Washing thoroughly fresh Ashwagandha roots

↓

Samples cut into 5cm length under the hygienic condition

↓

Samples pretreated with hot water at 100 ^{0}C for 2 min

↓

Drying of samples under various drying conditions

↓

Dehydrated roots

↓

Quality evaluation of dried roots
(Senapati at al., 2014) [23]

The fresh and bone dried roots weights were taken to calculate the moisture content expressed as g water /g dry matter.

Various methods of drying of Ashwagandha Root: The most commonly adopted drying practices for Ashwagandha root are sun drying, convective drying and microwave drying.

Sun drying

Desai *et al.* (2017) [6] conducted a field experiment to study the growth, yield and quality of Ashwagandha root. They were dried the roots under sun and found dry root weight (2.13 %) and quality parameters like total withanolide yield (0.55 %).

Sun drying, shed drying and cabinet drying

Agrawal *et al.* (2014) [1] studied the influence of drying on the quality parameters like colour and withanolides content of Ashwagandha (*Withania somnifera*), the ancient system of Indian medicine and belong to the family Solanacae. The dried roots of the plant are used in the treatment of nervous disorders. The fresh Ashwagandha roots were dried in shade (30-32^0 C), sun (33 – 37^0 C) and cabinet dryer (air velocity 1.4-1.6 ms-^{1} and temperature 52 – 61 ^{0}C and Air velocity 1.8-2.0 ms-^{1} and temperature 55 – 61 ^{0}C). Fresh Ashwagandha dried in shade and sun for about 13 hours and 6 hours moisture depletion of 21% and 25% was noticed, respectively. Whereas when dried in cabinet dryer about 49-52% moisture loss is observed in only 3.15 hours of drying.

Convective drying

Senapati *et al.* (2017) [22] investigated the application of convective drying of Ashwagandha roots. A laboratory convective dryer which was already developed had the provision of regulating of air temperature and air velocity. Ashwagandha roots of uniform size were used in the drying experiment that were conducted at air temperatures of 40, 50, and 60 ^{0}C, air velocities of 1.0 and 1.5 m/s. Convective drying was carried out till the moisture content of the Ashwagandha roots reduced from initial moisture content of 5.06 kg water/kg of dry matter to a safe level of about 0.06 kg water/kg of dry matter. It was found that the drying time decreased with increasing the drying air velocity. The convective drying technique was more efficient than sun drying of Ashwagandha roots and resulted in savings to extend of about 90% of drying time. The results revealed that air velocity of 1.5 m/s and air temperature of 60 ^{0}C lower drying time of 8 h dehydrated Ashwagandha roots in convective drying process.

Microwave Drying

Senapati *et al.* (2014) [23] studied microwave for drying of Ashwagandha roots. Ashwagandha roots of uniform size were used in the drying experiment which were carried out at air temperatures of 40, 50 and 60 °C, air velocities of 1.0 and 1.5 m/s and microwave power levels of 2, 4 and 6 W/g. Convective- microwave drying was accomplished till the moisture content of the Ashwagandha roots reduced from initial moisture content of 5.06 kg water/kg of dry matter to a safer level of 0.06 kg water/kg of dry matter. The effect of power level increment of convective -microwave drying was reduced the drying time thereby increased the drying rate. It is quite clear that the increase in air velocity reduced the drying time in convective-microwave drying of Ashwagandha roots. The drying is attributed to the increase in the heat and mass transfer coefficients at the evaporating surface with the increase in air velocity for a given air temperature. It is evident that at given air temperature and microwave power level, the increase in air velocity increased the drying time. The optimum operating conditions of Ashwagandha roots for power level, velocity and air temperature in convective-microwave drying process were 6 W/g, 1.5 m/s and 60 °C, respectively and found the lowest drying time of 45 min of dehydrated Ashwagandha roots.

Quality evaluation of dehydrated Ashwagandha root

Desai *et al.* (2017) [6] conducted a field experiment to study the growth, yield and quality of Ashwagandha root. They dried the Ashwagandha roots under sun drying and reported the value of dry root weight (2.13 %) and quality parameters like total withanolide (0.55 %). Agrawal *et al.* (2014) [1] studied the influence of drying on the quality parameters like colour and withanolides content of Ashwagandha (Withania somnifera). The dried roots of the plant are used in the treatment of nervous disorders. The fresh Ashwagandha roots were dried in shade (30-32 ^{0}C), sun (33 – 37 ^{0}C) and cabinet dryer (air velocity 1.4-1.6 ms-^{1} and temperature 52 – 61 ^{0}C and Air velocity 1.8-2.0 ms-1 and temperature 55 – 61 ^{0}C). The colour (L, a, b value) of the dried products does not vary in different drying conditions. Maximum withanolide-A (%) was observed in shade drying (0.049%) followed by sun drying (0.032%) and cabinet drying (0.029%) with an air velocity of 1.4 – 1.6 ms^{-1}.

Senapati *et al.* (2017) [22] investigated the application of convective drying of Ashwagandha roots. A laboratory convective dryer which was already developed had the provision of regulating of air temperature and air velocity. Ashwagandha roots of uniform size were used in the drying experiment that were conducted at air temperatures of 40, 50,

and 60 ^{0}C, air velocities of 1.0 and 1.5 m/s. The quality attributes of fresh and dehydrated Ashwagandha roots were evaluated in terms of colour parameter (L*, a*, b*), rehydration ratio and total alkaloids content (Govt. of India, 1986; Owais *et al*., 2005) [7]. The good quality parameters of Ashwagandha roots dehydrated by convective drying at air velocity of 1.5 m/s and air temperature of 50 ^{0}C were the colour value (L=37.22, a=5.09, b=11.82), rehydration ratio (3.972) and alkaloids content (2.55%) which was found superior to the sun drying samples (colour parameters like L=35.20, a=4.51, b=9.51, rehydration ratio= 2.76 and alkaloids content=1.54 %).

Senapati *et al* (2014) [23] reported microwave drying of Ashwagandha roots. Ashwagandha roots of uniform size were used in the drying experiment which was carried out at air temperatures of 40, 50 and 60 °C, air velocities of 1.0 and 1.5 m/s and microwave power levels of 2, 4 and 6 W/g. The quality attributes of fresh and dehydrated Ashwagandha roots were evaluated for colour changes (L, a, b values), total alkaloids content and rehydration ratio (Ranganna, 1986 and Bouraoui *et al*., 1994) [17, 4]. The quality of Ashwagandha roots dehydrated by convective -microwave drying was found to be to be better followed by sun drying. The optimum operating conditions of Ashwagandha roots for power level, velocity and air temperature in convective- microwave drying process were 6 W/g, 1.5 m/s and 50°C, respectively and found a good quality of dehydrated Ashwagandha roots. Corresponding to values of process variables i.e. 6 W/g, 1.5 m/s and 50°C, the values of rehydration ratio, total alkaloids content, total colour change value(less ΔE) were 4.16, 1.94 % and 5.654, respectively.

Modeling of Drying of Ashwagandha Root

The observed drying data i.e., weight loss of the sample with time for each drying value were converted into different parameters such as moisture content (kg water/kg dry matter) and drying rate (kg water/kg dry matter/min) and moisture ratio (MR). The moisture content of the sample was calculated from the weight of the sample measured at different times during the course of drying and was expressed on dry mater basis. The Page model was employed to describe the drying kinetics of convective drying method (Sharma & Prasad, 2001; Maskan, 2000) [20, 11].

$$MR = \frac{M - M_e}{Mo - M_e} = \exp(-kt^n) \quad ..(2)$$

Where, MR = moisture ratio = (M -Me)/ (M0 -Me); M =moisture content (kg water/kg dry matter) at time t, Me = equilibrium moisture content (kg water/kg dry matter); M0 = initial moisture content (kg water/kg dry matter) at time = 0; K = drying rate constant (min-1); n is the parameter of Page's model; and t = drying time in min. Moisture ratio (MR) data for drying of Ashwagandha roots was tabulated used to test the applicability of the Page model.

Senapati *et al*. (2017) [22] investigated convective drying of Ashwagandha roots. Ashwagandha roots of uniform size were used in the drying experiment that were conducted at air temperatures of 40, 50, and 60 ^{0}C, air velocities of 1.0 and 1.5 m/s. Convective drying was carried out till the moisture content of the Ashwagandha roots reduced from initial moisture content of 5.06 kg water/kg of dry matter to a safe level of about 0.06 kg water/kg of dry matter. The empirical Page's model adequately described the thin layer convective drying for Ashwagandha roots. Page model was best fitted for convective drying condition ($R^2 > 0.9$).The effect of process parameters on rehydration ratio and total alkaloids content was found significant at 1% level of significance for convective drying method.

Senapati *et al*. (2014) [23] studied microwave for drying of Ashwagandha roots. Ashwagandha roots of uniform size were used in the drying experiment which were carried out at air temperatures of 40, 50 and 60 °C, air velocities of 1.0 and 1.5 m/s and microwave power levels of 2, 4 and 6 W/g. Convective- microwave drying was accomplished till the moisture content of the Ashwagandha roots reduced from initial moisture content of 5.06 kg water/kg of dry matter to a safer level of 0.06 kg water/kg of dry matter. Page model was found to be best fit for convective - microwave drying condition. The process parameters were optimized by using statistical analysis ANOVA for responses with 1% level of significance by Panse and Sukhatme (1967) [12]. The optimum operating conditions of Ashwagandha roots for power level, velocity and air temperature in convective- microwave drying process were 6 W/g, 1.5 m/s and 50 °C, respectively. The analysis yielded high values of R^2 ($R^2 > 0.9$) for convective-microwave drying method which was found to be in good agreement with the previous findings (Maskan, 2000; Sharma & Prasad, 2001) [11, 20]. It is evident that the rate constant 'k' increased with increase in drying air temperature satisfying higher drying rates at higher temperatures as well as the same trend for 'k' was also observed at both the air velocities (Sharma and Prasad, 2001) [20].

Conclusion

Ashwagandha roots dried under convective-microwave drying was found to be faster than convective drying, cabinet drying followed by sun drying and shed drying resulted in savings to an extend of about 90 % of drying time. The drying data of Ashwagandha root of convective-microwave drying and convective drying conditions was best fitted by Page model. The maximum quality parameters like rehydration ratio, colour (L, a, b values), total alkaloids were observed in convective-microwave (6 W/g, 1.5 m/s and 50°C,) convective drying(1.5 m/s and 50°C) and the maximum withanolide-A (%) was found in shade drying (0.049%) followed by sun drying (0.032%) and cabinet drying (0.029%) with an air velocity of 1.4 – 1.6 ms^{-1}.

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