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Variable Spray Drying Parameters in Production of Passion Fruit (*Passiflora* Edulis) Dried Powder

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Abstract.
Passion fruit juice, highly acidic and with a characteristic, intense flavor, constitutes a good source of niacin, riboflavin and vitamins C and A. It is a seasonal fruit and it is not available all year round. Only a very small proportion of the yearly harvest reaches the international market, mainly due to the lack of a good method of preservation that facilitates transportation and storage. Spray drying can also be used to process the passion fruit juice (*Passiflora edulis*) and obtain a powdered product, which is stable and suitable for storage and transportation. Spray-drying is a unit operation by which a liquid product is atomized in a hot gas current to instantaneously obtain a powder. Stickiness of fruit juice powders occurs at temperatures normally prevailing in spray dryers. Stickiness problem during spray drying of fruit juices can be minimized by use of high molecular weight drying carrier agents which increase the glass transition temperature of resulting powder. The aim of this work was to study the feasibility of spray drying of passion fruit juice. Various characteristics of spray-dried fruit juice powders are well affected by spray-drying conditions including kind of atomization, inlet spray drying temperature, feed flow rate, juice concentration, drying carrier agent.

Keywords: *Passion fruit, spray drying, powder, atomization, carrier agent*

I. Introduction

Passion fruit (*Passiflora edulis*) belongs to the family Passifloraceae, is an attractive high value crop. An aromatic mass of double-walled, membranous sacs containing orange colour pulpy juice and as many as 250 small, dark brown to black pitted seeds, inside the fruit are the edible portion. The fruit is round or ovoid and has a tough, smooth, waxy dark purple or yellow hued rind with faint, fine white specks. The fruit has high nutritional and medicinal value. A ripe fruit is refreshing, delicate flavour with pleasing aroma and high nutritive value. It is a rich source of Vitamin A and C and contains fair amounts of iron, potassium, sodium, magnesium, sulphur and chlorides and has dietary fibre and protein. Fruits are eaten fresh or processed into products like jams, squash, juice, cakes, pies and ice-cream (Rocky Thokchom and Goutam Mandal, 2017). Yellow passion fruit (*Passiflora edulis*) it is predominantly utilized in juice processing (Meletti, 2011). Passion fruit cannot be stored for more than eight days at 25 °C (Paula Becker Pertuzatti et al., 2015). The juice of the passion fruit is very difficult to be spray-dried, because the total sugar is composed of fructose (45%) glucose (46%) and sucrose (9%) (Vera et al., 2003) and their Tg values are 5 °C, 31°C and 62 °C, respectively (Bhandari and Howes, 1999).

Spray drying process is considered a conventional method to convert fruit juices to powder form. Process of spray-drying consists of three basic steps, including atomization, droplet-hot air contact and moisture evaporation, and separation of dry product from the exit air (Khalid Muzaffar et al., 2018). The initial liquid feeding the spray-dryer can be a solution, an emulsion or a suspension (Gharsallaoui et al., 2007). The resulting dried product conforms to powders, granules or agglomerates, the form of which depends upon the physical and chemical properties of the feed and the dryer design and operation. The characteristics of spray-dried fruit juice and pulp powders depends on spray-drying conditions including concentration of drying carrier agent used, inlet air temperature, feed flow rate, feed characteristics etc. (Chegini et al., 2008). Spray-dryers come in different forms/patterns including cocurrent, counter current and mixed-flow. Cocurrent spray-dryers (where the feed droplets travel in the same direction as that of the drying gas flow) are most common and widely used dryers when compared to other systems (Zbicinski et al., 2002).

There were several research mentioned to spray drying of passion fruit. 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 passion fruit juice (Ruiz Cabrera Miguel Angel et al., 2009). A work was to microencapsulate passion fruit juice (PFJ) by spray-drying in two different biopolymers blends: Gum Arabic-mesquite gum-maltodextrin (H. Carrillo-Navas et al., 2011). Passion fruit juice was encapsulated with *n*-octenylsuccinate-derivatised starch using a spray-dryer and stored at two different temperatures (DanielaBorrmann et al., 2013).

Spray drying is one of the most complex methods for fruit juice drying. Passion fruit juice is very sensitive and affected the different drying parameters. The aim of this work was to study the feasibility of spray drying of passion fruit juice. Various characteristics of spray-dried fruit juice powders well affected by spray-drying conditions including kind of atomization, inlet spray drying temperature, feed flow rate, juice concentration, drying carrier agent were examined.

II. Material And Method

2.1 Material

Fresh passion fruits were collected from Hau Giang province, Vietnam. The fruits were washed and cut into halves, discarding the skins and keeping only the pulp, which was treated with the enzymatic method to obtain the juice suitable for atomization. The juice was stored at –18 °C and later defrosted at the room temperature right before the experiment.

2.2 Researching method

2.2.1 Effect of kind of atomizations to moisture content, water activity, total phenolic, ascorbic acid, carotenoid,

bulk density, total plate count, sensory score in spray-dried powder

Different kinds of atomizations such as rotary atomizer, pressure nozzle, pneumatic nozzle and sonic nozzle were 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 (m**g GAE/g**), ascorbic acid (mg/100g), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score.

2.2.2 Effect of inlet spray drying temperature to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, total plate count, sensory score in spray-dried powder

Different inlet air drying temperature (120^{o}C, 130^{o}C, 140^{o}C, 150^{o}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), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score.

2.2.3 Effect of speed flow rate to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, total plate count, sensory score in spray-dried powder

Different speed flow rate (5, 10, 15, 20 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 (m**g** GAE/g), ascorbic acid (mg/100g), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score.

2.2.4 Effect of juice concentration to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, total plate count, sensory score in spray-dried powder

Different juice concentrations (55%, 60%, 65%, 70%) were 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), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score.

2.2.5 Effect of drying carrier agents to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, total plate count, sensory score in spray-dried powder

Different drying carrier agents such as maltodextrin, gum arabic, modified starch, whey protein concentrate were 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), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score.

2.3 Physico-chemical, microbial and sensory evaluation

Moisture content (%) was determined by comparing the weights of the sample with the electronic balance. Water actitity (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 (2002). Ascorbic acid (mg/ 100g) was measured by 2,6-dichlorophenolindophenol titration. Carotenoid content (mg/ 100g) was calculated by measuring the absorbance at 450 nm using a spectrophotometer (Jagannath, Napjappa, Das Gupta, & Bawa, 2006). 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 (Gallo,et al., 2011). The total plate count (cfu/g) was enumerated during the storage period by Petrifilm - 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.

2.4 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 Statgraphics Centurion XVI.

III. RESULT & DISCUSSION

3.1 Effect of kind of atomizations to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, total plate count, sensory score in spray-dried powder

Atomization is the most important stage in spray-drying process, which converts the fluid feed into tiny droplets/particles (Murugesan and Orsat, 2012). The atomization is achieved by atomizers which are generally classified as rotary atomizers, pressure nozzles, pneumatic nozzles and sonic nozzles (Cal and Sollohub, 2010). Atomizers are selected based upon the feed which needs to be dried and targeted final properties of the dried product as well as the particle size (Murugesan and Orsat, 2012).

From table 1, sonic nozzle is better than other atomizations such as rotary atomizer, pressure nozzle, pneumatic nozzle so we choose sonic nozzle for further experiments.

3.2 Effect of inlet spray drying temperature to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, 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 (Phisut, N., 2012). According to Walton (2000), 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 (Goula & Adamopoulos, 2008) or a lower residual moisture content (Chengini & Ghobadian, 2005), which may be the reason why bulk density decreased dramatically as the inlet airdrying temperature increased.

From table 2, the optimal inlet spray drying temperature should be 140^{o}C so we choose this value for further experiments.

Ferrari et al. (2012) 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.

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 (Yue Shi et al., 2018).

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 (Tuyet T. A. Tran and Ha V. H. Nguyen, 2018).

3.3 Effect of speed flow rate to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, 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 (G.R. Chegini and B. Ghobadian, 2007). Different speed flow rate (5, 10, 15, 20 ml/ min) was examined. From table 3, the optimal speed flow rate was noticed at 15 ml/min so this value was selected for further experiments.

Chegni et al. (2005) 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.

3.4 Effect of juice concentration to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, total plate count, sensory score in spray-dried powder

High moisture content in the fruit leads to have high water activity which can cause quality loss in fruits by increasing the chances of enzyme activity and microbial growth. Therefore, the reducing moisture content and water activity in fruits is always desirable to maintain the quality.

From table 4, the juice concentration was optimal at 65% so this value was selected for further experiments.

Spray drying of orange juice with 65% concentration was studied. Inlet air temperature and feed flow rate have significant effect on the dryer yield and wall deposit of spray dryer individually and jointly. Also with the addition of liquid glucose, the optimum conditions have been obtained with feed flow rate of 15 ml min, inlet air temperature of 130°C and outlet air temperature of 85°C. For the orange powder 1 containing 2% moisture, the sticky point temperature was 44°C (G.R. Chegini and B. Ghobadian, 2007).

Table 1. Effect of kind of atomizations to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score in spray-dried powder

Kind of atomization	Rotary atomizer	Pressure nozzle	Pneumatic nozzle	Sonic nozzle
Moisture (%)	5.41 ± 0.01^{a}	5.39 ± 0.02^{ab}	5.39 ± 0.01^{ab}	5.37 ± 0.03^{b}
Water activity (a_w),	0.32 ± 0.02^{a}	0.31 ± 0.01^{ab}	0.31 ± 0.03^{ab}	0.30 ± 0.01^{b}
Total phenolic (mg GAE/g)	57.38 ± 0.01^{b}	57.40 ± 0.03^{ab}	57.41 ± 0.00^{ab}	57.43 ± 0.02^{a}
Ascorbic acid (mg/ 100g)	64.75 ± 0.02^{b}	64.77 ± 0.01^{ab}	64.77 ± 0.01^{ab}	64.82 ± 0.01^{a}
Carotenoid (mg/ 100g)	25.24 ± 0.01^{ab}	25.26 ± 0.03^{ab}	25.26 ± 0.02^{ab}	25.29 ± 0.00^{a}
Bulk density (g/ml)	0.37 ± 0.02^{a}	0.36 ± 0.01^{ab}	0.36 ± 0.01^{ab}	0.35 ± 0.01^{b}
Total plate count (cfu/g)	$1.2x10^{1}\pm0.01^{a}$	$1.1x10^{1}\pm0.02^{ab}$	$1.1x10^{1}\pm0.02^{ab}$	$1.0x10^{1}\pm0.00^{b}$
Sensory score	7.45 ± 0.01^{b}	7.46 ± 0.00^{ab}	7.47 ± 0.00^{ab}	7.49 ± 0.02^{a}

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%).

Table 2. Effect of inlet spray drying temperature (120, 130, 140, 150°C) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score in spray-dried powder

Inlet spray drying temperature (°C)	120°C	130°C	140°C	150°C
Moisture (%)	5.37 ± 0.03^{a}	5.35 ± 0.02^{ab}	5.34 ± 0.02^{ab}	5.33 ± 0.02^{b}
Water activity (a_w),	0.30 ± 0.01^{a}	0.30 ± 0.03^{a}	0.30 ± 0.01^{a}	0.29 ± 0.01^{a}
Total phenolic (mg GAE/g)	57.43 ± 0.02^{b}	57.45 ± 0.02^{ab}	57.48 ± 0.02^{a}	57.44 ± 0.03^{ab}
Ascorbic acid (mg/ 100g)	64.82 ± 0.01^{b}	64.84 ± 0.01^{ab}	64.87 ± 0.01^{a}	64.83 ± 0.01^{ab}
Carotenoid (mg/ 100g)	25.29 ± 0.00^{b}	25.30 ± 0.02^{ab}	25.34 ± 0.00^{a}	25.31 ± 0.02^{ab}
Bulk density (g/ml)	0.35 ± 0.01^{a}	0.34 ± 0.00^{ab}	0.32 ± 0.01^{b}	0.34 ± 0.03^{ab}
Total plate count (cfu/g)	$1.0x10^{1}\pm0.00^{a}$	$1.1x10^{1}\pm0.02^{a}$	$1.1x10^{1}\pm0.02^{a}$	$1.0x10^{1}\pm0.02^{a}$
Sensory score	7.49 ± 0.02^{b}	7.51 ± 0.00^{ab}	7.54 ± 0.00^{a}	7.50 ± 0.03^{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%).

Table 3. Effect of different speed flow rate (5, 10, 15, 20 ml/ min) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score in spray-dried powder

Speed flow rate (ml/ min)	5	10	15	20
Moisture (%)	5.34 ± 0.02^{b}	5.35 ± 0.01^{ab}	5.35 ± 0.01^{ab}	5.36 ± 0.01^{a}
Water activity (a_w),	0.30 ± 0.01^{b}	0.31 ± 0.02^{ab}	0.32 ± 0.00^{ab}	0.33 ± 0.03^{a}
Total phenolic (mg GAE/g)	57.48 ± 0.02^{a}	57.50 ± 0.00^{a}	57.50 ± 0.01^{a}	57.50 ± 0.01^{a}
Ascorbic acid (mg/ 100g)	64.87 ± 0.01^{a}	64.87 ± 0.02^{a}	64.87 ± 0.02^{a}	64.87 ± 0.02^{a}
Carotenoid (mg/ 100g)	25.34 ± 0.00^{a}	25.34 ± 0.01^{a}	25.34 ± 0.03^{a}	25.34 ± 0.03^{a}
Bulk density (g/ml)	0.32 ± 0.01^{b}	0.32 ± 0.01^{b}	0.33 ± 0.02^{b}	0.36 ± 0.01^{a}
Total plate count (cfu/g)	$1.1x10^{1}\pm0.02^{a}$	$1.1x10^{1}\pm0.01^{a}$	$1.1x10^{1}\pm0.01^{a}$	$1.0x10^{1}\pm0.01^{a}$
Sensory score	7.54 ± 0.00^{b}	7.57 ± 0.00^{ab}	7.60 ± 0.03^{a}	7.52 ± 0.01^{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%).

Table 4. Effect of juice concentration (55%, 60%, 65%, 70%) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score in spray-dried powder

Juice concentration (%)	55	60	65	70
Moisture (%)	5.35 ± 0.01^{b}	5.37 ± 0.02^{ab}	5.38 ± 0.03^{ab}	5.41 ± 0.02^{a}
Water activity (a_w),	0.32 ± 0.00^{b}	0.33 ± 0.01^{ab}	0.35 ± 0.01^{ab}	0.38 ± 0.01^{a}
Total phenolic (mg GAE/g)	57.50 ± 0.01^{a}	57.50 ± 0.03^{a}	57.50 ± 0.00^{a}	57.50 ± 0.03^{a}
Ascorbic acid (mg/ 100g)	64.87 ± 0.02^{a}	64.87 ± 0.01^{a}	64.87 ± 0.03^{a}	64.87 ± 0.01^{a}
Carotenoid (mg/ 100g)	25.34 ± 0.03^{a}	25.34 ± 0.03^{a}	25.34 ± 0.01^{a}	25.34 ± 0.01^{a}
Bulk density (g/ml)	0.33 ± 0.02^{b}	0.33 ± 0.00^{b}	0.34 ± 0.01^{ab}	0.36 ± 0.02^{a}
Total plate count (cfu/g)	$1.1x10^{1}\pm0.01^{a}$	$1.1x10^{1}\pm0.00^{a}$	$1.1x10^{1}\pm0.02^{a}$	$1.0x10^{1}\pm0.00^{a}$
Sensory score	7.60 ± 0.03^{b}	7.63 ± 0.01^{ab}	7.68 ± 0.01^{a}	7.54 ± 0.00^{c}

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%).

Table 5. Effect of spray drying carrier agents (maltodextrin, arabic gum, modified starch, whey protein concentrate) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), carotenoid (mg/ 100g), bulk density (g/ml), total plate count (cfu/g), sensory score in spray-dried powder

Juice concentration (%)	Maltodextrin	Arabic gum	Modified starch	Whey protein concentrate
Moisture (%)	5.38 ± 0.03^{b}	5.40 ± 0.03^{ab}	5.31 ± 0.01^{ab}	5.41 ± 0.01^{a}
Water activity (a_w),	0.35 ± 0.01^{b}	0.36 ± 0.02^{ab}	0.37 ± 0.02^{ab}	0.39 ± 0.02^{a}
Total phenolic (mg GAE/g)	57.50 ± 0.00^{a}	57.47 ± 0.01^{ab}	57.43 ± 0.01^{b}	57.46 ± 0.01^{ab}
Ascorbic acid (mg/ 100g)	64.87 ± 0.03^{a}	64.83 ± 0.02^{ab}	64.78 ± 0.00^{b}	64.82 ± 0.02^{ab}
Carotenoid (mg/ 100g)	25.34 ± 0.01^{a}	25.31 ± 0.01^{ab}	25.28 ± 0.00^{b}	25.30 ± 0.03^{ab}
Bulk density (g/ml)	0.34 ± 0.01^{b}	0.36 ± 0.03^{ab}	0.38 ± 0.02^{a}	0.36 ± 0.01^{ab}
Total plate count (cfu/g)	$1.1x10^{1}\pm0.02^{a}$	$1.1x10^{1}\pm0.01^{a}$	$1.1x10^{1}\pm0.01^{a}$	$1.0x10^{1}\pm0.01^{a}$
Sensory score	7.68 ± 0.01^{a}	7.54 ± 0.03^{ab}	7.50 ± 0.00^{b}	7.55 ± 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%).

3.5 Effect of drying carrier agents to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, total plate count, sensory score in spray-dried powder

Maltodextrins are products of starch hydrolysis, consisting of D-glucose units linked mainly by α (1→4) glycosidic bonds. Maltodextrins are low cost and very useful for spray drying process on food materials (Bemiller and Whistler, 1996). Gum Arabic is natural plant exudates of Acacia trees, which consists of a complex heteropolysaccharide with highly ramified structure. It is the only gum used in food products that shows high solubility and low viscosity in aqueous solution, making easier the spray drying process (Rodriguez-Hernandez et al., 2005). Starch is a major carbohydrate easily extractable from various native sources, like potato, maize, corn, wheat. Since time immemorable various attempts are being made in order to modify this highly flexible polymer with an aim to enhance the positive attributes and eliminate the short comings of the native starches (Kavlani Neelam et al., 2012). Whey protein concentrate contains a low level of fat and cholesterol but, in general, have higher levels of bioactive compounds, and carbohydrates in the form of lactose (Hemant H Gangurde et al., 2011). Different drying carrier agents such as maltodextrins, gum Arabic, modified starches and proteins are used in spray-drying to minimize the stickiness problem (Caliskan and Drim, 2013; Sahin-Nadeem, 2013; Rascon et al., 2011). Some authors (Jaya and Das, 2004; Krishnan et al., 2005) have proposed the combination of maltodextrin, arabic gum, modified starch, and anticaking agents like glycerol monostearate and tricalcium phosphate as yet another alternative. According to Quek et al. (2007), maltodextrins and gum Arabic are mainly used in spray drying due to their high solubility and low viscosity that are important properties of the spray-dried powder. Additionally, there are few reports found that the combination of gum Arabic and maltodextrin in spray drying was more efficient than using them separately (Krishnan, S. et al., 2005; Fernandes, R.V.D.B. et al., 2014).

From table 5, maltodextrin was better than other carrier agents so this substance was appropriate for application.

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 passion fruit 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 (Ruiz Cabrera Miguel Angel et al., 2009).

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 (H. Carrillo-Navas et al., 2011).

Ferrari et al. (2012) 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.

Passion fruit juice was encapsulated with *n*-octenylsuccinate-derivatised starch using a spray-dryer and stored at two different temperatures. Octenylsuccinate-derivatised starch showed to be an interesting material for the encapsulation of passion fruit juice, and spray-drying proved itself as an inexpensive alternative to freeze-drying, capable of retaining vitamin C during a long time of storage, and easy to be diluted in order to reconstitute the passion fruit juice for human consumption (DanielaBorrmann et al., 2013).

Mishra et al. (2014) 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.

Suhag and Nanda (2015) studied the effect of spray-drying process conditions to develop nutritionally rich honey powder using whey protein concentrate (WPC) as drying carrier agent. The results revealed that increasing inlet air temperature lowered the bulk density, antioxidant activity, total phenolic content and vitamin C, but increased powder hygroscopicity. With increase in WPC concentration, there was increase in the bulk density and decrease in powder hygroscopicity. Increase in concentration of WPC showed positive effect on total phenolic content, antioxidant activity and retention of vitamin C in honey powder, which is related to superior encapsulation property of WPC and also prevented oxidative damage due to oxidation.

Muzaffar et al. (2018), 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. Increase in concentration of maltodextrin significantly increased the powder recovery and 20% of maltodextrin was required for successful spray drying of pomegranate juice (powder recovery > 50%). Color values of pomegranate juice powder were significantly influenced by concentration of maltodextrin. With increase in concentration of maltodextrin powder, lightness (L* value) increased from 45.54 to 74.46, a* value decreased from 20.43 to 11.45 and b* value decreased from 2.16 to −3.83.

IV. CONCLUSION

Spray drying of fruit juices 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 passion fruit, creating new varieties of products and make available throughout the year. Spray drying can be used to convert passion fruit juice into stable powder with new possibilities of industrial applications.

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