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RESEARCH ARTICLE

Development of Foam Dried Veld Grape Powder

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ABSTRACT

Veld grape (*Cissus quadrangularis*), a valuable medicinal plant native to India, is renowned for its nutritional benefits, containing substantial amounts of vitamin C, carotene, and anabolic steroidal substances. However, its widespread use has been hindered by the skin irritation caused by its peel and its seasonal availability. To preserve the heat-sensitive therapeutic compounds within Veld grape s, foam drying was identified as a promising processing technique. This method involves encapsulating the plant material in a foam matrix, protecting it from high temperatures and oxidative damage. After blanching and pulping, Veld grapes were foam-dried using a combination of soy protein (1%) and methylcellulose (0.5%) as foaming agents. The drying process was conducted at three different temperatures: 60°C, 70°C, and 80°C. The study comprehensively evaluated various aspects of the foam drying process, including foam properties, drying characteristics, quality parameters of the resulting powder, and associated costs. The results demonstrated that Veld grape powder produced at 60°C exhibited superior quality, with higher levels of key bioactive compounds and overall nutritional value. Moreover, foam drying proved to be a cost-effective method for producing Veld grape powder with a per kg production cost of Rs. 618.

Keywords: *Veld grape, Foam drying, Soy protein, Methylcellulose, medicinal plant powder*

INTRODUCTION

India, renowned as the "botanical garden of the world," boasts a rich biodiversity of medicinal plants. With over 45,000 plant species concentrated in regions like the Eastern Himalayas, Western Ghats, and Andaman & Nicobar Islands, India has a vast potential for medicinal herb production. While traditional practitioners utilize over 6,000 medicinal plants, only 3,000 are officially documented.

Ayurveda, the traditional Indian medicine system, has over 250,000 registered practitioners, serving 70% of the rural population. Medicinal plants contain phytochemicals with diverse health benefits, including anti-mutagenic, antioxidant, anti-carcinogenic, and immunomodulatory properties (Farmsworth and Bunyapraphatsara, 1992). The World Health Organization estimates that 80% of the developing world relies on traditional plant-based medicines (WHO, 2005). Many modern medicines are derived from medicinal plants, offering advantages like easy availability, fewer side effects, lower costs, environmental friendliness, and lasting curative properties.

India and China are global leaders in medicinal plant production, accounting for 40% of the world's biodiversity and rare species. These countries supply raw materials to the pharmaceutical, cosmetic, fragrance, and flavor industries. However, the integration of herbal plants into modern lifestyles is hindered by a lack of scientific data and understanding of their efficacy and usage. Standardization is crucial to ensure product quality and safety.

Veld grape (*Cissus quadrangularis*) is a common medicinal plant in India, known for its potential in treating various ailments. It contains phytochemicals

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like carotene, phytosterol, terpenoids, and β-sitosterol. In Ayurveda, Veld grape is used for conditions like osteoarthritis, rheumatoid arthritis, osteoporosis, asthma, burns, and wounds (Paulsen *et al*, 2007).

Preservation of medicinal plants is vital and has been carried out using traditional drying methods are used. However, foam drying is a suitable method for preserving heat-sensitive medicinal plants like Veld grape. It offers advantages over conventional drying methods, such as reduced drying time, minimal shrinkage, and better product quality. This study aims to investigate the physical properties of the Veld grape, a medicinal plant, and to evaluate the foam-drying process for preserving its nutritional and bioactive compounds.

MATERIAL AND METHODS

Veld grape

The study was conducted using freshly harvested Veld grape.

Chemicals used

Soy protein and Methylcellulose were purchased from Zenith Nutrition and DuPont in India.

Packaging Material

To pack the dried Veld grape powder Low Density Polyethylene (LDPE) packaging materials were purchased from Local market.

Physical Properties of Veld grape

The length and diameter of the Veld grape were measured using vernier calipers (Mitutoyo, Japan) having a least count of 0.1 mm.

Pulp content of Veld grape

After cleaning and washing, the fresh-harvested Veld grape was cut into small pieces using a sterilized knife. The skin was removed from the cut pieces to conduct further studies.The pulp (%) was calculated using Equation 1.

$$Pulp\ \% = \frac{W_1}{W_2} \times 100 \qquad 1$$

where,

$W1$ - Weight of pulp (g)

$W2$ - Weight of whole Veld grape (g)

Foam Density (FD) of the Veld grape Pulp

The density of the foamed Veld grape was determined in terms of weight by volume and represented as g/cm^3. Foam Density is calculated using equation 2.

$$FD = \frac{M_f}{V_f} \qquad 2$$

where,

M_f = Mass of foam (g)

V_f = Final volume of formed material (cm^3)

Many authors have used foam density as the main parameter to evaluate the quality of foam (Falade *et al*., 2012; Bag *et al*., 2011) particularly whipping properties. The more the air incorporated during whipping, the lower the FD.

Foam expansion of the Veld grape Pulp

Foam expansion was analyzed by putting 250 mL of Veld grape pulp in the beaker, adding foaming agents (1% soy protein and 0.5% methylcellulose), and beating the pulp for 20 min at high speed. The increase in volume was noted. The foam expansion of the foamed Veld grape was determined using equation 3.

$$FE = \frac{V_f - V_0}{V_0} \qquad 3$$

where,

V_f= Final volume of foamed material (mL)

V_0 = Initial volume of material (mL).

Foam stability of the Veld grape Pulp

Foam stability was analyzed by taking 100 mL of foamed pulp in the beaker and left for an hour. The volume after time interval was noted. The foam stability index is expressed as equation 4.

$$FS = \frac{V_0}{\Delta V / \Delta t} \qquad 4$$

where,

Δt - Change in volume of foam occurring during the time interval, Δt,

V_0 - Initial volume of foam directly after whipping (cm^3).

The foam stability is influenced by film thickness, mechanical strength, protein protein interactions and environmental factors such as pH and temperature.

Drying Procedure

The foamed Veld grape was spread uniformly in the tray with thickness of 2mm. Foamed Veld grape in trays were dried in a Tray dryer at 60°C, 70°C and 80°C. During the drying process, the weight of tray was recorded periodically. Drying was stopped when there was no significant reduction in weight. The dried Veld grape was scraped off and ground to fine powder.

Drying Characteristics of Veld grape powder

The moisture ratio of Veld grape powder during drying experiments was calculated using the following equation 5.

$$Moisture\ ratio, MR = \frac{M_i - M_e}{M_o - M_e} \quad 5$$

where,

M_i - Moisture content at any time, (% db.),

M_e - Equilibrium moisture content, (% db.) and

M_o - Initial moisture content (% db.).

The experiments were conducted for different drying conditions. The values of M_e computed were relatively small or negligible as compared to M_i or M_o. Therefore, the moisture ratio can calculated using the following equation 6.

$$Moisture\ ratio, MR = \frac{M_i}{M_o} \quad 6$$

The Drying rate was calculated by using the following equation 7.

$$Drying\ rate = \frac{dx}{dt} \quad 7$$

where,

dx - Change in moisture content (%),

dt - Time interval (hour).

Quality parameters of Veld grape powder

The quality parameters of the Veld grape powder dried using Foam Mat drying at three different temperatures (60°C, 70°C and 80°C) were analyzed. The quality parameters were analyzed as nutritional and functional parameters.

Nutritional Parameters

The Nutritional parameters of Veld grape powder dried at three different temperatures (60°C, 70°C and 80°C) using Foam Mat Drying were analyzed. The nutritional parameters like Moisture, Fat, Protein, Fiber, Ash, Carbohydrates, Antioxidant activity and Ascorbic acid were analyzed for Veld grape powder.

Estimation of Moisture content of Veld grape powder

It was worked out by weighing 5 g sample accurately and subjected to oven drying at 110°C for 4 to 5 h. Oven dried samples were cooled in desiccators and weighed. The drying was repeated until the constant weights were obtained. The resultant loss in weight was calculated as percent moisture content (Sharon *et al*., 2015).

Nutritional Quality Parameters of Veld grape powder

The quality parameters like pH, Acidity, Moisture, Protein, Fat, Crude Fiber, Ash, Ascorbic Acid and Antioxidant Activity sensory were analysed as per standard Association of Official Analytical Chemists protocol (Anitha *et al*., 2023).

Functional Parameters of Veld grape powder

The functional parameters of the Veld grape powder dried using Foam Mat Drying at three different temperatures (60°C, 70°C and 80°C) were analyzed. The functional parameters like Total yield, Carr's index, Hausner's index, Rehydration Ratio and Dehydration Ratio were analyzed.

Estimation of total yield of Veld grape powder

The total yield was determined by calculating the percentage of powder obtained with respect to the quantity of Veld grape taken (Karadbhajne *et al*., 2014). The total yield of the Veld grape powder was calculated using the following equation: 8.

$$Yield\ of\ Pirandai\ Powder\ (\%) = \frac{W_s}{W_p} \times 100 \quad 8$$

where,

W_s - Weight of (g)

W_p - Weight of powder (g)

Estimation of Bulk Density and Tapped Density of Veld grape powder

Veld grape powder (30 g) was filled into the 100 mL measuring cylinder with the aid of a funnel without any losses. The initial volume was noted and the sample was then tapped until no further reduction in volume was noted. The initial volume gave the bulk density value and after tapping the volume reduced, giving the value of tapped density.

Estimation of Carr's Index of Veld grape powder

Carr's index has been used as an indirect method of quantifying powder flow ability from bulk density; this method was developed by Carr. The percentage compressibility of a powder is a direct measure of the potential powder arch or bridge strength and stability, and is calculated according to equation 9.

$$Carr's\ index\ (\%\ Compressibilty) = 100 \times \left[1 - \frac{D_b}{D_t}\right] \quad 9$$

where,

D_b - Bulk density (g/cm^3)

D_t - Tapped density (g/cm^3)

Estimation of Hausner's ratio of Veld grape powder

Hausner's ratio has also been used as an indirect method of quantifying powder flow ability from bulk density. The Hausner's ratio was calculated by using the following equation 10.

$$Hausner's\ ratio = \frac{D_t}{D_b} \quad 10$$

Estimation of Rehydration ratio and Dehydration ratio of Veld grape powder

The dehydration ratio was determined as the ratio of the weight of the sample before drying to the dried weight of the sample. Whereas rehydration ratio was determined as the ratio of the weight of the rehydrated sample to that of dehydrated sample. Rehydration Ratio was analyzed by taking 1g of Veld grape powder in 80 mL distilled water and boil it for 30 s then filter it using Whatmann filter paper. The rehydration ratio and dehydration ratio were calculated by using the equation 11 and 12 respectively.

$$Dehydration\ ratio = \frac{W}{W_D} \quad 11$$

$$Rehydration\ ratio = \frac{W_r}{W_D} \quad 12$$

where,

W - weight of the sample before drying (g)

W_D - weight of the sample after drying (g)

W_r - Rehydrated sample weight (g).

Cost Analysis

The cost of production of Veld grape powder was calculated as per standard protocol.

Statistical analysis of Veld grape powder

The statistical analysis of the data has been done with Microsoft Excel - 2020. The values were expressed as means and standard deviation (SD). The mean values of each of the attributes under study obtained from duplicate samples of six replications were subjected to statistical analysis.

RESULTS AND DISCUSSION

Physical properties of Veld grape

The Veld grape was observed for different physical properties with respect to length, width and thickness. The results pertaining to physical properties are presented in Table 1.

Table 1. Physical Properties of Veld grape

S. No.	Parameter	Observations
1	Length (mm)	60.12 ± 0.32
2	Width (mm)	1.2 ± 0.12
3	Thickness (mm)	1.6 ± 0.28

The study showed that the plant was very long, green, thick, fleshy and like a succulent cactus. Three variants of Veld grape were reported to have square, med round med and flat in shape. They were four angled with four thick and long wings are central part of the plant (Vijayalakshmi *et al*, 2013).

Foam Properties of Veld grape Pulp

Higher FD (Foam Density) results in prolonged drying time leading to poor product quality caused by thermal degradation. Numerous studies indicated that higher foam density in the range of 0.2 to 0.6 g cm^3 is suitable for foam drying.

Table 2. Foaming properties and yield percentage of Veld grape pulp

S. No.	Properties	Values
1	Foam Density (g/cm^3)	0.245±0.15
2	Foam expansion (%)	25.55±0.45
3	Foam Stability (%)	91.83±0.29
4	Pulp (%)	84.15±0.18

Drying Characteristics of Veld grape powder

The Drying Characteristics of Veld grape powder was studied at three different temperatures (60°C, 70°C and 80°C). The drying rate and moisture ratio of the Veld grape powder dried at 60°C was shown in the Fig.1. It shows that the drying occurs only in the falling rate period. The drying time is 11.50 hours for 60°C. The moisture ratio decreases with increase in drying time.

The drying rate and moisture ratio of the Veld grape powder dried at 70°C was shown in Fig. 2. The curve shows that the drying occurs in the falling rate period.

The drying time for 70°C is 10.5 hours. The Moisture ratio decreases with increase in drying time.

The drying rate and moisture ratio of the Veld grape powder dried at 80°C was shown in Fig. 3. The curve shows that the drying occurs in the constant rate period and falling rate period. The drying time for 80°C is 7.5 hours. The Moisture ratio decreases with increase in drying time.

The graphical representation of the drying pattern of Veld grape was performed. It was clear that the rise in the temperature resulted in the acceleration of the rate of the drying process. It was observed that moisture ratio reduced with drying time and the curve was steeper decreasing with the rise in the operating temperature. Constant drying rate was observed only in the temperature of 80°C. At 70°C and 60°C, the drying occurs in the falling rate period.

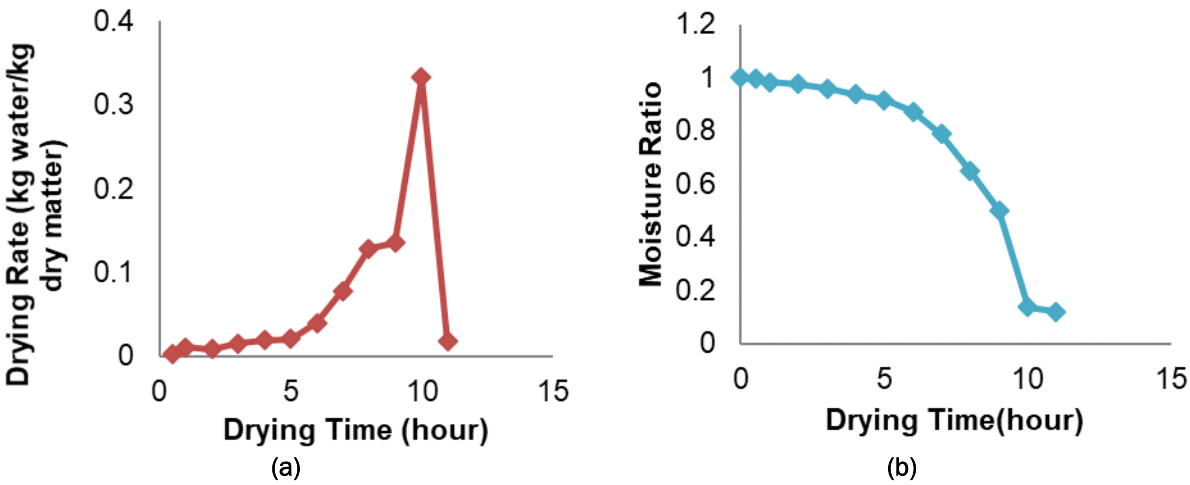

Fig. 1 Effect of drying at 60°C on (a) Drying Rate and (b) Moisture Ratio

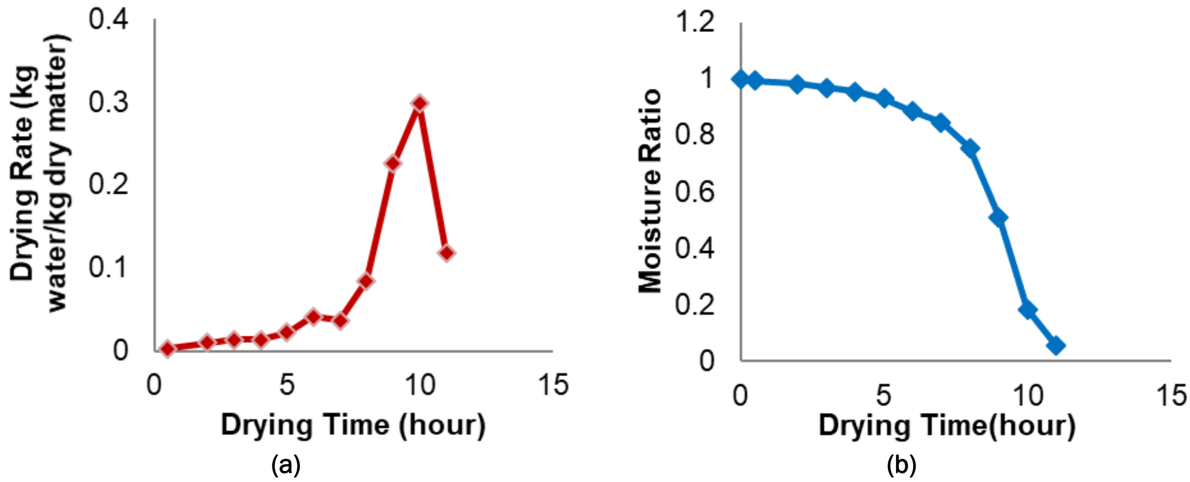

Fig. 2 Effect of drying at 70°C on (a) Drying Rate and (b) Moisture Ratio

Quality Parameters of Veld grape powder

The moisture content of Veld grape powder dried at 60°C, 70°C and 80°C are shown in Fig. 4(a). The moisture content of Veld grape powder decreased with an increase in temperature. This may be due to some bound water in the sample dried at low temperature. The Moisture content of the Veld grape powder dried at 60°C, 70°C and 80°C were 6.26 ± 0.13%, 6.17 ± 0.07% and 6.09 ± 0.12% respectively.

The fat content of Veld grape powder dried at 60°C, 70°C and 80°C are shown in Fig. 4(b). The fat content decreased with an increase in temperature. The fat content of the Veld grape powder dried at 60°C,

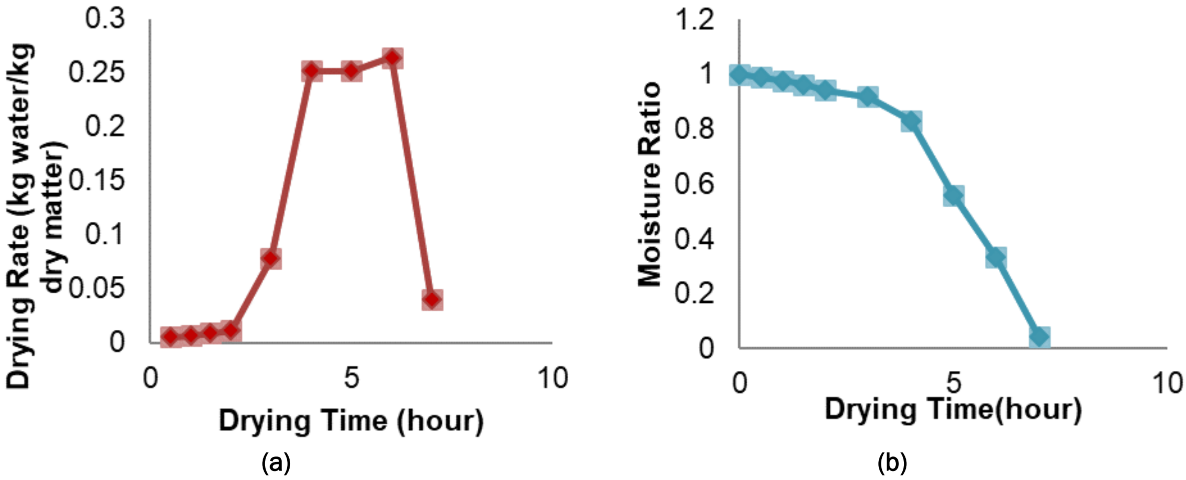

Fig. 3 Effect of drying at 80°C on (a) Drying Rate and (b) Moisture Ratio

70°C and 80°C were 14.61 ± 0.23%, 14.58 ± 0.14% and 14.56 ± 0.12% respectively. Fats and oils are concentrated sources of energy. Fat is used in transport and absorption of the fat soluble vitamins. So, the efficacy of a particular medicinal herb depends on its chemical constituents either organic of inorganic or on a combined effect.

The protein content of Veld grape powder dried at 60°C, 70°C and 80°C are shown in Fig. 4(c). The protein content increased with increase in temperature. The protein content of the Veld grape powder dried at 60°C, 70°C and 80°C were 16.46 ± 0.16%, 16.50 ± 0.24% and 16.54 ± 0.15% respectively. The results show that the protein content of Veld grape powder was higher. Dietary proteins supply raw materials for the formation of digestive juice, hormones, plasma proteins, haemoglobin, Hormones, plasma proteins, haemoglobin, Vitamins, and enzymes.

The fiber content of Veld grape powder dried at 60°C, 70°C and 80°C are shown in Fig. 4(d). The increase in drying air temperature decreased the crude fiber content of Veld grape powder. The fiber content of the Veld grape powder dried at 60°C, 70°C and 80°C were 3.55 ± 0.91%, 3.43 ± 0.10% and 3.25 ± 0.29% respectively.

Ash content is the mineral matter in the Veld grape powder. From the Fig. 4(e) an increase in the total ash content of foam dried Veld grape powder with an increase in drying air temperature is observed. The ash content of the Veld grape powder dried at 60°C, 70°C and 80°C were 18.18 ± 0.15%, 18.31 ± 0.32% and 18.37 ± 0.43% respectively.

The Carbohydrate content of Veld grape powder dried at 60°C, 70°C and 80°C are shown in Fig. 4(f)). The Carbohydrate decreases with increase in temperature. The Carbohydrate content of the Veld grape powder dried at 60°C, 70°C and 80°C were 44.79 ± 0.10%, 44.72 ± 0.32% and 44.69 ± 0.36% respectively. Carbohydrates supply energy for the immediate use of the body.

The antioxidant activity of foam mat dried powder at 60°C, 70°C and 80°C were 85.54 ± 0.65%, 77.70 ± 0.37% and 68.94 ± 0.05% respectively. From Fig. 5(a), it was clear that the antioxidant activity decreases when temperature increases.

The ascorbic acid content of Veld grape powder dried at 60°C, 70°C and 80°C are shown in Fig. 5(b). The loss in ascorbic acid content increased with increase in drying temperature. The vitamin C or ascorbic acid content of foam mat dried powder at 60°C, 70°C and 80°C were 1.48 ± 0.11mg/100g, 1.23 ± 0.04mg/100g and 1.07 ± 0.50mg/100g respectively.

The higher dehydration ratio of Veld grape powder may be due to the formation of higher percentage of foam volume and subsequent increase in surface area and easy moisture removal during dehydration. The increase in rehydration ratio of foam mat dried Veld grape powder may be due to the formation of a honeycomb structure during foaming and increased surface area with micron level thickness of foam, which absorbs water quickly. Fig. 7(a) and (b) show an increase in drying temperature decreases the rehydration ratio

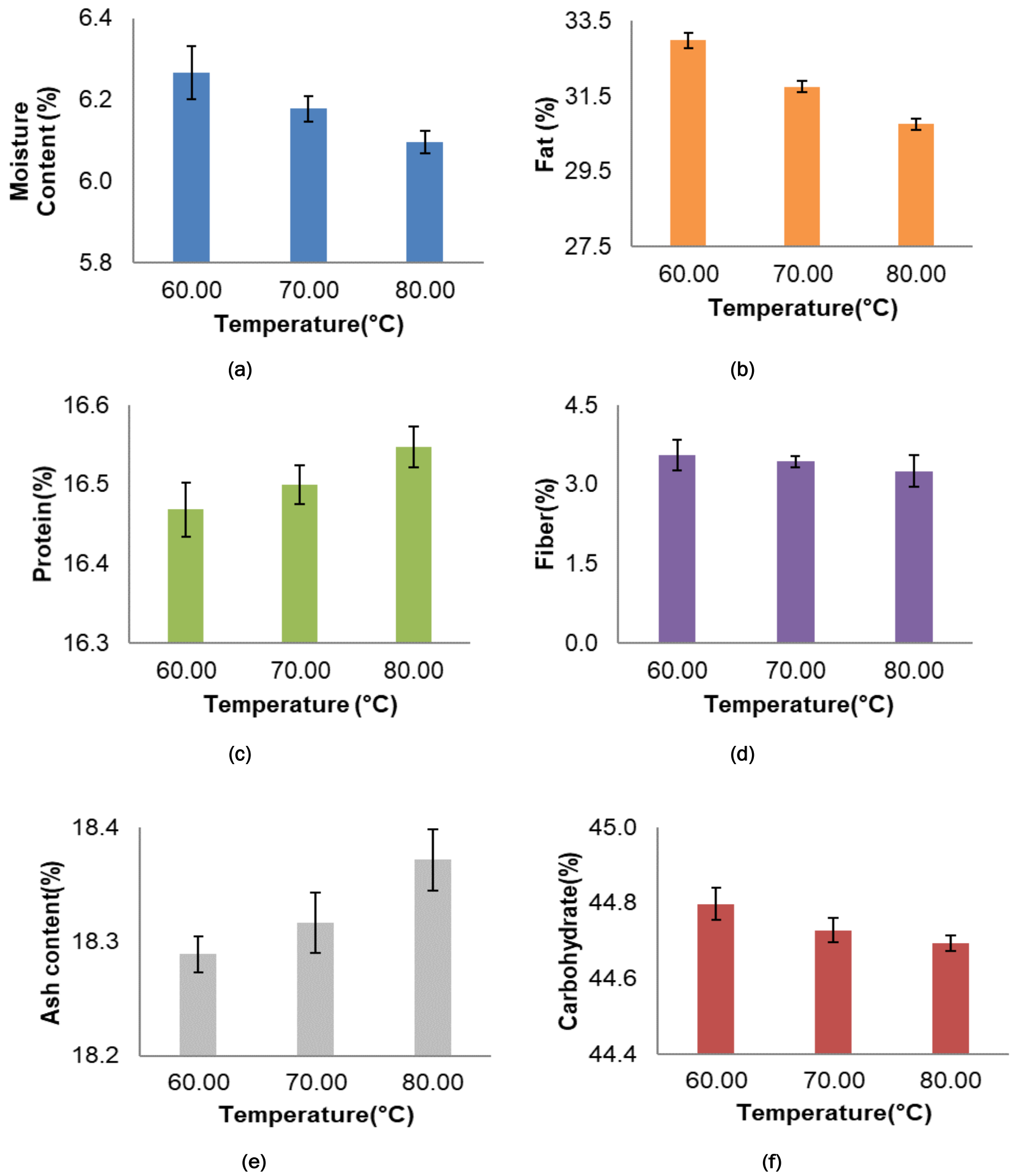

Fig. 4 Effect of different drying temperatures (60°C, 70°C and 80°C) on (a) Moisture Content (%) (b) Fat content (%) (c) Protein content (%) (d) Fiber content (%), (e) Ash content (%) and (f) Carbohydrate content (%)

and dehydration ratio. The Rehydration ratio and dehydration ratio of the Veld grape powder dried at 60°C, 70°C and 80°C were 16.59±0.31, 15.53±0.26 and 15.47±0.36 and 12.33±0.35, 12.10±0.26 and 12.00±0.39 respectively.

Carr's index of less than 10 and Hausner's ratio of 1.00-1.11 were considered excellent flow ability. Powders with Hausner's ratios of 1.12-1.18 have good flow ability. The carr's index and Hausner's ratio were independent of drying temperature. Fig. 6(c) and 6(d) shows that the Carr's index and Hausner's index of the Veld grape powder drired at 60°C, 70°C and 80°C were 9.66 ± 0.33, 9.96 ± 0.40 and 10.02 ± 0.04 and 1.00 ± 0.03, 1.13 ± 0.16 and 1.15 ± 0.40 respectively. Therefore, the foam mat dried powder has excellent flowability.

The cost of production of 1 kg powder of Veld grape powder produced using Foam Mat Drying is found to be Rs.618.09. The market rate of Veld grape powder per kg was Rs.1400. There is no significant profit occurs in the first year of Production. A reduction in cost of Production may be possible in the subsequent years.

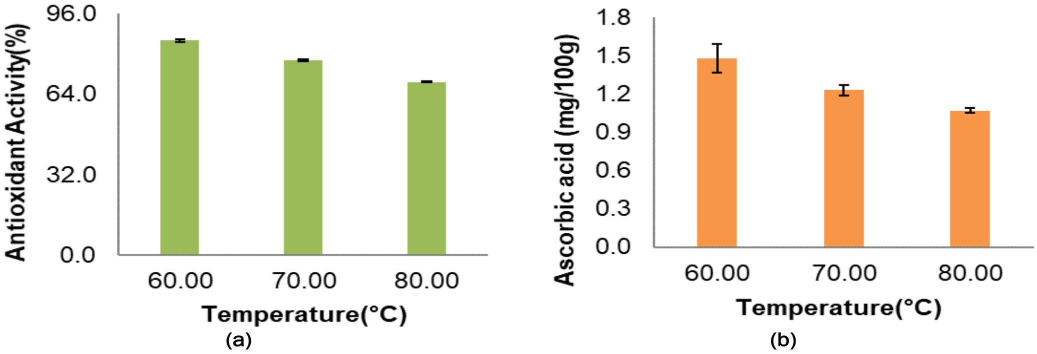

Fig. 5 Effect of different drying temperatures (60°C, 70°C and 80°C) on (a) Antioxidant activity (%) and (b) Ascorbic acid (mg/100g)

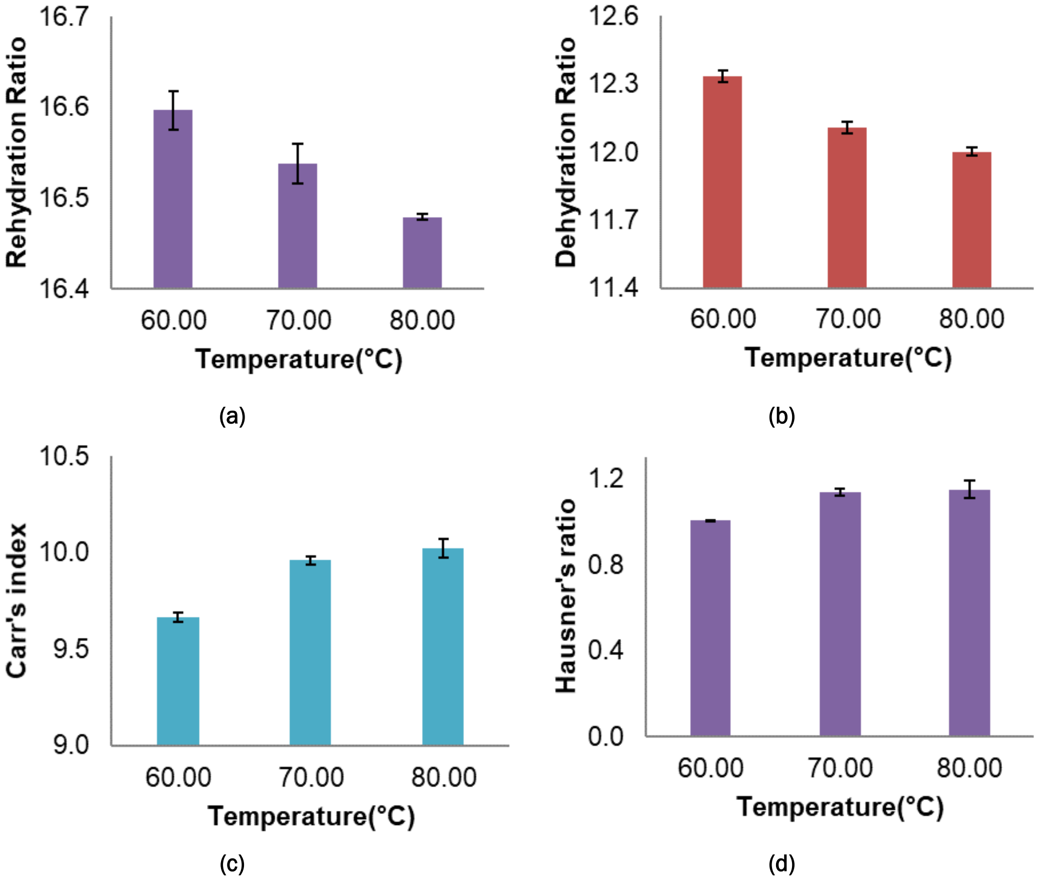

Fig. 6 Effect of different drying temperatures (60°C, 70°C and 80°C) on (a) Rehydration Ratio (b) Dehydration Ratio, (c) Carr's index and (d) Hausner's ratio

CONCLUSION

The Veld grape powder dried using Foam Drying at 60°C has higher Fat content, Fiber content, Carbohydrate content, Antioxidant activity, Ascorbic acid, Rehydration and Dehydration ratio, Carr's index, Hausner's ratio, and Yield percentage than the Veld grape powder dried using Foam Drying at 70°C and 80°C. Therefore, the Veld grape powder dried using Foam Drying at 60°C is more efficient than the Veld grape powder dried using Foam Drying at 70°C and 80°C.

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