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Original research

Beverage powder based on Shahani grape pomace extract: Physicochemical properties of foam-mat freeze-dried and spray-dried powders

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ABSTRACT

In this study physicochemical properties of foam-mat freeze-dried and spray-dried powders of Shahani grape pomace were investigated. DPPH radical scavenging activity (RSA), anthocyanin and polyphenol compounds in Shahani grape pomace extract (SPE) were 84%, 133 mg/100 mL and 957 mg GAE/g; respectively. The effect of Maltodextrin (MD) and Arabic gum (AG) as foam stabilizers and carriers were evaluated. The foam stabilizers improved foam properties in expansion, density, and stability. According to the results, foam-mat freeze-dried (FMFD) powders had higher amounts of anthocyanin, total phenolic content, RSA, Carr's index, degree of caking, solubility, hygroscopicity as well as tapped and particle density in comparison to spray-dried (SD) powders. However, the FMFD powders had lower cohesiveness in comparison to SD powders. According to the results, the addition of MD and AG has led to some improvements in the quality properties of Shahani grape pomace beverage powder, and freeze drying was determined as the more suitable method for production of the beverage powder based on SPE.

Keywords: Grape pomace; Arabic gum; Maltodextrin; Spray-drying; Foam-mat freeze-drying

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1. Introduction

Grape (*Vitis vinifera*) is considered a nutritious food and a rich source of bioactive compounds. Different varieties of this fruit are widely cultivated worldwide and consumed. Peel, pulp, and seeds are constituent components of grapes, with chemical composition dependent on grape species and variety, the climate of the cultivation area, and processing factors. Grapes contain different phytochemicals, such as polyphenols, that function as antioxidants, anti-inflammatory, cardioprotective, anticarcinogenic, and neuroprotective activities (Gomes et al., 2019). According to FAO (2020), about 1945930 tons of grapes were produced in Iran, and the area under cultivation of grapes was 155203 ha (FAO, 2020). Grape juice is produced via the pressing of grapes, and the residual grape marc, also known as grape pomace, is obtained. Grape pomace produced through grape juice production is immediately discarded. Besides, in the filtration and stabilization steps, additional residues are removed from grape juice (Spigno et al., 2017). Small pieces of stalk, seeds, skin, and some amounts of pulp are components of the grape pomace. However, pomace is a biodegradable food by-product, and its disposal causes in triggering massive industrial waste poses some environmental problems (Theagarajan et al., 2019). Grape pomace considers a source of bioactive compounds. Shahani grape variety (*Vitis Vinifera L.*) mainly include phenolic compounds, anthocyanins, flavonols, flavan-3-ols, and phenolic acids (Goula et al., 2016). Malvidin, cyaniding, petunidin, delphinidin, and peonidin are some of the most abundant anthocyanin aglycones. Anthocyanins aglycones are glycosidically linked to sugars in the C-3 position of the anthocyanidin. Anthocyanins are pigments liable for the red color of grape skin and are produced during the ripening of this fruit (Kedage et al., 2007). Grape pomace is mainly characterized by two fractions: (I) seedless pomace (containing skin, residual pulp, and some stems) and (II) the seeds (Bordiga et al., 2019). These agro-industrial by-products are mainly used as animal feed, distillation, compost, or buried in the soil, causing some problems for the environment. These components gained increasing attention for use in value-added products (Valls et al., 2017). The possibility of adding grape pomace powder to

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different products such as pasta, tea infusion, tomato puree, snacks, biscuits, cookies, and other products has been evaluated (Marchiani et al., 2016).

Due to the high moisture content, grape pomace is highly prone to spoil (Goula et al., 2016). Drying is one of the best ways to preserve food products (Qadri et al., 2020). Foam-mat drying is an excellent method of producing powdered food products. The process of foam-mat drying is described as the alteration of liquid or semi-liquid foods into stable foams using foaming agents and stabilizing additives, followed by intense agitation and drying (Hajiaghaei and Sharifi, 2022). Foam-mat freeze-drying is a process that involves the freeze-drying of food foams (Qadri et al., 2020). The spray drying process involves contacting hot air with atomized concentrated liquid or slurry, then separating the produced powdered product (Sharifi et al., 2015). Foam properties significantly impact the physicochemical properties of powders produced in the foam-mat drying process (Gao et al., 2022). Low dextrose equivalent (DE) maltodextrin is a low-cost ingredient suitable for providing dried powders with good physical properties due to the high glass transition temperature (Franceschinis et al., 2014). High-molecular weight drying aids such as maltodextrin and Arabic gum reduce the stickiness of powder (Seerangurayar et al., 2018).

Several types of research have been conducted in the field of foam-mat drying. To the best of our knowledge, no information is present about the production of beverage powder based on Shahani grape pomace via spray-drying and foam-mat freeze-drying methods. This study aims to (1) production of beverage powder based on grape pomace extract via foam-mat freeze-drying and spray-drying and (2) investigate the effect of these methods and foam stabilizers and carriers, i.e., maltodextrin and Arabic gum on the physicochemical attributes of produced powders.

2. Material and Methods

The grape pomace was obtained from the Shahani grape variety (*Vitis Vinifera Linné* Subsp. *Vinifera*), locally harvested in the summer of 2022 from vineyards in Qazvin province, Iran. The grape pomace was prepared after grape juice processing, followed by the separation of seeds. Maltodextrin (MD, DE 12), albumin powder, Folin-Ciocalteu reagent, sodium carbonate, gallic acid, chloridric acid, 2,2- diphenyl-1-picrylhydrazyl (DPPH), petroleum ether, methanol, and ethanol were purchased from merk (Darmstadt, Germany), and Arabic gum was acquired from Sigma-Aldrich (St. Louis, MO, USA).

Grape pomace was dried using a vacuum drying oven (Behdad, Iran) at 45 ℃ for 4-5 hours, powdered with a blender (Moulinex, Germany), and sieved (35 mesh) to obtain uniform particles. The pomace powder was put into dark glasses and kept at -18 ℃ for further analysis. Shahani grape pomace extract (SPE) was extracted using the method of Rajaei et al. (2010) with some modifications. Briefly, the SPE was prepared using the ratio of 1:8 pomace powder to water (w/v) in an ultrasonic water bath (Technology- Up200h, Germany) operating at a frequency of 35 kHz for 15 min at 55℃. The prepared extract was separated from the solids using a vacuum pump (KNF N838.3KT.45.18, Germany) and filter papers (Whatman No.5, Wallingford, UK).

2.1. Extract analysis

2.1.1. Total anthocyanin content (TAC)

The TAC of the extract was determined by the spectrophotometric pH differential method (Sharifi and Khoshnoudi-Nia, 2022). A total amount of 0.1 g extract was added to the 10 ml acidic methanol. After centrifugation at 6000 rpm for 15 min, the supernatant was incubated in a dark place for 24 h. The absorbance of the solution was read at 510 and 700 nm using a UV/Visible spectrophotometer (Perkin Elmer, Inc., USA, model: Lambda 35). TAC of the extract was calculated using equation (1) and expressed as mg cyaniding 3-Glucoside equivalent per 100 mL of extract:

$$TAC\ (mg\ /100\ mL) = A \times MW \times DF \times 1000/\varepsilon \times L \qquad (1)$$

Where A is the difference of absorbance of anthocyanin, calculated as (A510 nm-A700 nm) pH_1 - (A510 nm-A700 nm) $pH_{4.5}$, MW is the molecular weight of Cyanidin 3-Glucoside (449.2 $gmol^{-1}$), DF is the dilution factor, L is the path length of the cell (1cm), and ε is the cyanidin 3-Glucoside molar absorptivity (26900 $Lmol^{-1}$ cm^{-1}).

2.1.2. Total phenolic content (TPC)

The TPC of the extract was determined using the method of Zareei et al. (2019) with some modifications. Briefly, 1 ml of extract was added to 9 ml distilled water and 1 ml Folin-Ciocalteu reagent. After 5 min, sodium carbonate (7%) solution was added to the mixture and incubated for 60 minutes at room temperature. The sample's absorption at 725 nm was read in a spectrophotometer against a blank. The blank sample was prepared without extract. The TPC in the extract was reported as Gallic acid equivalent (GAE)/ g of sample (wet weight). A standard curve was used for the determination of TPC.

2.1.3. DPPH radical scavenging activity (RSA)

The RSA of the extract was determined according to the method described by Kalantari et al. (2020) with a brief modification. Briefly, 50 ml extract was mixed with 1 ml methanolic solution of DPPH (1,1-diphenyl-2-picryhydrazyl) (0.2 mM). The mixture was incubated for 30 min at room temperature in a dark place, followed by a vortex for 1 min. The reduction of adsorption at 517 nm was read in a UV/Visible spectrophotometer and calculated using equation (2). Methanol was used as the blank sample.

$$(\text{RSA}\%) = \left(1 - \frac{Sample\ adsorption}{Blank\ adsorption}\right) \times 100 \qquad (2)$$

2.2. Drying processes

Preparation of foam for foam-mat freeze-drying based on Shahani grape pomace extract (SPE) was done using albumin powder as a foaming agent at a constant level of 3% (w/w) and a mixture of Arabic gum (AG) and Maltodextrin (MD) as foam stabilizers at different levels, followed by mixing using a mixer (IKA LABORTECHNIK, Germany) for 8 minutes. AG and MD used for spray-drying just as carrier.

The drying process of samples was done via two different methods: foam-mat freeze-drying and spray-drying. To this purpose, different percentages of AG and MD were tested, and some of the more compatible formulations for each drying method were taken for further analysis. Results showed that the preferred formulations for foam-mat freeze-drying were 7.5% MD+7.5% AG and 15%

MD+15% AG, and those for spray-drying was determined as 8% MD+8% AG, 12% MD+4% AG, 4% MD+12% AG. Samples produced in foam-mat freeze-drying and spray-drying methods are labeled as FMFD and SD, respectively. The control sample (without MD and AG) was produced via foam-mat freeze-drying. Produce control sample of SD without MD and AG was not possible.

In order to foam-mat freeze-drying, a roughly 1 cm layer of foam was spread on glass plates and kept at -70°C in a deep freezer for 24 h. The drying process was conducted in a freeze dryer (Zist Farayand Tajhiz Sahand, Iran) for 24 hours at -50°C and a vacuum chamber pressure of 190 mtorr (Hajiaghaei and Sharifi, 2022). The dried foams were grounded and sieved (60 mesh).

To perform the samples for spray-drying process, SPE with carriers were spray-dried in a BUCHI Mini Spray Dryer (B-290, Switzerland) at an air inlet temperature of 160°C, the outlet temperature of 90°C, and feed volumetric flow rate of 0.3-1.1 ml/s (Sharifi et al., 2015).

The prepared powders resulting from these two approaches were kept in the dark glasses at 4°C. Samples were labeled as control, 7.5% MD+7.5% AG: FMFD, 15% MD+15% AG: FMFD; 8% MD+8% AG: SD, 12% MD+4% AG: SD, 4% MD+4% AG: SD.

2.3. Experiments of powders

2.3.1. Moisture content

Approximately 2 grams of the powder samples were put into Petri dishes and dried in an oven (Binder, USA) at 105°C for 3h. The moisture content was evaluated using differences between the weight of samples before and after drying (Eq. 3) (Affandi et al., 2017):

$$\text{Moisture (\%)} = \frac{W_2 - W_3}{W_2 - W_1} \times 100 \quad (3)$$

Where W_1 = weight of the wet plate (g), W_2 = weight of wet plate containing wet sample (g), and W_3 = weight of plate containing sample after drying (g)

2.3.2. Solubility

The solubility of powders was determined using the method of Seerangurayar et al. (2018). An approximate amount of 1 gram of powder was added to 10 ml of distilled water, followed by stirring using a magnetic stirrer for 10 min. After keeping it for 30 min at 37°C, the solution was centrifuged (model: Hermle Z 323 K, Hermle Labortechnik GmbH, Germany) at 3500 rpm for 15 min. The supernatant was dried in an oven at 105°C, and the solubility was determined using equation (4).

$$Solubility\ (\%) = \frac{m_2}{m_1} \times 100 \quad (4)$$

Where m_1 is the weight of the dried supernatant (g), and m_2 is the weight of the initial sample (1 g).

2.3.3. Hygroscopicity

The hygroscopicity was measured using the method of Samyor (2017) with some modifications. About 1 g of powder was put into a petri dish of 9 cm diameter and placed in a sealed desiccator containing the super saturated salt solution of NaCl (75% RH) and kept at 25°C. The Petri dishes were weight in regular periods, and after reaching a constant weight, the hygroscopicity was evaluated using equation (5).

$$\text{Hygroscopicity} = \left(\frac{b + H}{a - H}\right) \times 100 \quad (5)$$

Where a is the primary weight of powder (g), b is the amount of increase in weight of powders (g), and H is the primary moisture content of powder (1 g).

2.3.4. Degree of caking

Caking degree of powders was determined according to the method explained by Seerangurayar et al. (2018). After evaluating the hygroscopicity, the wet powders were placed into the oven at 105°C and dried for one hour. After cooling, samples were weight and sieved for 5 min. The weight of the powder that remained on the surface of the sieve was measured. Caking degree was determined as follows:

$$Caking\ degre = \frac{mass\ of\ powder\ remained\ on\ the\ seive\ (g)}{Initial\ weight\ of\ the\ seived\ powder\ (g)} \times 100 \quad (6)$$

2.3.5. Bulk and tapped density

The bulk density of powders was determined by putting 1 g of beverage powder into a graduated cylinder without tapping the cylinder, followed by measuring the volume of powders (Eq. 7). The cylinder containing powder was tapped 15 times from a height of about 10 cm, and the volume of powder was recorded (Jinapong et al., 2008). The tapped density was calculated following Equation (8).

$$\rho Bulk = \frac{mass\ of\ powder\ (g)}{volume\ of\ powder\ (cm^3)} \quad (7)$$

$$\rho Tapped = \frac{mass\ of\ powder\ (g)}{volume\ of\ tapped\ powder\ (cm^3)} \quad (8)$$

2.3.6. Particle density

About 1 g of powder was placed into a 10 ml graduated cylinder, followed by adding 5 ml petroleum ether. The tube was shaken for some seconds to ensure the complete suspension of particles. To rinse the lumps of powders probably attached to the wall of the cylinder, 1 ml of additional petroleum was added. The total volume of the mixture was taken, and the particle density (g/cm^3) was determined as follows (Jinapong et al., 2008):

$$\rho Particle = \frac{weight\ of\ powder\ (g)}{Total\ volume\ of\ suspended\ particles\ and\ petroleum\ ether\ (mL) - 6} \quad (9)$$

2.3.7. Cohesiveness and flowability of powders

The cohesiveness and flowability of powders were determined in terms of the Hausner ratio (HR) and Carr's index (CI), respectively. The cohesiveness of powders was determined by

dividing the tapped density by the bulk density. The CI was determined according to equation (10) (Jinapong et al., 2008).

$$CI = \frac{\rho Tapped - \rho Bulk}{\rho Tapped} \times 100 \quad (10)$$

2.3.8. Total anthocyanin content (TAC)

The TAC of powders was determined by the spectrophotometric method based on the pH differential approach (Hajiaghaei and Sharifi, 2022). TAC was calculated using Eq. (1) and expressed as mg cyaniding 3-Glucoside equivalent 100 mL.

2.3.9. Total phenolic content (TPC)

The TPC was determined in accordance Folin–Ciocalteau method. The absorbance was calculated at 765 nm by a spectrophotometer (UV/visible, Shimadzu, Japan) and the results were expressed in terms of mg Gallic Acid Equivalents per gram of sample (mg GAE/100 mL) (Seerangurayar et al. 2018).

2.3.10. DPPH radical scavenging activity (RSA)

The RSA of powders was determined as the ability of the powder to scavenge free radicals of DPPH, followed by the method described by Kalantari et al. (2020) (Eq. 2).

2.4. Statistical analysis

This research was done as a complete randomized design project using the statistical analysis software (SAS) (9.2, USA). An analysis of variance was used for statistical analysis, and a comparison of means was done using the Duncan test (α=0.05) at three replications.

3. Results and Discussion

3.1. Extracts analysis

Results showed DPPH radical scavenging activity, anthocyanin and polyphenol compounds in Shahani grape pomace extract (SPE) were 84%, 133 mg/100mL and 957 mg GAE/g; respectively.

3.2. Powder properties

3.2.1. Moisture content

Statistical analysis showed that adding Arabic gum (AG) and Maltodextrin (MD) decreased the moisture content of Freeze-dried powders (Table 1). The most and the least moisture content of powders belonged to the control and the 8% MD+8% AG: SD, respectively. In the SD process, increasing the ratio of AG to MD has led to the elevation of moisture content compared to an equal ratio of MD and AG. In the FMFD process, although different percentages of carrier concentration had no significant effect on moisture content, it reduced the property compared with the control. The decreasing effect of carrier agent on moisture content was also reported in foam-mat drying of beetroot, quince fruit, and cinnamon extract instant beverage powder and freeze-dried mulberry powder (Hajiaghaei and Sharifi, 2022, Tchabo et al., 2018).

3.2.2. Solubility

The solubility of beverage powders based on SPE produced with various concentrations of foam stabilizes MD and AG, are presented in Table 1. According to the results, adding carrier agent increased the solubility of FMFD powders ($p \leq 0.05$). Increasing the concentration of carriers at various ratios also positively affected the solubility of SD powders. A similar trend was also reported in the Foam-mat freeze-drying of date powder (Seerangurayar et al., 2018).

3.2.3. Hygroscopicity

The hygroscopicity of samples is presented in Table 1. It is evident that the most and the least hygroscopicity belonged to 15% MD+15% AG: FMFD and 12% MD+4% AG: SD, respectively. The hygroscopicity of FMFD powders increased as the concentration of carriers increased ($p \leq 0.05$). According to Seerangurayar et al. (2018), as the hygroscopicity of powders increases, the free flow behavior decreases, and they become more sticky.

3.2.4. Degree of caking

Statistical analysis showed that adding MD and AG has led to a decrease in the degree of caking in FMFD powders ($p \leq 0.05$) (Table 1). The lowest amount of caking degree belonged to the 8% MD+8% AG: SD sample. Results showed that FMFD samples had a higher caking degree in comparison to SD samples. Caking of powders is defined as contacting and also interacting of some macro particles so that they become unable to have an independent transitional movement (Seerangurayar et al., 2018). The control sample had the highest degree of caking. A similar result was also reported by Seerangurayar et al. (2018) in foam-mat drying of date powder. The reduction of caking degree concomitant with increasing career concentration is attributed to the increase of glass transition temperature and equilibrium moisture level.

3.2.5. Bulk and tapped density

Density is an important parameter affecting powders' functional properties (Asokapandian et al., 2016). The most value of powder's bulk density in each method of drying belonged to the samples 7.5% MD+7.5% AG: FMFD and 12% MD+4% AG: SD (Table 2). Treatment 8% MD+8% AG: SD had the lowest bulk density among all the samples, even in comparison to the control sample ($p \leq 0.05$). Bulk density is a property related to the moisture content of particles (Jakubczyka et al., 2011).

3.2.6. Particle density

As presented in Table 2, FMFD powders had higher particle density in comparison to SD powders. The particle density of FMFD powders increased as the MD and AG concentration increased ($p \leq 0.05$). The most and the least particle density of powders belonged to the samples 15% MD+15% AG: FMFD and 8% MD+8% AG: SD, respectively.

3.2.7. Total anthocyanin content (TAC)

The fresh grape extract had a total anthocyanin content of 133 mg/100 mL. FMFD powders had significantly higher TAC in comparison to SD powders ($p \leq 0.05$) (Fig. 1).

Table 1. Physical properties of the beverage powders based on Shahani grape pomace extract (SPE).

Drying method	Treatments	Moisture content(%)	Solubility (%)	Hygroscopicity (%)	Degree of caking (%)
FMFD	Control	5.44±0.17^{a}	94.14±0.97^{b}	10.52±0.47^{c}	83.9±0.6^{a}
	7.5%MD+7.5%AG	5±0.19^{b}	96.66±0.89^{a}	17.33±0.39^{a}	82.63±0.76^{a}
	15%MD+15%AG	4.94±0.16^{b}	96.03±0.96^{a}	17.45±0.46^{a}	74.41±0.92^{b}
SD	8%MD+8%AG	4.5±0.21^{c}	89.05±0.91^{d}	16.23±0.41^{b}	63.61±0.23^{d}
	12%MD+4%AG	5.02±0.18^{b}	91.34±0.88^{c}	9.47±0.38^{d}	67.42±0.57^{c}
	4%MD+12%AG	5.05±0.19^{b}	91.65±0.79^{c}	10.75±0.39^{c}	68.62±1.25^{c}

Mean ± standard deviation (n=3). Significant statistical differences are shown with different small letters (p≤0.05). FMFD: Foam-mat freeze-drying, SD: Spray-drying, MD: Maltodextrin, and AG: Arabic gum.

Table 2. Density, flowability, and cohesiveness of beverage powders based on Shahani grape pomace extract (SPE).

Drying method	Treatments	Bulk density(g/cm^3)	Tapped density(g/cm^3)	Particle density(g/cm^3)	Flowability(%)	Cohesiveness
FMFD	Control	0.25±0.008^{c}	0.28±0.01^{c}	1.42±0.02^{b}	12.49±0.54^{d}	1.14±0.008^{c}
	7.5%MD+7.5%AG	0.33±0.009^{a}	0.4±0.01^{a}	1.423±0.02^{b}	16.67±0.64^{b}	1.18±0.012^{b}
	15%MD+15%AG	0.28±0.009^{b}	0.33±0.009^{b}	1.66±0.029^{a}	14.28±0.29^{c}	1.16±0.008^{bc}
SD	8%MD+8%AG	0.22±0.008^{d}	0.28±0.009^{c}	1.1±0.41^{d}	22.22±0.80^{a}	1.29±0.009^{a}
	12%MD+4%AG	0.33±0.008^{a}	0.33±0.01^{b}	9.47±0.38^{c}	14.28±0.57^{c}	1.01±0.02^{d}
	4%MD+12%AG	0.28±0.004^{b}	0.33±0.008^{b}	10.75±0.39^{c}	16.67±0.50^{b}	1.14±0.01^{c}

Mean ± standard deviation (n=3). Significant statistical differences are shown with different small letters (p≤0.05). FMFD: Foam-mat freeze-drying, SD: Spray-drying, MD: Maltodextrin, and AG: Arabic gum.

Carrier concentration had no significant effect on TAC among samples produced via FMFD or SD processes. Anthocyanins are some kinds of water-soluble flavonoids that cause the pink or purple color of leaves and other parts of plants. Higher concentrations of these pigments in FMFD powders are attributed to the lower temperature and non-detrimental effect of this method. The higher amount of anthocyanin retention of FMFD compared to SD samples was also reported by Darniadi et al. (2019) in the drying of blueberry powder and Turan et al. (2015) in microencapsulation of blueberry's bioactive compounds.

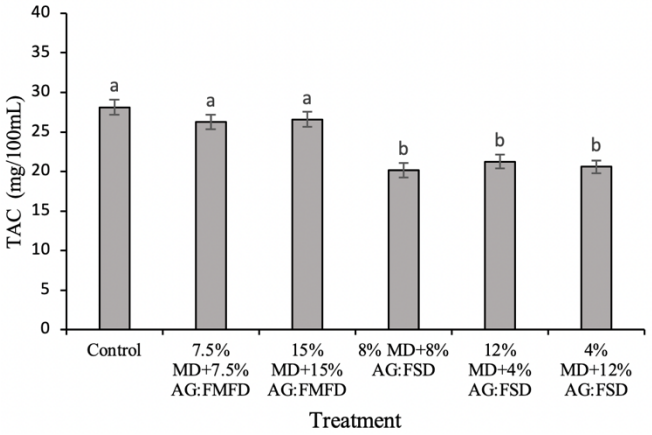

Fig. 1. Effects of carriers (MD and AG) and drying methods on total anthocyanin content (TAC) of beverage powders based on SPE. Mean ± standard deviation (n=3); significant statistical differences are shown with different small letters (p≤0.05).

3.2.8. Total phenolic content (TPC)

Phenolic compounds are of great importance among different natural antioxidants. Phenolic compounds with special structures can scavenge free radicals, chelate metals, and inhibit the oxygen-reactive species produced due to stress (Sharma et al., 2019, Rizk et al., 2018). The TPC of the fresh extract was measured as 957.5 mg GAE/g. Statistical analysis of powders showed that FMFD samples had higher TPC than SD samples (Fig. 2). Similarly, Darniadi et al. (2019) reported that the SD process caused a lower TPC of blueberry powders in comparison to the FMFD process. They reported that increasing the ratio of carriers improved TPC retention. Such a trend was also reported in comparison of freeze and spray-dried blueberry powder using maltodextrin as a carrier agent (Franceschinis et al., 2014). An increase in TPC was observed with increasing the ratio of AG in the blend of carriers. Similarly, a higher amount of TPC in date powders containing AG in comparison to MD added powders was also previously reported by Seerangurayar et al. (2018).

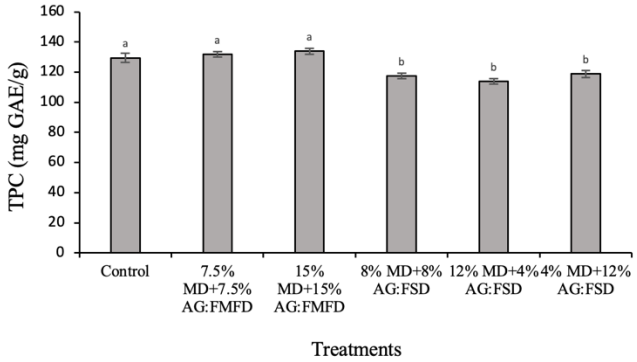

Fig. 2. Effects of carriers (MD and AG) and drying methods on total phenolic content (TPC) of beverage powders based on SPE. Mean ± standard deviation (n=3); significant statistical differences are shown with different small letters (p≤0.05).

3.2.9. DPPH radical scavenging activity (RSA)

The RSA of the fresh extract of grape pomace was measured as 84.27%. The RSA of powders is shown in Fig. 3. Similar to TAC

and TPC; the FMFD powders had higher RSA than SD powders ($p \leq 0.05$). No significant effect of the concentration of carriers or their ratio on RSA was observed among samples dried via the same procedure. Antioxidants could decrease the harmful effects of free radicals. The reduction of antioxidant activity followed by the reduction of phenolic compounds was also reported by Turan et al. (2015).

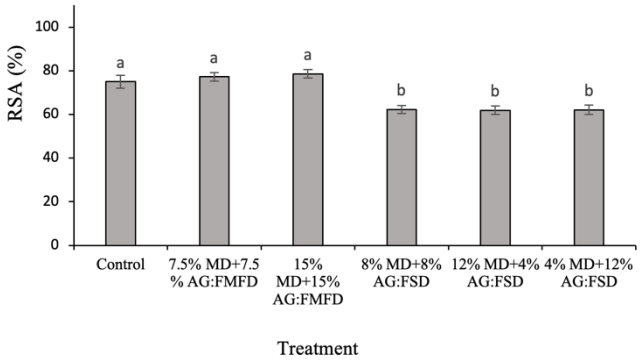

Fig. 3. Effects of carriers (MD and AG) and drying methods on DPPH radical scavenging activity (RSA) of beverage powders based on SPE. Mean ± standard deviation (n=3); significant statistical differences are shown with different small letters ($p \leq 0.05$).

4. Conclusion

This study evaluated the production of beverage powder based on Shahani grape pomace extract (SPE). The drying process of samples was performed using foam-mat freeze-drying and spray-drying. Experiments of foam-mat freeze-dried powders showed that adding maltodextrin and Arabic gum has increased bulk, tapped and particle density, cohesiveness, solubility, and hygroscopicity of powders while decreasing moisture content, flowability, and degree of caking. The statistical analysis of the above-mentioned characteristics of spray-dried samples showed that sample 8% MD+8% AG: SD had the most suitable properties. Results showed maltodextrin and Arabic gum improve consequently produce high-quality beverage powders. Freeze drying method was determined as the more suitable method for production of the beverage powder based on SPE.

Conflict of interest

The authors declare that there is no conflict of interest.

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