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Original Research Article

Physicochemical Properties and Antioxidant Activity of Spray-Dried Pomegranate (*Punica granatum*) Juice Powder

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Abstract: This study aimed to investigate the effect of different carrier agents on the physicochemical properties and antioxidant activity of the spray-dried pomegranate juice. Maltodextrin and gum Arabic were used at 20% and 30%, respectively. The results revealed that spray-dried pomegranate juice with 20% gum Arabic exhibited higher drying yield and bulk density than other powders. Spray-dried powder with both concentrations of maltodextrin (20% and 30%) demonstrated higher water solubility and lower hygroscopicity and moisture content than that of gum Arabic. Anthocyanin content (4.64 mg/L), phenolic content (528.40 mg GAE/g), and antioxidant activity (1288.5 mM GAE/g DW for FRAP and 363.9mM GAE/g DW for DPPH) were all noticeably higher in powder with 20% maltodextrin compared to the powder encapsulated with gum Arabic. The type and concentration of carrier agent did not significantly affect the colour properties of the pomegranate juice powder.

Keywords: pomegranate; spray-dried; maltodextrin; gum Arabic; antioxidant

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1. Introduction

Pomegranate (*Punica granatum* L.) is a fruit belonging to the Punicaceae family. It is gaining popularity worldwide, as it meets the dietary and health needs of people in diverse nations. The global annual production of pomegranate fruit reached approximately 3 million tons in 2014 and 3.8 million tons in 2017 (Šavikin *et al.*, 2021). It originated in Iran and Afghanistan and was cultivated in Europe, Asia, North Africa, the Mediterranean and South Africa (Fawole & Opara, 2013). The arils of pomegranate contain high levels of acids, sugars, vitamins, polysaccharides, polyphenols, and essential minerals (Muzaffar *et al.*,2016). The aril's dark red or purple colour is due to anthocyanin compounds (Viuda-Martos *et al.,*2010). Besides being a source of natural antioxidants, pomegranate has antimicrobial, anti-inflammatory, antiviral, and antidiabetic properties (Viuda-Martos *et al.,*2010). In addition, pomegranate juice showed the highest antioxidant ability compared to other drinks rich in polyphenols, including green tea, red wine, grapefruit, orange, cranberries, and grape juice (Vučić *et al.,*2019). However, pomegranate is seasonal and has a limited shelf life under ambient conditions (Khalid Muzaffar *et al.*, 2016). The phenolic compounds in the juice degrade when exposed to adverse environmental conditions, such as oxygen or light (Robert & Fredes, 2015). Therefore, microencapsulation using spray drying technology can improve the stabilisation of these antioxidant compounds. In this matter, Robert *et al.* (2010) proved that the degradation of polyphenols and anthocyanins in fresh pomegranate juice was faster than in microencapsulated powder. Additionally, converting pomegranate juice into powder, offers functional benefits such as enhanced antioxidant properties, a longer shelf life and can be used in various food systems, thus further supporting their economic feasibility (Yousefi *et al.*, 2011).

Spray drying is extensively used to preserve fruit and vegetable juices by converting them into powder. The primary objective is to achieve high-quality fruit and vegetable powders (Shishir & Chen, 2017). Spray-dried food powder has a long shelf life (Yousefi *et al.*,2011) and is suitable for mass transportation and storage (Kha *et al.,*2010). Moreover, the drying technique produced more nutritious products by preserving their anthocyanin and antioxidant activities during food processing and storage (Lima *et al.,*2019). However, one of the concerns in spray drying is the adhesion of food particles on the chamber wall due to high sugar and acid content aswell as the high hygroscopicity and low molecular weight in fruit juice (Adetoro *et al.,*2020). Therefore, carrier agents with high molecular weights, such as maltodextrin, gum Arabic, waxy starch, pectin, vegetable fibres, and starches, are often used in spray drying (Sablani *et al.,*2008; Adhikari *et al.,*2004; Osorio *et al.,*2010).

Carrier agents improve drying yield, reduce the powder's adhesion and hygroscopicity, and protect sensitive compounds from heat, oxygen, light and moisture at appropriate concentrations (Shishir & Chen, 2017). In this aspect, the food industry extensively uses the maltodextrin, a hydrolysed starch, because of its many benefits, including its affordability, fragrance, mild flavour, low viscosity at high solids concentrations (Santiago *et al*., 2016), availability, and legality (Mahdavi *et al*., 2014). Meanwhile, gum Arabic has high solubility and low viscosity in aqueous solution (Tonon *et al*., 2009) and is one of the most applied carrier materials (Belšcak-Cvitanovic *et al.*, 2015; de Souza *et al.*, 2015). According to Tonon *et al*. (2010), both wall materials can increase the glass transition temperature, minimise stickiness in the drying chamber, and prevent crystallisation while processing and storing fruit juice that is high in sugar.

Thus, this study was conducted to assess the effect of different carrier agents (maltodextrin and gum Arabic) and concentrations (20% and 30%) on the physicochemical properties and antioxidant activity of spray-dried pomegranate juice.

2. Materials and Methods

2.1. Materials

Potassium chloride buffer (0.025 M, pH 1.0) prepared from potassium chloride and hydrochloric acid, sodium acetate buffer (0.4 M, pH 4.5) prepared from sodium acetate trihydrate and hydrochloric acid, Folin-Ciocalteu reagent, sodium carbonate, 2,2-Diphenyl-1-picrylhydrazyl (DPPH), methanol, sodium acetate buffer pH 3.6 prepared from sodium acetate trihydrate and glacial acetic acid, 2,4,6-tripyridyl-s-triazine (TPTZ), 40 mM hydrochloric acid, Ferum (III) chloride, sodium chloride, gallic acid, maltodextrin 20 dextrose equivalent (DE), and gum Arabic.

2.2. Preparation of Spray-Dried Pomegranate Juice

Pomegranate fruit was purchased from a local supermarket in Kota Kinabalu, Sabah. The skin was removed, and the fleshy aril was manually separated from the fruit. Fresh juice was extracted by blending the aril with distilled water at a 1:1 ratio. The juice with 15% total soluble solids (TSS) was then filtered twice using a screen mesh filter before adding carrier agents. Maltodextrin (20 DE) and gum Arabic were added separately at concentrations of 20% and 30% (w/v), respectively, and homogenised with the juice for 3 mins using a Waring blender. According to Bazaria and Kumar (2016), maltodextrin with a DE value of more than 20, is preferable to be used as a drying carrier for sugar-containing juices. The feed mixture was spray-dried using a spray dryer (Mobile Minor®, GEA Process Engineering A/S, Soeborg, Denmark) with inlet temperature, feed rate, and outlet temperature at 150°C, 18 mL/min, and 80°C, respectively (Kha *et al.*,2010; Muzaffar *et al.*,2016). The design of this study was a 2 x 2 factorial design.

2.3. Physicochemical Analysis

2.3.1. Drying yield

The yield of spray-dried pomegranate juice powder was calculated according to Amin *et al.* (2021). Equations (1) and (2) were used to determine the relationship between the total solid (TS) content of the final powder and feed mixture, and the drying yield was determined as the percentage of the weight of the total water loss during the drying process.

$$\text{TS content (\%)} = 100 - \text{moisture (\%)} \tag{1}$$

$$\text{Drying yield (\%)} = \frac{\text{TS (\%)powder} \times \text{powder yield after drying (g)}}{\text{TS (\%)feed mixture} \times \text{feed mixture (g)}} \times 100\% \tag{2}$$

2.3.2. Colour determination

The colour properties of pomegranate powder were determined using a Minolta Chroma Meter calibrated with a white standard tile and expressed as Hunter colour values of *L**, *a**, and *b**. The *L** denotes lightness, *a** redness and greenness, and *b** yellowness and blueness (Kha *et al.*, 2010).

2.3.3. Water solubility index (WSI)

The WSI was determined using the method described by Jafari *et al.* (2017) with slight modification. In a centrifuge tube, 2.5 g of pomegranate powder was suspended in 30 mL of distilled water and vortexed for one minute. The suspension was placed in a water bath at 37℃ for 30 minute and then centrifuged at 10,000 rpm for 20 minutes at 4℃. The resulting supernatant was poured into a pre-weighed dish and dried at 105℃ to a constant weight. WSI was computed using the following formula:

$$\text{WSI (\%)} = \frac{\text{Weight of dried supernatant}}{\text{Initial weight of sample}} \times 100 \tag{3}$$

2.3.4. Hygroscopicity of powder

The hygroscopicity of pomegranate powder was determined according to Amin *et al.* (2021). Approximately 1 g of powder was placed in a pre-weighed dish and set inside a desiccator containing a saturated NaCl solution (relative humidity, RH=75.3%). After 7 days of storage, the samples were weighed and expressed as grams (g) of absorbed moisture per 100 g of dry solids (g/100 g).

2.3.5. Bulk density

Bulk density (g/mL) was determined by adding 3 g of pomegranate powder in a 10 mL graduated measuring cylinder (Amin *et al.*,2021). The ratio of the powder mass to the volume occupied by the powder determines the bulk density.

$$\text{Bulk density} = \frac{\text{Mass of powder}}{\text{Volume of powder}} \quad (4)$$

2.3.6. Moisture content

The moisture content was measured using the AOAC (2012) method. A 2 g of pomegranate powder was spread evenly on an aluminium dish and dried in an oven at 70 ± 1°C for 24 h. Then, the samples were removed from the oven, cooled in the desiccator, and weighed. The moisture content of pomegranate powder was calculated using the following Equation (5):

$$\text{Moisture content (\%)} = \frac{(\text{W3 - W1})}{(\text{W2 - W1})} \times 100 \quad (5)$$

2.3.7. Anthocyanin content

The anthocyanin content of pomegranate powder was determined according to the spectrophotometric pH by Ferrari *et al.*, (2012a), which is based on the transformation of the prevailing anthocyanin structure with a change in pH (coloured at pH 1.0 and colourless at pH 4.5). Potassium chloride (KCl) buffer (pH 1.0, 0.025M) and sodium acetate (CH_3CO_2Na–$3H_2O$) buffer solutions at pH 4.5 (0.4M) were prepared. Anthocyanin in the powders was extracted using 96% methanol and 0.1M hydrochloric acid. Briefly, 5 mL of extract was mixed with 20 mL of buffer solution and read against water at 520 nm and 700 nm. The absorbance was recorded and calculated using Equation (6) and (7):

$$A = (A_{520} - A_{700})_{\text{pH } 1.0} - (A_{520} - A_{700})_{\text{pH } 4.5} \quad (6)$$

The amount of anthocyanin content (mg cyanidin-3-glucoside/100g of powder) was calculated as:

$$\text{Total anthocyanin content (mg L}^{-1}\text{)} = (A \times M_W \times DF \times 10^3)/\ (\varepsilon \times L) \quad (7)$$

where Mw (molecular weight) = 449.2 g mol-^{1} for cyanidin-3-glucoside, DF = dilution factor, L = path length (1cm), ε = 26.900 molar extinction coefficients, in L mol^{-1} cm^{-1}, for cyanidin-3-glucoside, and 10^3 = factor for conversion from g to mg (Jafari *et al.*,2017).

2.3.8. Total phenolic content

Determination of total phenolic content was performed by the Folin-Ciocalteu method described by Mishra *et al*. (2014) with slight modification. Briefly, sample extraction was carried out by mixing 500 mg of the sample with 10 mL of 80% methanol followed by centrifugation at 4000 × g for 15 minutes. Then, 250 µL of the supernatant, 2.5 mL Folin-Ciocalteu reagent and 2 mL of sodium carbonate solution were added to 250 µL of water. The mixture was allowed to stand in the dark for 2 h. The absorbance was measured at 765 nm using a UV-Vis spectrophotometer (Shimadzu, Japan) against a standard solution of gallic acid. The results were represented as milligrams of gallic acid equivalent (GAE).

2.3.9. Antioxidant activity

2.3.9.1. Sample extraction

Sample extraction for antioxidant activity was carried out according to Amin *et al.* (2021). Approximately 500 mg of pomegranate powder was added in 10 mL of 80% methanol and incubated in a water bath at 40°C for 24 h. After that, the mixture was centrifuged at 4000 rpm for 15 mins. The resulting supernatant was collected and stored at 4°C for further analysis.

2.3.9.2. Ferric reducing antioxidant power (FRAP) assay

FRAP assay of pomegranate powder was conducted as described by Amin *et al.* (2021). FRAP reagents were prepared by mixing sodium acetate (300mM, pH3.6), 10 mM of 2,4,6-tripyridyls-triazine (TPTZ) solution in 40 mM HCl, and 20 mM of $FeCl_3$ solution in the proportion of 10:1:1 (v/v), respectively. FRAP reagents were prepared fresh and warmed in a water bath at 37°C before use. After that, 150 µL of sample extract was added in 2.85 mL of FRAP reagent, and the mixture was incubated at room temperature for 30 mins. The absorbance of the reaction mixture was measured at 593 nm using a UV-Vis spectrophotometer (Shimadzu, Japan). FRAP assay was carried out in triplicate. A standard curve was constructed using gallic acid, and the results were expressed in mM of GAE.

2.3.9.3. 2,2-Diphenyl-1-Picrylhydrazyl (DPPH) assay

The antioxidant activity of the extract was measured using the DPPH assay following the method of Amin *et al.* (2021). A 3.9 mL of 0.1 mM DPPH solution (prepared using 80% methanol) was mixed with 0.1 mL of sample extract in a centrifuge tube. Then, the mixture was vortexed for 15 s and incubated in the dark at room temperature for 15 minutes. The absorbance was measured at 515 nm using a UV-Vis spectrophotometer (Shimadzu, Japan) against 80% methanol as the reference. DPPH assay was conducted in triplicate. Gallic acid was used to prepare the standard curve, and the results were expressed in mM GAE/g dry weight (DW).

2.4. Statistical Analysis

All the analyses were carried out in triplicate, and the results were expressed as means ± standard deviations. Different mean values were analysed by one-way analysis of variance (ANOVA) ($p<0.05$) and the Tukey post hoc test using the Statistical Package for the Social Sciences (SPSS) version 28.0.

3. Results and Discussions

3.1. Drying Yield

The primary criterion for the spray drying process is powder yield as it has a a direct impact on production costs and efficiency (Khalid Muzaffar *et al.*, 2016). The effects of different carrier agents and concentrations on the yield of pomegranate powder are shown in Table 1. The drying yields of pomegranate juice powder ranged from 59% to 78%. According to Wang *et al*. (2020), more than 50% of yields after spray drying are considered successful. However, based on the result, increasing the concentration of carrier agents to 30% reduced the powder drying yield. These findings concur with Tonon *et al*. (2008), who found that increasing maltodextrin concentration decreased the drying yield. It was due to the increase in mixture viscosity, which caused more particles to adhere to the main chamber wall.

Table 1. Drying yield of pomegranate juice powder

Sample	Carrier Agent	Concentration (%)	Drying Yield (%)
F1	Maltodextrin	20	65.25 ± 0.27^{b}
F2		30	59.58 ± 0.59^{a}
F3	Gum Arabic	20	78.81 ± 0.59^{c}
F4		30	61.43 ± 1.29^{a}

Values are presented as mean±standard deviation. Values with different superscripts within the same column are statistically significant ($P<0.05$).

At a 20% concentration of gum Arabic, the drying yield of F3 powder was significantly ($p<0.05$) higher than that of the other powders. Thiswas due to the strong film-forming ability of gum Arabic. This finding is consistent with Yousefi *et al*. (2011), who found that using 12% gum Arabic in the spray drying pomegranate juice yielded better than maltodextrin. Chong and Wong (2015) also reported that using 20% to 30% (w/v) maltodextrin for Sapodilla juice increased the powder yield above 50%.

3.2. Colour

The colour parameters of the control and pomegranate juice powders are presented in Table 2. Increased concentrations of maltodextrin showed insignificant effects on the lightness values, but the a* values of the powder were reduced. It might be due to the maltodextrin having an inherent whitish colour (Muzaffar *et al*., 2016) compared to gum Arabic. For the *a** value, all powders showed positive values, which is within the red intensity, indicating the presence of anthocyanins. Powder with 20% maltodextrin recorded significantly ($p<0.05$) higher *a** values, indicating a higher anthocyanin content than the other powders as shown in Figure 1. Meanwhile, powders encapsulated with 30% gum Arabic are significantly higher in lightness and *b** value than other samples, possibly due to the whitish-yello colour of gum Arabic.

Figure 1. Spray dried pomegranate juice powder with 20% maltodextrin

Table 2. Colour parameters of pomegranate juice and powder

Sample	Carrier Agent	Concentration (%)	L*	a*	b*
F1	Maltodextrin	20	59.01±6.78^b	11.94±2.12^c	0.66±0.88^a
F2		30	68.04±1.28^b	8.40±0.29^b	0.95±0.27^a
F3	Gum Arabic	20	57.18±3.63^b	7.29±1.18^b	2.39±0.62^b
F4		30	75.49±2.96^c	7.68±0.25^b	4.13±0.35^c

Values are presented as mean±standard deviation. Values with different superscripts within the same column are statistically significant ($P<0.05$).

3.3. Water Solubility Index (WSI)

The WSI is an indicator of product behaviour in an aqueous phase and is used to evaluate the reconstitution quality of the powder (Jafari *et al*., 2017). The WSI of pomegranate juice powder (Table 3) varied from 92% to 96%, suggesting that all powders are highly soluble in water. A high WSI is preferred in the food and pharmaceutical industry as it can be easily dissolved and integrated with other food components (Tan *et al.*, 2015). As compared to powders containing 20% gum Arabic, those containing maltodextrin had significantly ($p<0.05$) better solubility. This is because maltodextrin has higher solubility in cold water and low viscosity values at high concentrations than gum Arabic (Akdeniz *et al.*, 2017; Tonon *et al.*, 2008).

3.4. Powder Hygroscopicity

Hygroscopicity indicates the capability of a material to absorb moisture from environments with high relative humidity and its caking behaviour during storage (Bhusari *et al.*, 2014). The addition of carrier agents such as maltodextrin and gum Arabic changed the hygroscopic properties of the spray-dried powder (Ferrari *et al.*,2012b). Based on Table 3, the hygroscopicity of pomegranate juice powders ranged from 13% to 16 %. Food powders with hygroscopicity values of less than 20% demonstrate less hygroscopic behaviour (Amin *et al.*, 2021; Henao-Ardila *et al.*, 2019; Molina *et al.*, 2014). The result showed that the lowest hygroscopicity values were obtained (F2) when the highest maltodextrin concentrations were used. These results were like those of Tonon *et al.* (2008) in the spray drying of açai pulp. Meanwhile, powder with gum Arabic has the highest hygroscopicity due to the highly branched structure of the gum Arabic, which eases moisture absorption. The same observation was reported by Adetoro *et al.* (2020), who found that gum Arabic showed the highest hygroscopicity compared to maltodextrin and waxy starch in pomegranate juice powder.

3.5. Bulk Density

By comparing the bulk density of the powders (Table 3), it can be inferred that powder with 20% gum Arabic showed the highest bulk density due to the higher molecular weight of gum Arabic compared to maltodextrin (Lee *et al.*,2018). The results also showed that the bulk density of all powders decreased with the increased concentration of carrier agents. It is possibly due to an increase in the viscosity of the feed during spray drying, which increases the particle size of the powder (Bhusari *et al.*, 2014), with more air between their cavities (Baysan *et al.*, 2019) and, therefore, required greater volume for packaging (Santhalakshmy *et al.*, 2015). The same findings were reported by Yousefi *et al.* (2011) and Fazaeli *et al.* (2012) for spray-dried pomegranate juice powder and black mulberry juice powder, respectively. This may also be due to a decreased moisture content or higher air trapped in particles, as maltodextrin and gum Arabic are film-forming substances (Fazaeli *et al.*,2012; Patel & Goyal, 2015).

3.6. Moisture Content

Moisture content is one of the properties that determine the quality and stability of powder (Sukri *et al.*,2021). Based on Table 3, the moisture content of pomegranate powder ranged from 4.76% to 5.54%. Pomegranate powder with the addition of gum Arabic showed higher moisture content because gum Arabic has several binding structures with hydrophilic groups, resulting in higher water binding capacity and more moisture during drying (Sukri *et al.*,2021). Meanwhile, the addition of maltodextrin results in a lower moisture content as the amount of solid content in the feed during spray drying reduces the amount of water for evaporation (Phisut, 2012). Similar results were reported by Suravanichnirachon *et al*. (2018) and Horuz *et al*. (2012), where the moisture content decreased as the concentrations of maltodextrin increased in mao powder and pomegranate juice powder, respectively.

Table 3. Water solubility index (WSI), hygroscopicity, bulk density, and moisture content of pomegranate powder

Sample	Carrier Agent	Concentration (%)	Water Solubility Index (%)	Hygroscopicity (g/ 100 g)	Bulk density (g/ mL)	Moisture content (%)
F1	Maltodextrin	20	96.05 ± 0.43^{b}	14.44 ± 0.07^{b}	0.47 ± 0.03^{ab}	4.83 ± 0.25^{ab}
F2		30	96.50 ± 1.21^{b}	13.83 ± 0.11^{a}	0.43 ± 0.00^{a}	4.76 ± 0.11^{a}
F3	Gam Arabic	20	92.34 ± 0.79^{a}	16.43 ± 0.18^{d}	0.51 ± 0.02^{b}	5.54 ± 0.05^{c}
F4		30	93.04 ± 0.99^{a}	15.48 ± 0.09^{c}	0.45 ± 0.01^{a}	5.19 ± 0.09^{bc}

Values are presented as mean±standard deviation. Values with different superscripts within the same column are statistically significant ($P<0.05$).

3.7. Anthocyanin Content

The anthocyanin content in the pomegranate powder ranged from 1.75 to 4.64 mg/L (Table 4). Results showed that powders encapsulated with 20% and 30% maltodextrin hadthe highest anthocyanin content (4.64 and 4.53 mg/L, respectively), while the addition of gum Arabic resulted in the lowest anthocyanin content. According to Adetoro *et al*. (2020), maltodextrin is more effective than gum Arabic in anthocyanin preservation in spray-dried pomegranate juice powder. It showed that the increase in the concentration of gum Arabic reduces the amount of anthocyanin content. This may be due to thawing, where juice particles were not fully encapsulated, and the carrier agent may only act as an agent to facilitate the drying process (Jafari *et al.*, 2017).

Table 4. Anthocyanin and total phenolic content of pomegranate juice powder

Sample	Carrier Agent	Concentration (%)	Anthocyanin content (mg/ L)	Total phenolic content (mg GAE/g)
F1	Maltodextrin	20	4.64±0.11^c	528.40±8.55^d
F2		30	4.53±0.18^c	290.40±4.72^a
F3	Gam Arabic	20	2.41±0.08^b	493.00±3.10^c
F4		30	1.75±0.07^a	310.60±6.07^b

Values are presented as mean±standard deviation. Values with different superscripts within the same column are statistically significant ($P<0.05$).

Additionally, spray-dried powder encapsulated with gum Arabic had a fine, expanded structure and had more surfaces exposed to oxygen, which caused a decrease in anthocyanin content (Yousefi *et al*., 2011). Meanwhile, our findings on the anthocyanin content are lower compared to those of other researchers. Jafari *et al.* (2017) reported that the anthocyanin content of pomegranate juice powders was between 6–8 mgL^{-1} using MD (25, 35 and 45% w/w) and inlet temperatures at 124 and 143°C. Similarly, Yousefi *et al.* (2011) encapsulated using MD and GA had 69.2–75.8 mgL^{-1} of anthocyanin content. This may be attributed to the higher inlet temperatures used in this study, which resulted in lower anthocyanin content in the final products due to thermal degradation and oxidation (Tuyen *et al.,* 2010).

3.8. Phenolic Content

As shown in Table 4, the type of carrier agents and their concentration have a significant effect ($p<0.05$) on the phenolic content. Powder with maltodextrin as a carrier agent has a significantly ($p<0.05$) higher phenolic content (528.40 mg/g), similar to the study by Horuz *et al*. (2012). Increasing the percentage of carrier agent to 30% caused a significant ($p<0.05$) reduction in the phenolic compound possibly because more solid contents were introduced into the feed, thus increasing the thickness of the powder wall and reducing the amount of phenolic content per powder mass. Mishra *et al*. (2014) reported a similar decrease in the total phenolic content with an increase in the concentration of the carrier agent in spray-dried amla powder.

3.9. Antioxidant Activity

The antioxidant activity of pomegranate juice powder by FRAP value ranged from 701.5 to 1288.5 mM GAE/g DW as shown in Table 5. In addition, the powder containing 20% maltodextrin had a significantly (p<0.05) higher FRAP value than the other powder samples. This was due to maltodextrin's properties of being highly soluble and having low permeability to oxygen and water. From the DPPH results, powder with 30% maltodextrin showed the lowest activity, indicating that antioxidant activity decreases with increasing carrier agent concentration.

Table 5. Antioxidant activity of pomegranate juice powder

Sample	Carrier Agent	Concentration (%)	FRAP (mM GAE/ g DW)	DPPH (mM GAE/ g DW)
F1	Maltodextrin	20	1288.5 ± 33.4^{d}	363.9 ± 16.2^{d}
F2		30	701.5 ± 21.8^{a}	93.3 ± 1.3^{a}
F3	Gum Arabic	20	1084.5 ± 9.2^{c}	270.8 ± 3.3^{c}
F4		30	952.5 ± 8.1^{b}	127.2 ± 0.8^{b}

Values are presented as mean±standard deviation. Values with different superscripts within the same column are statistically significant (P<0.05).

Identical outcomes were attained by Mishra *et al*. (2014) for amla powder. Moreover, a significant (p<0.05) difference in the DPPH values was observed between maltodextrin and gum Arabic. A study by Tonon *et al*. (2011) showed that acai powder produced with the aid of maltodextrin has a higher antioxidant capacity attributed to the high solubility properties of maltodextrin. Gum Arabic demonstrate only partial protection against oxidation, as it often acts as a semi-permeable membrane, which influences the stability and durability of microcapsules.

4. Conclusions

The effect of carrier agents and their concentration on the physicochemical properties and antioxidant activity of pomegranate juice powder has been determined. Spray-dried pomegranate juice powder with 20% gum Arabic showed high drying yield, bulk density, hygroscopicity and moisture content. Spray-dried pomegranate juice powder with the aid of 20% maltodextrin produced powder with less hygroscopicity, low moisture content, and high in a* value, anthocyanin, total phenolic and antioxidant activity. This study has shown that maltodextrin is the most suitable carrier agent compared to gum Arabic for spray drying of pomegranate juice powder. But, in general, the selection of carrier agents and concentrations depends on the characteristics of the desired final product.

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