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Infrared Drying Variables in Processing of Dried Flamboyant (*Delonix regia*) Flower Tea

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Infrared dehydration has potential for drying flowers because it is gentle and shortens the processing duration. The flamboyant (*Delonix regia*) flowers contain most of the active constituents. Drying is an important post-harvest strategy to enhance its product quality as well as commercial value. Purpose of this research focused on the influence of several major processing variables such as infrared drying power, temperature and air velocity time on total phenolic, flavonoid, carotenoid and overall acceptance of dried tea from flamboyant flowers under the infrared irradiation. Results revealed that these flowers should be dried at power 175 W, temperature 60°C with air velocity 1.2 m/s in the infrared drying cabinet. By infrared dehydration, major phytochemical constituents such as total phenolic, flavonoid, carotenoid as well as organoleptic attributes in the dried flamboyant flower could be preserved effectively

Keywords: Flamboyant flower, dehydration power, dehydration time, air velocity, phenolic, flavonoid, carotenoid, organoleptic

INTRODUCTION

Flamboyant (*Delonix regia*) is a large ornamental tree with fern-like bipinnately compound leaves and attractive red peacock flowers. Its flower is actinomorphic or somewhat irregular, slightly fragrant (Nidhi et al. 2016). Its flowers contain a rich source of β -sitosterol, galactomannan, tannins, saponins, flavonoids, steroids, alkaloids and carotene hydrocarbons. These phytochemical constituents can affect the enzyme involved in the activation and detoxification of xenobiotics including carcinogens (Shanmukhaet al. 2011). They possess insecticidal, antioxidant, hepatoprotective, gastroprotective, wound healing, antiarthritic, larvicidal, antimalarial, antifeedant, antiemetic, antibacterial, antifungal, antiinflammatory, antifertility, analgesic, antidiarrhoeal, antiheamolytic, diuretic, and anthelmintic activities (Deepa and Remadevi, 2011; Anuj et al. 2016). Aqueous extract of flowers is used for the dyeing

of silk and cotton fabrics to obtain a bright reddish-brown hue which showed resistance to fading and as an additive in herbal sunscreen formulation (Vankar and Shanker, 2009; Divya et al. 2013; Karthika and Jayshree, 2013; Jayshree and Karthika, 2013; Nidhi et al. 2016).

In dehydration, the water amount in raw material was decreased to safe level in order to prevent microbiological proliferation as well as to extend product shelf-life. Herbal aromatic flowers could be stored in a long stability by air drying. Dried tea could be easily blended, powdered or packed for further applications (Albert and Joachim, 2007). Infrared dehydration revealed different advantages compared to traditional one. Infrared heating used strong convection (Nowak & Lewicki, 2005). Infrared energy was transferred from hot air to sample, heating the material thoroughly. Moisture evaporated from the irradiated surface and drying time reduced (Nowak & Lewicki, 2004). The dehydration

reduced moisture content inside flowers to a point at which biochemical reactions were minimized while maintaining cell structure, pigment level and flower shape (Singh and Dhaduk, 2005). Dry flowers are economically important because fresh flowers are short lived and will retain only for few days or week while dry material will last indefinitely may be up to months or years. The demand of dry flowers is increasing day by day (Shailza et al. 2018). Their freshness and beauty is lost due to various biochemical changes and microbial activities. Purpose of our study examined the influence of infrared drying variables to quality attributes of dried flamboyant (*Delonixregia*) flower tea. Flamboyant (*Delonixregia*) is a large ornamental tree with fern-like bipinnately compound leaves and attractive red peacock flowers. Its flower is actinomorphic or somewhat irregular, slightly fragrant (Nidhi et al. 2016). Its flowers contain a rich source of β -sitosterol, galactomannon, tannins, saponins, flavonoids, steroids, alkaloids and carotene hydrocarbons. These phytochemical constituents can affect the enzyme involved in the activation and detoxification of xenobiotics including carcinogens (Shanmukhaet al. 2011). They possess insecticidal, antioxidant, hepatoprotective, gastroprotective, wound healing, antiarthritic, larvicidal, antimalarial, antifeedant, antiemetic, antibacterial, antifungal, antiinflammatory, antifertility, analgesic, anti diarrhoeal, antiheamolytic, diuretic, and anthelmintic activities (Deepa and Remadevi, 2011; Anuj et al. 2016). Aqueous extract of flowers is used for the dyeing of silk and cotton fabrics to obtain a bright reddish-brown hue which showed resistance to fading and as an additive in herbal sunscreen formulation (Vankar and Shanker, 2009; Divya et al. 2013; Karthika and Jayshree, 2013; Jayshree and Karthika, 2013).

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MATERIALS AND METHODS

Material

Flamboyant flowers were collected from SocTrang province, Vietnam. After collecting, they must be kept in dry cool cotton box, conveyed to laboratory for experiments. They were subjected to infrared drying under different conditions.

Researching method

Influence of infrared dehydration power (W) to the dried flamboyant flower quality

Fresh flamboyant flowers were dehydrated by infrared drying cabinet under different power (125, 150, 175, 200, 225 W) at temperature 50°C with air velocity 0.3 m/s. The dried flowers would be analyzed the total phenolic (mg GAE/100 g), flavonoid (mg CE/100 g), carotenoid (μ g/g) and overall acceptance (sensory score).

Influence of infrared dehydration temperature (°C) to the dried flamboyant flower quality

Fresh flamboyant flowers were dehydrated at power 175 W at different temperature (50°C, 55°C, 60°C, 65°C, 70°C) with air velocity 0.3 m/s. The dried flowers would be analyzed the total phenolic (mg GAE/100 g), flavonoid (mg CE/100 g), carotenoid (μ g/g) and overall acceptance (sensory score).

Influence of air velocity (m/s) in infrared dehydration to the dried flamboyant flower quality

Fresh flamboyant flowers were dehydrated at power 175 W, 60°C at different air velocity (0.3, 0.6, 0.9, 1.2, 1.5 m/s). The dried flowers would be analyzed the total phenolic (mg GAE/100 g),

flavonoid (mg CE/100 g), carotenoid (µg/g) and overall acceptance (sensory score).

Chemical and sensory analysis

Total phenolic content (mg GAE/100g) was determined through the HPLC method described by Cristina et al. (2015). Aluminum chloride colorimetric method was used for flavonoids (mg QE/100 g) quantification (Mandal et al. 2013). Carotenoid content (µg/g) was analyzed by HPLC (Chang HP et al. 2015). Sensory score was evaluated by a group of panelist using 9 point-Hedonic scale.

Statistical analysis

The experiments were run in triplicate with three different lots of samples. The data were presented as mean±standard deviation. Statistical analysis was performed by the Statgraphics Centurion version XVI.

RESULTS AND DISCUSSION

Influence of infrared dehydration power (W) to the dried flamboyant flower quality

Flamboyant flowers contain tannins, saponins, flavonoids, steroids, alkaloids, and caretenoids (Rahman et al. 2011; Kumar et al. 2013). In our research, fresh flamboyant flowers were dehydrated by infrared drying cabinet under different power (125, 150, 175, 200, 225 W) at temperature 40°C with air velocity 0.3 m/s. Results were showed in table 1. It's clearly noted that the optimal infrared dehydration power should be 175 W to preserve the best quality of dried flamboyant flower. So this value was selected for further experiments.

Influence of infrared dehydration temperature (°C) to the dried flamboyant flower quality

Veigas et al. (2007) have reported that antioxidant potential of *D. regia* may be related to the biochemical constituents in the flowers, viz., carotenoids (367 µg/g), anthocyanins (5.8 µg/g), and other polyphenolic compounds (33.5 mg/g). Temperature plays an important role in drying of flowers. Fresh flamboyant flowers were dehydrated at power 175 W at different temperature (50°C, 55°C, 60°C, 65°C, 70°C) with air velocity 0.3 m/s. Results were showed in table 2. It's clearly noted that the optimal infrared dehydration temperature should be 60°C to preserve the best quality of dried flamboyant flower. At higher temperature, the rate of transpiration was comparatively much higher. Diffusion pressure deficit of air increases with increase in temperature that stimulates diffusion and vaporization of internal moisture leading to high moisture loss (Shailza et al. 2018). Therefore 60°C was selected for further experiments. In another report, drying of Dutch rose flowers at 40°C by embedding in silica gel gave the best results for colour, texture and appearance (Safeena and Patil, 2006). Sharma et al. (2016) found that chincherinchee flowers embedded in silica gel kept at 50°C for 24 hours showed the maximum score for quality parameters. Singh et al (2004) reported that higher the temperature, faster was the dehydration as well as degradation of pigments viz; chlorophylls, carotenes, xanthophylls. Decrease of overall acceptance could be due to increase in temperature which caused liberation of moisture outside and also increased the concentration of the pigments following water loss.

Table 1: Influence of infrared dehydration power (W) to the dried flamboyant flower quality

Dehydration power (W)	125	150	175	200	225
Total phenolic (mg GAE/100g)	42.58±0.12 ^c	47.96±0.09 ^{bc}	59.45±0.15 ^a	54.12±0.06 ^{ab}	50.07±0.13 ^b
Total flavonoid (mg QE/100g)	19.49±0.04 ^c	21.33±0.07 ^{bc}	28.64±0.03 ^a	26.05±0.11 ^{ab}	23.31±0.08 ^b
Carotenoid (µg/g)	64.15±0.21 ^c	67.08±0.13 ^{bc}	79.33±0.27 ^a	74.18±0.10 ^{ab}	70.27±0.08 ^b
Sensory score	5.29±0.04 ^c	6.05±0.00 ^{bc}	7.26±0.03 ^a	6.95±0.05 ^{ab}	6.51±0.03 ^b

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant (α = 5%).

Table 2: Influence of infrared dehydration temperature (°C) to the dried flamboyant flower quality

Dehydration temperature (°C)	50	55	60	65	70
Total phenolic (mg GAE/100g)	59.45±0.15 ^b	62.18±0.28 ^{ab}	65.02±0.19 ^a	56.11±0.07 ^{bc}	52.09±0.16 ^c
Total flavonoid (mg QE/100g)	28.64±0.03 ^b	29.72±0.08 ^{ab}	33.16±0.11 ^a	20.43±0.05 ^c	13.31±0.09 ^d
Carotenoid (µg/g)	79.33±0.27 ^a	76.65±0.12 ^{ab}	72.23±0.31 ^b	69.83±0.14 ^{bc}	65.27±0.06 ^c
Sensory score	7.26±0.03 ^c	8.01±0.05 ^b	8.79±0.11 ^a	8.42±0.03 ^{ab}	7.69±0.08 ^{bc}

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant ($\alpha = 5\%$).

Table 3: Influence of air velocity (m/s) in infrared dehydration to the dried flamboyant flower quality

Air velocity (m/s)	0.3	0.6	0.9	1.2	1.5
Total phenolic (mg GAE/100g)	65.02±0.19 ^c	74.12±0.14 ^b	76.36±0.22 ^{ab}	79.13±0.17 ^a	80.02±0.08 ^a
Total flavonoid (mg QE/100g)	33.16±0.11 ^c	39.25±0.09 ^b	41.34±0.13 ^{ab}	43.69±0.04 ^a	43.85±0.15 ^a
Carotenoid (µg/g)	72.23±0.31 ^c	74.49±0.14 ^{bc}	76.25±0.24 ^b	79.07±0.19 ^{ab}	80.65±0.22 ^a
Sensory score	8.79±0.11 ^b	8.82±0.05 ^b	8.90±0.08 ^{ab}	8.93±0.16 ^a	8.95±0.09 ^a

Note: the values were expressed as the mean of three repetitions; the same characters (denoted above), the difference between them was not significant ($\alpha = 5\%$).

Influence of air velocity (m/s) in infrared dehydration to the dried flamboyant flower quality

Shabir et al. (2011) proved that flamboyant flowers contained total phenolic content (2.24 g GAE/100 g of dry weight) and total flavonoid content (0.81 g CE/100 g of dry weight). Fresh flamboyant flowers were dehydrated at power 175 W, 60°C at different air velocity (0.3, 0.6, 0.9, 1.2, 1.5 m/s). Results were showed in table 3. It's clearly noted that the optimal air velocity should be 1.2 m/s to preserve the best quality of dried flamboyant flower. The air velocity increasing reduced the drying duration and it is caused to increase the amount of phytochemical constituents. Raka and Tri (2017) found that the higher air temperature and velocity increased the evaporation rate. In another research, Saeidirad et al. (2014) proved that the best conditions for saffron flower drying were obtained at 50°C drying temperature and 0.5 m/s air velocity.

CONCLUSION

Flamboyant flowers contain rich source of potentially useful natural antioxidants like polyphenol and flavonoids. The fresh flamboyant flowers, though exquisite in their beauty, are expensive, short lived, sensitive to temperature and are available only during a particular season. In this research, we have successfully demonstrated that infrared dehydration is the best

method to have superior or better quality product.

CONFLICT OF INTEREST

The authors declared that present study was performed in absence of any conflict of interest.

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AUTHOR CONTRIBUTIONS

Nguyen Phuoc Minh arranged the experiments and also wrote the manuscript.

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