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RESEARCH ARTICLE

Technical Factors Influencing to Instant Powder from Strawberry (*Fragaria*) Juice

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Abstract

Strawberry (*Fragaria*), a rich source of phytochemicals (ellagic acid, anthocyanins, quercetin, and catechin) and vitamins (ascorbic acid and folic acid), has been highly ranked among dietary sources of polyphenols and antioxidant capacity. Bioactive compounds in strawberry revealed high abundance of anthocyanins, flavonols, flavanols, and cinnamic acid. To increase strawberrys popularity and expand their use in the food industry, it's neccesary to explore the appropriate postharvest handling and storage.The aim of this work was to study the feasibility of spray drying of strawberry juice juice. Various characteristics of spray-dried fruit juice powders are well affected by spray-drying conditions including inlet air temperature, out let air temperature, feed flow rate, drying carrier agent. Results revealed that inlet/ outlet spray drying temperature (155^{o}C: 85^{o}C), speed flow rate (12 ml/ min), γ-cyclodextrin: maltodextrin (4: 6 % w/v) were appropriated for spray drying of dried strawberry powder from its juice. The spray-dried product of γ-cyclodextrin-maltoxetrin-strawberry juice was considered to be the good technique to dry strawberry juice on the result of phytochemical determination, physical and chemical properties and antioxidant activity. Value addition of strawberry juice has been created by changing in the physical form of the agricultural produce which leads to its greater acceptability, extended availability, enhanced market viability and increased cost to benefit ratio for the grower of the strawberry produce.

Keywords: *Strawberry juice, Spray drying, Dried powder, Inlet air, Out let air, Speed flow rate, γ-cyclodextrin, maltodextrin.*

Introduction

Strawberry, a member of the Rosaceae family that belongs to the genus *Fragaria*, is very popular due to its attractive fruits with unique taste, spectacular aroma, and smooth red texture. Strawberry contains high levels of micronutrients and phytochemical compounds. These exhibit functional roles in plant growth and metabolism and are also essential for the nutritional and organoleptic qualities of the fruit [1].

Strawberries are the main dietary source of ellagic acid-containing compounds, such as ellagic acid and ellagitannins, which account for 51% of their total phenolic content [2]. Strawberry fruits rich in phenolic compounds can impart health benefits to humans [3]. The characteristic phenolic compounds in strawberries are anthocyanins, which are responsible for the red flesh color, flavonols, flavanols, and derivatives of hydroxycinnamic and ellagic acid. The nutritional quality of strawberry fruits correlates with the remarkable abundance of phenolic compounds, including anthocyanin, flavonoids, and nutrients such as folate, vitamin C, sugars, and minerals [4, 5]. The free radical scavenging effect of the fruit extract can be associated with the anthocyanin content [6].

The remarkable polyphenolic and antioxidant contents of strawberries improve the immune system and reduce obesity-related disorders and the risk of heart disease [7, 8]. Moreover, it has been shown that strawberry fruit extracts exhibit antioxidative and anticancer activities both and in vivo.

The bioavailability and metabolism of major strawberry phytochemicals as well as their actions in combating much pathology, including cancer, metabolic syndrome, cardiovascular disease, obesity, diabetes, neurodegeneration, along with microbial pathogenesis have been reviewed [7]. Consumption of strawberries has several other health benefits, such as improved eye condition, enhanced brain function, and relief from high blood pressure, arthritis, and various cardiovascular diseases [7].

Nutritional epidemiology shows inverse association between strawberry consumption and incidence of hypertension or serum C-reactive protein; controlled feeding studies have identified the ability of strawberries to attenuate high-fat diet induced postprandial oxidative stress and inflammation, or postprandial hyperglycemia, or hyperlipidemia in subjects with cardiovascular risk factors [9].

The nutritional quality of strawberry fruits can be considerably affected by several pre-harvest and post-harvest conditions, which, in most cases, may decrease the nutrient and the phytochemical contents of this fruit [10].Encapsulation is a process in which flavors, nutrients, oils, proteins, or probiotic bacteria are enveloped into a starch, protein, or lipid carrier matrix for preservation, masking, or delivery of the encapsulated agent.

Encapsulation can be accomplished by spray drying, extrusion, freeze drying, or fluid bed coating. Spray drying is one of the oldest and widely used methods. Its advantage is that it is easily applied on an industrial scale [11]. Spray drying has three fundamental steps, atomization of the liquid feed, mixing fine droplets with heated air stream to dry, and separation of dried particles from air stream for collection.

Modifying the process parameters can alter properties, such as particle size, particle shape, flow ability, bulk density, solubility, moisture content, thermal stability, or suitability for food applications [12]. Wall material is selected based on its ability to protect the core material from environments that cause deterioration or protect and increase the stability of the material. The wall material is selected for properties such as solubility, molecular weight, diffusibility, and emulsion properties [13], and is a low-molecular weight starch, gum, or protein.

Hydroscopicity is also a key property for selecting a wall material [14].Cyclodextrins are cyclic oligosaccharides produced by the degradation of starch resulting from intramolecular transglycosylation reactions caused by cyclodextrin glucanotransferase enzyme. There are several types-α-cyclodextrin which have six glucose molecules in the ring, β-cyclodextrin which have seven glucose molecules in the ring, and γ-cyclodextrin, which have eight or more glucose units [15].

The height of the cyclodextrin cavity is the same for all three types but the diameter varies with the number of glucose units. Small molecules are included in α-cyclodextrin, whereas larger molecules are included in γ-cyclodextrin.γ-Cyclodextrins have greater internal cavities, are more water soluble, and allows for the inclusion to be more bioavailable [16].

γ -Cyclodextrins can accommodate much larger molecules, such as, macrocycles and steroids [15].γ -Cyclodextrins can be absorbed by the human intestines which make it ideal for food applications [16]. It can achieve a nearly complete inclusion of a molecule, which can protect the inclusion molecule from autoxidation during storage [17]. Maltodextrins are products of starch hydrolysis, consisting of D-glucose units linked mainly by α (1→4) glycosidic bond. Maltodextrins are low cost and very useful for spray drying process on food materials. Raja et al [14].

Declared that maltodextrins with a dextrose equivalent (DE) of 10–20 worked best for wall materials in spray-dried powders due to less turbidity at high concentrations. The low haze formation of low DE makes for more uniform coating and greater preservation of coated material.

Peng, Li, Guan, and Zhao [18] observed that maltodextrin wall material was superior to β-cyclodextrin for protecting the antioxidant components. The material also needs to be inexpensive, food grade, readily available, and legally allowed [12]. Partanen et al [19].Observed that maltodextrin was more heat stable than β-cyclodextrin under dry conditions.

Several researches mentioned to spray drying of strawberry juice. Strawberry puree was processed using three different drying techniques each operating at different temperature conditions: vacuum-drying (-27-17 °C), spray-drying (130-160 °C) and PGSS-drying (112-152 °C) [20].

The effectiveness of two drying agents, namely whey protein isolates (WPI) and maltodextrin (MD), was evaluated during spray-drying of strawberry puree [21]. The stability of a microencapsulated strawberry flavour using different encapsulating agents and drying techniques: spray drying, freeze drying and fluid bed was studied [22].

Strawberry juice is very sensitive and affected the different drying parameters. Spray drying is one of the most complex methods for fruit juice drying. The aim of this work was to study the feasibility of spray drying of strawberry juice. Various characteristics of spray-dried fruit juice powders well affected by spray-drying conditions including inlet air temperature, out let air temperature, feed flow rate, drying wall material were examined.

Material and Method

Material

Fresh strawberry juice was collected from Lam Dong province, Vietnam. The juice was stored at 4-8 °C and transfer quickly to laboratory for experiment.

Figure 1: Strawberry fruit

Researching Method

Effect of Inlet and Outlet Air Spray Drying Temperature to Moisture Content, Water Activity, Total Phenolic, Ascorbic Acid, Cinnamic Acid, Bulk Density, Yield, Solubility, Hygroscopicity, Total Plate Count, Sensory Score in Spray-dried Powder

Different inlet: outlet air drying temperature (135°C: 75°C, 145°C: 80°C, 155°C: 85°C, 165°C: 90°C) was examined. The optimal parameter was selected by comparing different values of the spray-dried powder such as moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/100g), cinnamic acid (mg/ 100g), bulk density (g/ml), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score.

Effect of Speed Flow Rate to Moisture Content, Water Activity, Total Phenolic, Ascorbic Acid, Cinnamic Acid, Bulk Density, Yield, Solubility, Hygroscopicity, Total Plate Count, Sensory Score in Spray-Dried Powder

Different speed flow rate (6, 9, 12, 15 ml/ min) was examined. The optimal parameter was selected by comparing different values of the spray-dried powder such as moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/100g), cinnamic acid (mg/ 100g), bulk density (g/ml), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score.

Effect of Ratio of Drying Carrier Agents to Moisture Content, Water Activity, Total Phenolic, Ascorbic Acid, Cinnamic Acid, Bulk Density, Yield, Solubility, Hygroscopicity, Total Plate Count, Sensory Score in Spray-Dried Powder

Different ratio of drying carrier agent by γ-cyclodextrin: maltodextrin (3:7, 4:6, 6:4, 7:3% w/v) were used to prepare the juice using a shear mixer. The optimal parameter was selected by comparing different values of the spray-dried powder such as moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/100g), cinnamic acid (mg/ 100g), bulk density (g/ml), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score.

Physico-chemical, Microbial and Sensory Evaluation

Moisture content (%) was determined by comparing the weights of the sample with the electronic balance. Water activity (a_w) was measured was measured by a water activity meter with the standard solution of 0.25 and 0.50 as the control samples. Total phenolic content was determined using the FolinCiocalteu method described by Rocha and Morais [23]. Ascorbic acid (mg/ 100g) was measured by 2, 6-dichlorophenolindophenol titration. Cinnamic acid (mg/100 g_{DW}) content of the strawberry *(Fragaria)* was determined by chromatographic method [24].

Bulk density was determined by gently pouring spray-dried powder into a 10 cm^3 graduated cylinder, and was calculated as the ratio of the weight (g) of the sample contained in the cylinder to the volume occupied [25]. The total plate count (cfu/g) was enumerated during the storage period by Petri-film - 3M. The sensory attributes such as visual appearance, color, taste, flavor and acceptability was carried out by selected panel of judges (9 members) rated on a five point hedonic scale. The yield of the spray drying process was calculated by taking into consideration the total solid content of the feed sample with carrier agent and weight of the final dry powder.

Yield (%) was calculated using the equation: Yield (%) = Weight of the solids in dried powder x 100/ Solid content of the feed material [26]. The solubility (%) was determined according to the method described by Chau et al [27]. Briefly, samples were mixed with distilled water (1:10 w/v), stirred for 1 h at room temperature and centrifuged at 1,500 rpm for 10 min. The supernatant was collected, dried and weighed.

Solubility (%) = weight (g) of supernatant after drying x100/ weight (g) of sample. The hygroscopicity (%) property of the sample powders was determined according to Cai and Corke (2000) with some modifications. Briefly, 2 g of spray dried powder samples were placed in pre-weighed glass vials and placed in desiccators containing saturated salt solution of sodium chloride (relative humidity of 75.09%) maintained at 30^{o}C and kept for 7 days. After the incubation period, sample vials were weighed and hygroscopicity was expressed as g moisture/100 g solids.

Statistical Analysis

The experiments were run in triplicate with three different lots of samples. Data were subjected to analysis of variance (ANOVA) and mean comparison was carried out using Duncan's multiple range test (DMRT). Statistical analysis was performed by the Stat graphics Centurion XVI.

Result & Discussion

Effect of Inlet/ Outlet Spray Drying Temperature to Moisture Content, Water Activity, Total Phenolic, Ascorbic Acid, Cinnamic Acid, Bulk Density, Yield, Solubility, Hygroscopicity, Total Plate Count, Sensory Score in Spray-Dried Powder

Processing factors affecting particle size, loose density and nutrient contents of the spray-dried powder include inlet and outlet drying temperature [28]. When feed temperature is increased, then the viscosity and droplet size is decreased. Also, drying rate is increased. This results in a finer powder. Although, Chong et al [29].Observed that spray drying with maltodextrin at higher drying temperature and faster drying rate resulted in larger droplet sizes.

They theorized that the fast drying rate restricted the shrinkage of the droplets during drying. If encapsulating a volatile compound, higher temperatures lead to loss of volatiles [30, 29]. Spray drying is the method of choice for heat-sensitive foods. Therefore, there is a balance between inlet temperature and preservation of the encapsulated compound [31] of which compounds in pomegranate juice can be sensitive. At higher drying temperatures, the spray-dried product results in lower moisture contents [31].

According to Walton [32], increasing air-drying temperature or decreasing feed flow rate generally resulted in a decrease in bulk density and there was a greater tendency for particles to be hollow. This could have resulted from a higher evaporation rate [33] or lower residual moisture content [34], which may be the reason why bulk density decreased dramatically as the inlet air drying temperature increased.

Table 1: Effect of inlet/ outlet spray drying temperature (135°C: 75°C, 145°C: 80°C, 155°C: 85°C, 165°C: 90°C) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), cinnamic acid (mg/ 100g), bulk density (g/ml), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score in spray-dried powder

Inlet/ outlet spray drying temperature (oC)	135oC: 75oC	145oC: 80oC	155oC: 85oC	165oC: 90oC
Moisture (%)	5.42±0.03a	5.39±0.03ab	5.36±0.01ab	5.33±0.01b
Water activity (aw)	0.34±0.01a	0.33±0.04a	0.33±0.04a	0.33±0.03a
Total phenolic (mg GAE/g)	176.80±0.02c	177.13±0.02b	179.94±0.02a	178.44±0.02ab
Ascorbic acid (mg/ 100g)	32.74±0.04c	33.68±0.03b	34.27±0.00a	33.89±0.01ab
Cinnamic acid (mg/ 100g)	26.84±0.02c	27.73±0.00b	28.39±0.02a	27.85±0.03ab
Bulk density (g/ml)	0.36±0.01a	0.35±0.01ab	0.33±0.03b	0.34±0.01ab
Yield (%)	74.85±0.00c	76.17±0.03b	77.53±0.01a	76.79±0.02ab
Solubility (%)	57.28±0.03c	59.42±0.00b	63.71±0.02a	61.52±0.03ab
Hygroscopicity (%)	12.07±0.01a	11.81±0.02ab	11.63±0.00b	11.98±0.01ab
Total plate count (cfu/g)	1.2x101±0.02a	1.2x101±0.03a	1.2x101±0.01a	1.2x101±0.03a
Sensory score	7.51±0.01b	7.64±0.01ab	7.76±0.01a	7.69±0.02ab

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

From table 1, the optimal inlet/ outlet spray drying temperature should be 155°C: 85°C so we choose this value for further experiments. The effect of the inlet temperature on the quality of watermelon powder after spray drying was evaluated. Inlet temperatures of the drying air of 120, 130, 140, and 150°C maintained water solubility of the watermelon powder at 96%. An inlet temperature of the drying air of 130°C was the optimal temperature for the production of watermelon powder [35].

Increased inlet temperature affected color, decreased water-holding capacity, and decreased astringency index [11]. Mishra et al [36].Studied the effect of drying carrier agent concentration (maltodextrin) and inlet air temperature on the physicochemical properties of spray-dried amla juice powder. Moisture content and hygroscopicity of the powder were significantly affected by inlet air temperature and maltodextrin level. An increase in drying temperature and maltodextrin concentration decreased the free radical scavenging activity of the powder. Drying temperature and maltodextrin concentration also showed significant effect on total phenolic content of spray-dried amla juice powder. Ferrari et al [37]. Studied the effect of spray-drying conditions on the physicochemical characteristics of blackberry juice powder. A higher inlet air temperature significantly increased the hygroscopicity of the powder, decreased its moisture content, and led to the formation of larger particles with smooth surfaces.

Effect of Speed Flow Rate to Moisture Content, Water Activity, Total Phenolic, Ascorbic Acid, Cinnamic Acid, Bulk Density, Yield, Solubility, Hygroscopicity, Total Plate Count, Sensory Score in Spray-Dried Powder

Feed flow rate have significant effect on the dryer yield and wall deposit of spray dryer individually and jointly [38]. Different speed flow rate (6, 9, 12, 15 ml/ min) was examined. From Table 2, the optimal speed flow rate was noticed at 12 ml/min so this value was selected for further experiments.

Table 2: Effect of different speed flow rate (6, 9, 12, 15 ml/ min) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), cinnamic acid (mg/ 100g), bulk density (g/ml), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score in spray-dried powder

Speed flow rate (ml/ min)	6	9	12	15
Moisture (%)	5.36±0.01^b	5.37±0.02^{ab}	5.37±0.00^{ab}	5.38±0.01^a
Water activity (a_w)	0.33±0.04^a	0.34±0.01^a	0.34±0.03^a	0.35±0.03^a
Total phenolic (mg GAE/g)	179.94±0.02^b	181.13±0.03^{ab}	182.28±0.01^a	182.30±0.00^a
Ascorbic acid (mg/ 100g)	34.27±0.00^b	35.11±0.02^{ab}	35.87±0.03^a	35.90±0.02^a
Cinnamic acid (mg/ 100g)	28.39±0.02^b	29.41±0.03^{ab}	30.11±0.01^a	30.15±0.00^a
Bulk density (g/ml)	0.33±0.03^b	0.34±0.00^{ab}	0.35±0.02^a	0.35±0.03^a
Yield (%)	77.53±0.01^b	79.24±0.01^{ab}	81.43±0.01^a	81.50±0.02^a
Solubility (%)	63.71±0.02^c	64.28±0.03^b	65.39±0.03^a	64.75±0.01^{ab}
Hygroscopicity (%)	11.63±0.00^b	11.64±0.02^{ab}	11.66±0.00^{ab}	11.67±0.03^a
Total plate count (cfu/g)	1.2x10^1±0.01^a	1.2x10^1±0.01^a	1.2x10^1±0.01^a	1.2x10^1±0.01^a
Sensory score	7.76±0.01^b	7.82±0.02^{ab}	7.91±0.02^a	7.85±0.01^{ab}

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

Spray-dried technique was selected and used as drying process of young coconut juice. Maltodextrin was used as encapsulating agent to dried powder. Spray-dried maltodextrin-young coconut juice powder 20% (w/v) was selected to future study because of their good physical appearance, physicochemical properties, antioxidant activity and good stability [39]. Chegni et al [34]. Studied the effect of feed flow rate, atomizer speed, and inlet air temperature on various properties of spray-dried orange juice powder. The results indicated that increasing inlet air temperature increased the particle size, average time of wettability, and insoluble solids, and decreased the bulk density and moisture content of the powder.

Increasing atomizer speed results in increasing the bulk density and average time of wettability of powder and decreases the particle size, moisture content and insoluble solids of powder. Increase in feed flow rate increased the bulk density, particle size, and moisture content of the powder and decreased the average time of wettability and insoluble solids of powder.

Effect of Ratio of Drying Carrier Agents to Moisture Content, Water Activity, Total Phenolic, Ascorbic Acid, Cinnamic Acid, Bulk Density, Yield, Solubility, Hygroscopicity, Total Plate Count, Sensory Score in Spray-Dried Powder

Encapsulating the complex of compounds in food, for example, a juice may take multiple complexation materials. Many complexing mixtures include maltodextrins, cyclodextrins, gums, such as gum arabic, and protein isolates, such as whey and soy [40]. γ-Cyclodextrin has been shown to increase the capacity of carriers [41]. Koeda et al [17].Observed that a mixture of α-cyclodextrin and maltodextrin exhibited greater stability of retinyl palmitate, than with β- and γ-cyclodextrin. Inulin combined with whey protein concentrate resulted in fewer surface cracks, along with a smoother surface [40].

Table 3: Effect of different ratio of drying carrier agents (γ-cyclodextrin: maltdextrin) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), cinnamic acid (mg/ 100g), bulk density (g/ml), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score in spray-dried powder

Γ-cyclodextrin: Maltodextrin (% w/v)	3:7	4:6	6:4	7:3
Moisture (%)	5.37±0.00^{ab}	5.37±0.00^{a}	5.37±0.00^{a}	5.37±0.00^{a}
Water activity (a_w)	0.34±0.03^{a}	0.34±0.03^{a}	0.34±0.00^{a}	0.34±0.00^{a}
Total phenolic (mg GAE/g)	182.28±0.01^{b}	185.79±0.02^{a}	184.32±0.02^{ab}	183.58±0.03^{ab}
Ascorbic acid (mg/ 100g)	35.87±0.03^{b}	37.25±0.00^{a}	37.04±0.03^{ab}	36.75±0.00^{ab}
Cinnamic acid (mg/ 100g)	30.11±0.01^{c}	33.28±0.00^{a}	32.84±0.01^{ab}	31.64±0.03^{b}
Bulk density (g/ml)	0.35±0.02^{a}	0.30±0.02^{c}	0.33±0.01^{b}	0.34±0.02^{ab}
Yield (%)	81.43±0.01^{c}	84.32±0.03^{a}	83.11±0.02^{ab}	82.87±0.01^{b}
Solubility (%)	65.39±0.03^{c}	68.49±0.01^{a}	67.35±0.03^{ab}	66.94±0.03^{b}
Hygroscopicity (%)	11.66±0.00^{a}	11.49±0.03^{c}	11.55±0.01^{b}	11.61±0.00^{ab}
Total plate count (cfu/g)	1.2x10^{1}±0.01^{a}	1.2x10^{1}±0.01^{a}	1.2x10^{1}±0.01^{a}	1.2x10^{1}±0.01^{a}
Sensory score	7.91±0.02^{c}	8.35±0.01^{a}	8.04±0.01^{ab}	8.12±0.03^{b}

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

From table 3, ratio of γ-cyclodextrin: maltodextrin (4: 6 % w/v) was appropriate for application. The stability of a microencapsulated strawberry flavour using different encapsulating agents and drying techniques: spray drying, freeze drying and fluid bed was studied. According to the quantification of volatile compounds, the blend MDs/Hi-Cap (9/1) at a fixed concentration of CDs (1.7%) was the most appropriate for microencapsulating the strawberry flavour.

The best drying yield was observed in the case of freeze drying. In the case of the moisture content, spray drying samples presented the lowest values, followed by freeze drying and fluid bed. The study of stability at different temperatures and times revealed that the presence of CDs in the blend enabled a higher presence of volatile compounds in the powder than in its absence. Microphotographs showed smooth spherical particles in the case of spray drying, whereas the structure of the powder was amorphous, like glass, with freeze drying and irregular in the case of fluid bed [6].

The effectiveness of two drying agents, namely whey protein isolates (WPI) and maltodextrin (MD), was evaluated during spray-drying of strawberry puree. With the increase of WPI substitution in the feed material, the surface tension of strawberry puree decreased, and powder recovery increased. Powder recovery (Rp) increased from 39.2 ± 2.3% (S: MD: WPI = 60:40:0) to 56.5 ± 2.8% when MD was replaced by WPI (S: MD: WPI = 60:39:1).

Surface morphology of powders showed that the addition of WPI resulted in shrunken particle surface, which gave rise to smaller DB and particle size. The particles were not spherical, and even with the addition of 0.5% WPI, the particle morphology was altered. The surface shrinkage of strawberry powder increased with increase in WPI from 0.5% to 10%.

The production efficiency of strawberry powder could be greatly improved when MD was replaced by 1% WPI [21]. Muzaffar et al [42].Studied the effect of drying carrier agent concentration (maltodextrin) on determination of production efficiency, color, glass transition, and sticky point temperature of spray dried pomegranate juice powder.

A research was conducted to identify influences of spray-drying temperatures and carriers on physical and antioxidant properties of lemongrass leaf extract powder. Two variables including: inlet temperatures (110 ◦C, 120 ◦C, 130 ◦C, 140 ◦C and 150 ◦C) and carriers (Gum Arabic, Maltodextrin and Gum Arabic: Maltodextrin mixture) were studied.

The powder samples produced by mixing with Maltodextrin at 130 ◦C retained the high levels of antioxidant capacity, TFC, TPC and had the highest water-soluble ability and lowest moisture content as compared to the others, matching well with quality requirements for an instant powder product [43]. Ratios of maltodextrin and γ-cyclodextrin (20:0, 19:1, and 17:3% w/w) were dissolved in water and mixed with pomegranate juice for spray drying with inlet temperatures of 120, 140, and 160°C.

The effects on physical properties (water activity, % water content, color, pH, soluble solids (Brix), and methyl cellulose precipitable tannin assay (MCPTA) were examined. Blending of γ-cyclodextrins to maltodextrins slightly increased the water-holding capacity, increased pH, slightly affected color, and preserved the color over time, slightly better [11].Ferrari et al [37]. Studied the effect of spray-drying conditions on the physicochemical characteristics of blackberry juice powder. Powders produced with higher maltodextrin (DE 20) concentrations were less hygroscopic and had lower moisture content. The color of the blackberry juice powder was mainly affected by maltodextrin concentration, which led to the formation of powders that were whiter and less red as the concentration of maltodextrin increased.

With respect to powder morphology, higher inlet air temperatures resulted in larger particles with smooth surfaces, whereas particles produced with lower maltodextrin concentrations were smaller. Strawberry puree was processed using three different drying techniques each operating at different temperature conditions: vacuum-drying (-27-17 °C), spray-drying (130-160 °C) and PGSS-drying (112-152 °C). The results obtained from the experimental work indicate that investigated fruit powders without or with minimal addition of maltodextrin can be produced [20].

A work was to microencapsulate passion fruit juice (PFJ) by spray-drying in two different biopolymers blends: Gum Arabic-mesquite gum-maltodextrin. The best vitamin C retention level occurred at 25 ◦C, aW = 0.447 [44]. A study was to assess the effectiveness of the blends with different levels of lactose-maltodextrin (8:5, 10:5, and 12:5 % w/v) during the spray-drying of the strawberry juice.

The drying was carried out in a laboratory spray dryer at two inlet air temperatures (180 and 190 °C), and two air pressures (0.10 and 0.20 MPa). The moisture content, hygroscopicity and vitamin C retention were evaluated in the powder obtained. Response surface plots showed that the lowest values of the moisture content and hygroscopicity were reached in the temperature range of 188-190 °C and at 12:5 % (w/v) concentration of lactose-maltodextrin; the best vitamin C retention level occurred at 180 °C and 0.2 MPa [45,46].

Conclusion

Microencapsulation protects sensitive nutrients, masks flavors, or enhances delivery. The strawberry (Fragaria X ananassa, Duch.) represents a relevant source of micronutrients, such as minerals, vitamin C, folate and phenolic substances, most of which are natural antioxidants and contribute to the high nutritional quality of the fruit. All these compounds are essential for health and, in particular, strawberry phenolics are best known for their antioxidant and anti-inflammatory action, and possess directly and indirectly antimicrobial, anti-allergy and antihypertensive properties, as well as the capacity to inhibit the activities of some physiological enzymes and receptor properties. Spray drying of strawberry juice is important in order to handle the market demand throughout the year. Drying as a preservation method may be an alternative for a better utilization of strawberry juice, creating new varieties of products and make available throughout the year. Spray drying can be used to convert strawberry juice into stable powder with new possibilities of industrial applications. Value addition is desirable from both the producer's as well as the consumer's point of view.

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