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Research Article

Physicochemical Properties of Red Beetroot and Quince Fruit Extracts Instant Beverage Powder: Effect of Drying Method and Maltodextrin Concentration

Marziyeh Hajiaghaei and Akram Sharifi

Department of Food Science and Technology, Faculty of Industrial and Mechanical Engineering, Qazvin Branch, Islamic Azad University, Qazvin, Iran

Correspondence should be addressed to Akram Sharifi; asharifi81@gmail.com

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In this study, production of instant beverage powder by the foam-mat drying method (foam-mat freeze- and hot-air drying) from red beetroot, quince fruit, and cinnamon extracts without and with maltodextrin (MD) (0%, 10%, 20%, and 30%) were investigated. The results showed that an increase in the MD level has led to a decrease in the moisture content of powders. Drying method and MD concentration had a significant effect on rehydration time, color, and total phenolic content ($p \leq 0.05$). Foam-mat hot-air-dried powder containing 20% MD had a good flowability. According to the statistical analysis, MD content had a more significant effect on the antioxidant activity of powders than the drying method ($p \leq 0.05$). The total phenolic content of foam-mat hot-air-dried powders was higher than that of foam-mat freeze-dried powders. Based on the results, the produced powder containing 20% MD via foam-mat hot-air drying (60°C) was the optimum sample.

1. Introduction

This research has focused on preparing instant beverage powder based on red beetroot extract. Instant beverage powder is a convenient way to make drinks, by simply adding either hot or cold water [1]. Red beetroots are a rich source of polyphenols, antioxidants, vitamins, carotenoids, flavonoids, and minerals [2]. Beetroot supplementation can serve as a beneficial strategy to boost internal antioxidant defenses [3]. As a source of nitrate, beetroot ingestion supplies an indigenous means of augmenting in vivo nitric oxide (NO) availability and has emerged as a potential approach to prevent and manage pathologies associated with reduced NO bioavailability, especially hypertension and endothelial function [3]. Betanin or beetroot red is one of the betalains color dyes that is liable for the purplish-red color of the beet [4]. Betalains are water-soluble pigments containing nitrogen. Malic acid is reported as the most abundant organic acid in beetroot juice and other beetroot products, followed by citric acid and ascorbic acid [2]. Another remarkable characteristic of the beet is its different flavor. Geosmin is a chemical that causes the specific earthy aroma of beets [2]; so, in this study, quince and cinnamon extracts were also used to improve the aroma and flavor of the red beetroot extract-based instant beverage powder as well as increasing its nutritional value.

Quince fruit (*Cydonia oblonga* Miller, Rosaceae family) contains several phenolic compounds, which along with ascorbic and citric acid contribute to its antioxidant activity. A large number of volatile compounds in quince fruit are responsible for its special fragrance [6]. Cinnamon derives from the internal bark of tropical evergreen cinnamon trees [7]. The major compounds isolated and identified in cinnamon belong to two chemical types: polyphenols and volatile phenols [8]. Cinnamaldehyde is liable for the flavor and aroma of cinnamon [7].

Drying is an important method to preserve raw food materials [9]. Of the methods used to produce powdered

food products, drying by foam layer (foam-mat drying) is noteworthy. This method consists of the conversion of liquid or semiliquid foods into stable foams via intense agitation and insertion of air, along with using foaming agents and stabilizers [9]. As liquid foams are metastable, the use of stabilizing agents is needed, which are usually surfactant molecules. The stabilizers delay the several mechanisms of foam aging such as drainage, coalescence, and coarsening [10]. Some foam stabilizers include xanthan gum, propylene glycol alginate (PGA), methylcellulose, Arabic gum, and maltodextrin. In foam-mat drying, the process of drying usually refers to dehydration of the thin layer of foam by hot air. Besides foam-mat hot-air drying, other methods of drying include freeze-drying, vacuum-drying, infrared-drying, and microwave-drying have also been reported [11,12].

Production of barberry *(Berberis vulgaris)* extract powder [1], foam-mat freeze-drying of date powder [13], foam-mat drying of jambolan [*Syzygium cumini* (L.)] juice [14], and development of beetroot (*Beta vulgaris*) powder using foam-mat drying [4] are some of the research studies that had been conducted in this field.

This study aimed to evaluate the influence of the addition of maltodextrin as well as the effect of the drying method (foam-mat freeze- or hot-air drying) on some of the physicochemical properties of the beverage powders based on red beetroot, quince fruit, and cinnamon extracts.

2. Material and Methods

Red beetroot (*Beta vulgaris* L. ssp. *vulgaris*) and quince fruit (*Cydonia oblonga* Miller) were obtained from a local market in Qazvin, Iran, in November 2019. Samples were uniform in size and shape and free from physical and insect damages. The cinnamon (*Cinnamomum verum*) extract was purchased from Zardband company (Yasuj city, Iran). Maltodextrin (MD) (DE 20), Folin-Ciocalteu reagent, gallic acid, methanol, albumin powder, and sodium carbonate were purchased from Merck (Darmstadt, Germany), and 2,2-diphenyl-1-picrylhydrazyl (DPPH) was acquired from Sigma-Aldrich (St. Louis, MO, USA).

Beetroot and quince fruit extracts were prepared according to the procedure described by Slavov et al. (2013) with some modifications [15]. For this purpose, washed and sanitized red beetroot and quince fruit pieces were pressed with a centrifugal juicer (Santos Juicer, Lyon, France) at 3500 rpm separately, and the residual pomace was used for the extraction of their residual extract. The extraction procedure was done two times with different ratios of pomace to water, 1 : 4 and 1 : 2, respectively at room temperature in the dark (1 h for the first extraction and 0.5 h for subsequent extraction).

2.1. Extracts Experiments. The red beetroot, quince fruit, and cinnamon extracts were mixed in ratio of 75 : 24 : 1 (% w/w) and used to determine the moisture content, pH, and total soluble solids (degree Brix) [16].

2.2. Preparation of Foam. For the preparation of foam, a constant level of 3% albumin powder and 0, 10, 20, and 30% (%w/w) MD were added to the mixed extracts and whipped using a blender (IKA Labortechnik, Germany) at maximum speed (788 rpm) for 8 minutes. The foam prepared with 0% maltodextrin was used as a control sample.

2.3. Foam Experiments

2.3.1. Foam Expansion. The prepared 50 g foam was poured into a graduated cylinder, and its volume was measured [4]. The foam expansion was calculated using equation (1):

$$\%\ \text{foam expansion} = \frac{V_1 - V_0}{V_0} \times 100, \tag{1}$$

where V_1 is final foam volume (cm^3) and V_0 is the initial extract volume.

2.3.2. Foam Density. The prepared foam was transported to a measuring cylinder without foam structure collapse or trapping air bubbles [17]. The foam density was determined using equation (2):

$$\text{foam density} = \frac{\text{mass of foam}\,(g)}{\text{volume of foam}\left(cm^3\right)}. \tag{2}$$

2.3.3. Foam Stability. The prepared foam was poured into a graduated cylinder and kept at room temperature for 3 hours [18]. Foam stability was calculated using

$$\text{foam stability}\,(\%) = \frac{V_{\text{foam}}}{V_0} \times 100, \tag{3}$$

where V_{foam} is the final foam volume (cm^3) and V_0 is the initial foam volume of the experiment (zero time) (cm^3).

2.4. Drying Processes. For foam-mat hot-air-drying, the foam samples were spread (constant thickness of 5 mm) on glass plates and put into a convection drying oven (SH-Scientific, Republic of Korea) at 60°C and a superficial air velocity of 1.5 m/s. Drying was continued until constant weight is achieved [4].

In the foam-mat freeze-drying method, foam samples were spread on glass plates at a foam thickness of 5 mm and, after deep-freezing, subjected to freeze-drying (Zist Farayand Tajhiz Sahand, Iran) for 24 hours at −65°C and a reduced pressure of 190 mtorr [19].

The dried foams were powdered with a mixer (Kinematica AG, Microtron MB 550, Luzern, Switzerland), sieved (60 mesh), and put into the dark glasses to prevent light degradations. Samples produced in foam-mat hot-air and freeze-drying methods were labeled as FMHD and FMFD, respectively.

2.5. Powder Experiments

2.5.1. Moisture Content. 2 g of powder samples were accurately weighed (ABJ 220–4 M, Kern & Sohn GmbH, Germany), put into Petri dishes, and forwarded to drying in

an oven (Binder, USA) at 105°C for 4 hours [16]. The moisture content was determined using

$$\%\ \text{moisture} = \frac{W_2 - W_3}{W_2 - W_1} \times 100, \quad (4)$$

where W_1 is wet plate weight (g), W_2 is wet plate weight with its sample (wet) (g), and W_3 is plate weight with its sample (dry) (g).

2.5.2. Flowability and Cohesiveness of Powders. The flowability and cohesiveness of powders were evaluated in terms of Carr's index (CI) and Hausner ratio (HR), respectively [20]. The bulk and tapped densities were calculated according to the method presented by Sharifi et al. [1]. The CI was determined using equation (5). According to Carr's index, flowability classified as very good (<15%), good (15%–20%), relatively good (20%–35%), bad (35%–45%), and very bad (>45%).

$$\text{CI} = \frac{\rho\,\text{Tapped} - \rho\,\text{Bulk}}{\rho\,\text{Tapped}} \times 100. \quad (5)$$

The cohesiveness of powders was determined using equation (6), as low (<1.2), moderate (1.2–1.4), and high (>1.4):

$$\text{HR} = \frac{\rho\,\text{Tapped}}{\rho\,\text{Bulk}}. \quad (6)$$

2.5.3. Rehydration Time. 0.5 g of powder was added to 50 ml water at 26°C. The mixture was stirred using a magnet (7 mm × 2 mm) on a magnetic stirrer (Velp Scientifica, Italy) at 900 rpm. The time was recorded using a chronometer until all particles of powder became invisible by the naked eye [21].

2.5.4. Total Phenolic Content. The total phenolic content (TPC) was evaluated using the procedure described by Seerangurayar et al. [13] with some modifications. About 2 g of the beverage powder sample was dissolved in 100 ml of distilled water. The solution was centrifuged (model: Hermle Z 323 K, Hermle Labortechnik GmbH, Germany) at 10000 rpm for 15 minutes. Following this, 0.3 ml of the supernatant was added to 2.5 ml of Folin-Ciocalteu reagent (10%), and after 5 minutes, a total of 2 ml sodium carbonate solution (7.5% W/V) was added to the mixture. After 90 minutes at room temperature, adsorption was read at 725 nm using a UV/Vis spectrophotometer (Perkin Elmer, Inc., USA, model: Lambda 35). A blank sample was prepared using all reagents in mentioned amounts except powder extract. For this purpose, 0.3 ml deionized water was added to 2.5 ml of Folin-Ciocalteu reagent (10%), and after adding 2 ml sodium carbonate solution, the absorbance reading was performed. The concentration of the TPC was reported as milligram gallic acid equivalents (GAE) per gram of powder. 50–500 ppm gallic acid solution was used to prepare the gallic acid calibration curve.

The TPC of mixed fresh extracts was also determined using the protocol described by Shahidi and Naczk (2004) with some modifications [22]. 0.5 ml of aliquot was added to 2.5 ml Folin-Ciocalteu reagent (prediluted in a ratio of 1 : 10) and the abovementioned steps were repeated.

2.5.5. Antioxidant Activity. The antioxidant activity was determined using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay, following the method described by Rigon and Zapata Noreña [23] with some modifications. 1 g of powder was suspended in 50 ml methanol (50%, v/v). After keeping for 60 minutes at room temperature, the mixture was centrifuged at 3500 rpm for 15 minutes. For the mixed fresh extracts, a 1 ml aliquot was added to 3 ml methanol (50%, v/v), homogenized using a vortex mixer (Velp, Inc., Italy, model: Classic), and kept for 60 minutes at room temperature in a dark place [23].

To determine the antioxidant activity of the prepared extracts, a 0.1 ml of diluted powder solution or extract was homogenized with 3.9 ml of 60 mM DPPH. Reduced adsorption against a blank (methanol) was monitored using a UV/Visible spectrophotometer (Perkin Elmer, Lambda 35, USA) after 45 minutes at 515 nm [23]. The results were reported as a percentage of antioxidant activity using

$$\text{Antioxidant activity}\,(\%) = \left(1 - \frac{A_{\text{sample}}}{A_{\text{controle}}}\right) \times 100, \quad (7)$$

where A_{sample}, sample adsorption and A_{control}, blank adsorption.

2.5.6. Color Measurement. Color measurement was conducted with the image processing method, using ImageJ processing software (version 1.42e, USA). The high-resolution images of powders were taken using a Canon PowerShot G3 digital camera placed in the upper side of a wooden box equipped with two illumination sources, at a distance of 22 cm from the sample [24]. The $L*$, $a*$, and $b*$ values were determined.

2.5.7. Sensory Evaluation. Sensory evaluation of samples was performed using the method described by Feguš et al. [25] with some modifications. The evaluation was performed with 15 panelists. The red beetroot extract-based beverages were evaluated in terms of color, taste, aroma, mouthfeel, and total acceptance using a five-point hedonic scale method and 1–5 scoring level. Score 1 indicates very bad, 2 bad, 3 moderate, 4 good, and 5 very good. Each of the samples was served to panelists in 50 ml glass cups, labeled with 3-digit randomized numbers. In order to prevent sensory disturbances, panelists were asked to rinse their mouth after each sample evaluation.

2.6. Statistical Analysis. For statistical analysis, an analysis of variance (ANOVA) was used, and a comparison of means was done using the Tukey test at 95% confidential level ($p \leq 0.05$) using Minitab 18/1 statistical software (Minitab

Inc., Torre Sul Paraíso, Brazil). Experiments were done at three replications, and mean ± SD was reported.

3. Result and Discussions

3.1. Extracts Analysis. The fresh mixture of extracts had the moisture content of 89% ± 0.17, total soluble solids of 11.4 ± 0.09 degree Brix, and pH of 5.35 ± 0.00. Addition of 10, 20, and 30% maltodextrin caused total soluble solids of 19.8 ± 0.03, 29.7 ± 0.01, and 39.2 ± 0.07°Bx, respectively.

3.2. Foam Analysis

3.2.1. Foam Expansion. Upon application of different percentages of MD, it was shown that the MD variable had a significant effect on foam expansion ($p \leq 0.05$) (Figure 1(a)). Generally, the foam expansion decreased as the MD level increased, indicating the low capacity of the mixture to allow air into its structure. High-viscosity samples prevent air trapping inside the foam structure during mechanical stirring [26]. Azizpour et al. [27] also stated that foam expansion of cherry foam decreased as viscosity increased.

3.2.2. Foam Density. In general, the foam density of samples increased as the MD level increased ($p \leq 0.05$) (Figure 1(b)). These data are compatible with the result of foam expansion, as the least density is related to the sample with the highest foam expansion and vice versa. Similarly, according to the results reported in foam-mat drying of sour cherry, the density of produced foam increased significantly, as methyl cellulose concentration increased ($p \leq 0.05$). The entry of air into the foam structure increases as the surface tension decreases and leads to a reduction in the density [28].

3.2.3. Foam Stability. Foam stability shows how long the foam can extend without liquid drainage [28]. The MD variable had a significant effect on foam stability ($p \leq 0.05$) (Figure 1(c)). Foam stability of samples increased as the MD level increased, but at the MD concentration of 30% w/w, a significant decrease in the foam stability was observed ($p \leq 0.05$). The creation of a network structure in the foam bulk phase, which occurs at higher viscosity of the aqueous phase, leads to producing a more stable foam with interfacial walls not easily breaking [29]. Reduced foam stability at an MD level higher than 20% was also reported by Phaechamud et al. [30] in the foam-mat drying of malabar tamarind extract.

3.3. Powder Experiments

3.3.1. Moisture Content. The MD level and the interaction of MD and the drying method had a significant effect on the moisture content of samples ($p \leq 0.05$). Moisture content in FMFD powders ranged from 8.64% to 3.28% and 6.95% to 4.83% in FMHD powders (Table 1). Similar observations were also made in the cases of apple juice powder and yacon juice powder where the moisture content depend on the drying method [31]. Generally, the moisture content of powders decreased as the MD level increased. As previously stated by Tchabo et al. [32] and Ekpong et al. [33], increased carbohydrate concentration may cause an increase in sample solids, a decrease in the total volume of moisture to be evaporated, and a reduction in the moisture content.

3.3.2. Rehydration Time. The drying method, MD level, and interaction of these variables had significant effects on the rehydration time of powders ($p \leq 0.05$). Powders containing 20% MD had the lowest rehydration time in both drying methods (Table 1), which contributed to its good foam expansion and stability. On average, FMFD powders had lower rehydration time than FMHD powders. The higher porosity of freeze-dried products plays an important role in their reconstitution properties [34].

3.3.3. Flowability and Cohesiveness of Powders. The flowability of a powder is used to determine the free-flow properties of the powder. An appropriate flow of powder is important for both consumers and manufacturers [34]. Asokapandian et al. [35] ascribed the free-flowing properties of foam-dried powder to the air incorporated during foaming, along with the foaming and stabilizing agents, which is also confirmed by this study. According to Carr's index, only the FMHD beverage powder containing 20% MD had good flowability, and the others had medium flowability (Table 1). An increased glass transition temperature concomitant with an increased MD level can caused a reduction in hygroscopicity and elevation in the flowability of powders [36].

The higher Hausner ratio means that the powder is more cohesive and has less ability to flow freely [34]. The cohesiveness of the beverage powders was medium in all the treatments (Table 1). The cohesiveness of powder particles is mostly affected by interparticle forces and also other factors such as mechanical interlocking [36].

3.3.4. Total Phenolic Content. The total phenolic content of fresh extracts mixture had 8.5 ± 0.71 mg GAE/g dry weight. The drying method, MD level, and interaction of these variables had significant effects on the TPC of the produced powders ($p \leq 0.05$). The control beverage powders (0% MD powders) had higher TPC than MD-added powders (Figure 2(a)). A similar trend of decreased TPC with an increase in carrier concentration was observed by Seerangurayar et al. [13] and Mishra et al. [37] for foam-mat freeze-dried date powder and spray-dried amla juice powder, respectively. This decrease in TPC is attributed to the dilution effect of carrier agents [13].

On an average, FMHD powders had higher TPC than FMFD powders. Different drying methods in different foods may have caused different results on their phenolic content. Some studies had shown that heat treatment caused an increase in the TPC in some food samples such as dry apricots and dry raisins [38]. Shokry [39] reported that the drying process increased the phenolic content of red

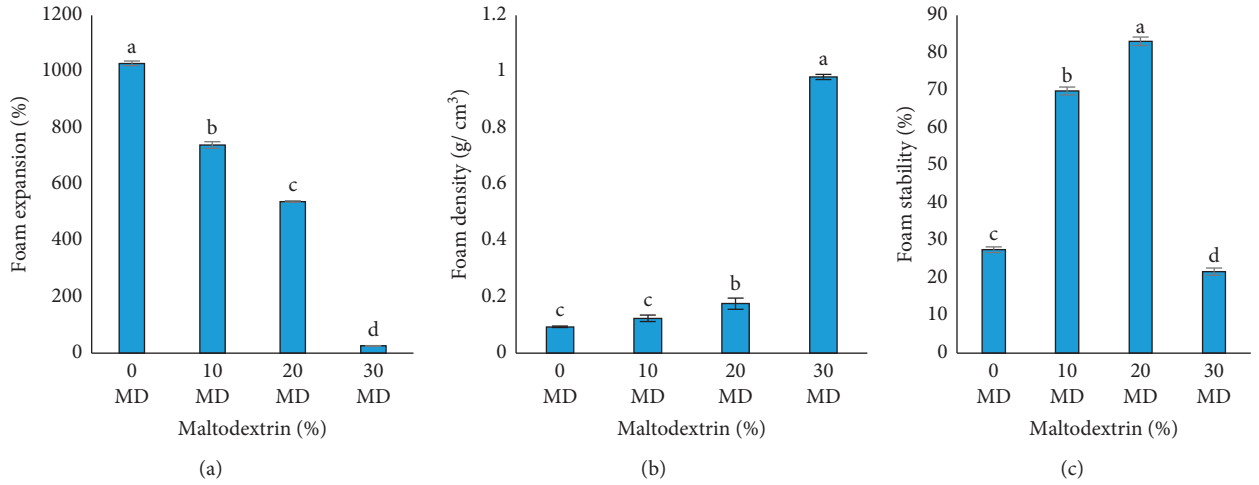

Figure 1: The effect of maltodextrin concentration on: (a) foam expansion (%), (b) foam density (g/cm^3), and (c) foam stability (%) of the red beetroot extract-based foams. Mean ± standard deviation ($n = 3$). Different small letters on each column show significant statistical differences.

Table 1: Physical properties of the foam-mat-dried instant beverage powders based on red beetroot extract.

Drying method	MD (%)	Moisture content (%)	Carr's index (%)	Hausner ratio	Rehydration time (s)
FMFD	0	8.64 ± 0.71^{a}	25.02 ± 0.35^{a}	1.33 ± 0.006^{a}	35.63 ± 0.55^{c}
	10	7.5 ± 0.38^{ab}	22.38 ± 0.32^{a}	1.29 ± 0.005^{a}	33.05 ± 1^{d}
	20	4.59 ± 0.74^{cd}	20.27 ± 0.67^{a}	1.25 ± 0.01^{a}	29.03 ± 1^{e}
	30	3.28 ± 0.5^{d}	21.85 ± 0.51^{a}	1.28 ± 0.008^{a}	40.52 ± 1.21^{b}
FMHD	0	6.95 ± 0.89^{ab}	24.15 ± 0.54^{a}	1.32 ± 0.009^{a}	34.03 ± 0.96^{cd}
	10	6.08 ± 0.79^{bc}	22.38 ± 0.20^{a}	1.29 ± 0.003^{a}	35.89 ± 0.28^{c}
	20	5.04 ± 0.53^{cd}	19.37 ± 0.56^{a}	1.24 ± 0.009^{a}	30.51 ± 0.5^{e}
	30	4.83 ± 0.21^{cd}	20.89 ± 0.18^{a}	1.26 ± 0.003^{a}	54.04 ± 0.14^{a}

Mean ± standard deviation ($n = 3$). Means with different letters in each column differ from each other significantly ($p \leq 0.05$). FMFD: foam-mat freeze-drying, FMHD: foam-mat hot-air drying, and MD: maltodextrin.

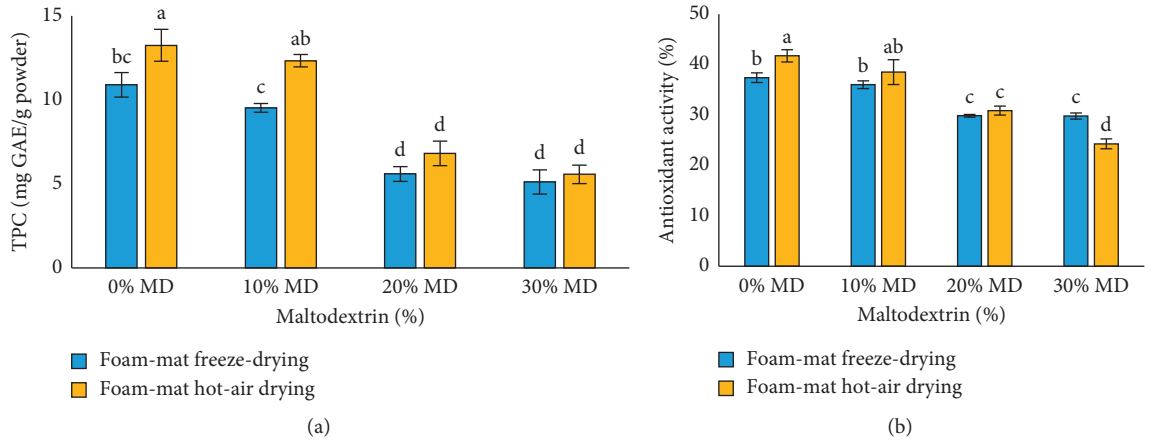

Figure 2: Effect of the drying method and maltodextrin concentration on the chemical properties of foam-mat-dried instant beverage powders based on red beetroot extract. (a) TPC and (b) antioxidant activity. Mean ± standard deviation ($n = 3$). Different small letters on each column show significant statistical differences.

beetroot powders. Torres et al. [40] reported a 33% increase in the phenolic content of quince pulp after cooking. According to the research, the thermal hydrolyzation during thermal processing is attributed to an elevation in quercetin content of cooked quince [40].

3.3.5. Antioxidant Activity. Statistical analysis of independent variables showed that the drying method had no significant effect on the antioxidant activity of powders ($p > 0.05$), but the MD concentration and also interaction of the variables had significant effects on this property

Table 2: Effects of different drying methods and MD levels on color values (L^*, a^*, and b^*) of foam-mat-dried instant beverage powders based on red beetroot extract, and sensory properties of the prepared beverages.

Drying method	MD (%)	L^*	a^*	b^*	Color	Taste	Aroma	Mouthfeel	Total acceptance
FMFD	0	10.32 ± 0.03^{h}	22.2 ± 0.32^{e}	1.17 ± 0.06^{g}	3 ± 0.76^{cd}	4.25 ± 1.04^{a}	4.5 ± 0.53^{a}	3.87 ± 0.6^{a}	4 ± 0.53^{ab}
	10	26.82 ± 0.05^{f}	43.87 ± 1.81^{d}	3.99 ± 0.01^{f}	3.13 ± 0.64^{bcd}	4.25 ± 0.7^{a}	3.88 ± 0.64^{abc}	3.87 ± 1^{a}	4.13 ± 0.64^{ab}
	20	44.11 ± 0.01^{b}	59.38 ± 0.48^{a}	4.27 ± 0.04^{e}	4.38 ± 0.52^{a}	3.63 ± 0.91^{ab}	4.25 ± 0.71^{ab}	4.5 ± 0.53^{a}	4.75 ± 0.46^{a}
	30	47.78 ± 0.07^{a}	58.29 ± 0.19^{a}	4.35 ± 0.05^{e}	4.5 ± 0.53^{a}	3.13 ± 0.83^{ab}	3.5 ± 0.76^{abc}	4.12 ± 0.64^{a}	3.5 ± 1.07^{ab}
FMHD	0	25.69 ± 0.09^{g}	42.3 ± 0.44^{d}	8.87 ± 0.04^{d}	2.63 ± 0.52^{d}	3.25 ± 0.89^{ab}	3.25 ± 0.71^{bc}	3.5 ± 0.8^{a}	3.25 ± 0.89^{b}
	10	33.13 ± 0.03^{e}	47.91 ± 1.13^{c}	9.58 ± 0.16^{c}	2.88 ± 0.64^{cd}	3 ± 0.93^{ab}	3.13 ± 0.83^{bc}	3.63 ± 0.74^{a}	3.38 ± 0.74^{b}
	20	38.76 ± 0.16^{d}	53.41 ± 0.35^{b}	9.86 ± 0.06^{b}	4.13 ± 0.64^{ab}	2.87 ± 0.83^{b}	3.13 ± 1^{bc}	4.25 ± 0.76^{a}	3.75 ± 0.89^{ab}
	30	40.16 ± 0.01^{c}	51.53 ± 0.2^{b}	10.9 ± 0.09^{a}	3.87 ± 0.83^{abc}	2.5 ± 0.76^{b}	2.88 ± 0.83^{c}	4 ± 0.53^{a}	3.25 ± 1.04^{b}

Means with different letters in each column differ significantly ($p \leq 0.05$). FMFD: foam-mat freeze-drying, FMHD: foam-mat hot-air-drying, and MD: maltodextrin

($p \leq 0.05$). The fresh extract mixture had antioxidant activity of 30.97%. The higher concentration of MD resulted in the lower antioxidant capacity of the beverage powders (Figure 2(b)). Similar results were reported in cranberry juice powders obtained with different carrier agents [41].

Antioxidant activity depends on the process [14]. On an average, FMHD powders had higher antioxidant activity than FMFD powders. It is also believed that higher phenolic content at higher drying temperatures might be related to higher antioxidant activity [42]. A positive correlation between the TPC and antioxidant capacity of cranberry powders was also reported [41].

3.3.6. Color Measurement. The coordinate $L*$ indicates the lightness of powders. According to Table 2, an increase in the MD concentration caused an increase in the $L*$ of produced powders too. Similar results were also reported in cranberry powder [41], date powder [13], and muskmelon powder [35]. According to Ekpong et al. [33], an increase in the lightness of samples might be a reflection of pale, white color of MD powder.

The coordinate $a*$ is an indication of greenness/redness. The highest $a*$ values reported for powders contain 20% MD (Table 2). As represented in Figure 3, the FMFD control sample (0% maltodextrin) had a dark brown color which represented the lowest $a*$ in image processing that might be related to its high moisture content. According to Gokhale and Lele [43], beetroot contains a high amount of red pigments that appeared dark when the color of its surface was measured (low $L*$), and so, lower values of coordinate $a*$ are recorded. Increased MD concentration to 30% has led to a decrease in the $a*$ value. This decreased $a*$ values may be related to the inert white color of MD.

The $b*$ value of beverage powders, as an indication of blueness/yellowness, increased as the MD concentration increased (Table 2). When FMFD and FMHD beverage powders were compared, FMHD samples had more $b*$. The higher $b*$ values in FMHD powders can be related to their higher drying temperature. Increased $b*$ (yellowness) reported in the production of guava powder was ascribed to nonenzymatic browning [44]. Color changes during drying processes may be due to carotenoid degradation and Millard reaction [35].

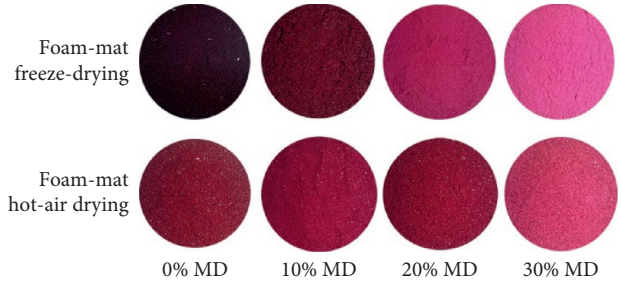

Figure 3: The color of foam-mat-dried instant beverage powders based on red beetroot extract; MD, maltodextrin.

3.3.7. Sensory Evaluation. Beverages prepared with FMFD powders gained better color scores than those of FMHD samples. Overall (Table 2), similar to Ekpong et al. [33], panelists reported better color as maltodextrin concentration increased ($p \leq 0.05$). In general, as MD concentration increased, the taste of beverages decreased, and samples received fewer points in the hedonic scale. Similarly, Moura Neto et al. [45] observed a significant reduction in the flavor of reconstituted juice of yellow mombin (*Spondias mombin* L.) atomized powder attributed to the use of a high concentration of maltodextrin, which was also probable in the case of reduction of the flavor in acerola and seriguela mixed powder [46].

The aroma of the beverages prepared with FMFD powders were more intense than FMHD beverages, which can be due to less temperature used in the freeze-drying method. Statistical analysis of the sensory evaluation of beverages had shown no differences in terms of mouthfeel ($p > 0.05$) (Table 2).

According to Table 2, there was a significant difference between beverages in terms of total acceptance ($p \leq 0.05$). Overall, prepared beverages with FMFD powders could receive more points in the hedonic scale than beverages prepared with FMHD powders. The highest hedonic scores in terms of total acceptance in FMHD and FMFD samples belonged to powders contain 20% MD.

4. Conclusion

In the present study, the beetroot extract-based beverage powders were produced using different concentrations of MD to evaluate some of the physicochemical properties of

the powders obtained after foam-mat freeze- and hot-air drying. Foam experiments showed that as maltodextrin level increased, foam expansion decreased and foam density increased. Foam prepared with 20% MD had the highest foam stability of 83.08%. According to the powder experiments, the moisture content of powders decreased as the MD level increased. In both drying methods, powders containing 20% MD had the lowest dissolving time. The highest $a*$ value belonged to 20% MD samples. FMHD powders had more TPC than FMFD powders. As the MD level increased, the TPC and the antioxidant activity of powders decreased. This study concluded that the powder containing 20% MD prepared with FMHD was an optimum sample.

Data Availability

The datasets generated and/or analyzed during the current study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare no conflicts of interest.

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