Nguyen Phuoc Minh et al /J. Pharm. Sci. & Res. Vol. 11(4), 2019, 1416-1421

ISSN:0975-1459
Journal of Pharmaceutical Sciences and Research
www.jpsr.pharmainfo.in

Some Factors Influencing the Properties of Dried Watermelon Powder during Spray Drying

Nguyen Phuoc Minh[1,*], Tran Thi Yen Nhi[2], Tran Ngoc Nguyen[3], Son Ngoc Bich[4], Duong Thi Thanh Truc[5]

[1]*Faculty of Chemical Engineering and Food Technology, Nguyen Tat Thanh University, Ho Chi Minh, Vietnam*
[2]*NTT Hi-Tech Institute, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam*
[3]*Bac Lieu University, Bac Lieu Province, Vietnam*
[4]*An Giang University, An Giang Province, Vietnam*
[5]*Can Tho University, Can Tho City, Vietnam*

Abstract.

The process of spray drying consists in transforming a product from fluid to a solid state in the form of powder, through the dispersion of the product's droplets inside a chamber, where it gets in contact with hot air. Spray drying results from application of energy, which acts on the liquid to the point of causing its rupture and disintegration, in order to divide it into millions of individual particles, thereby creating a mist or spray of droplets. Watermelon is an important fruit crop. Watermelon flesh contains high quantity of vitamins, minerals and other antioxidant compounds which play important role in human metabolism. Antioxidant components help in preventing human disease by acting as oxygen radical scavenger. Watermelon rind and seed also have many health benefits due to the presence of important amino acids citrulline, fibres, minerals and phenolic compounds. The aim of this work was to study the feasibility of spray drying of watermelon 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 (160°C: 85°C), speed flow rate (18 ml/ min), arabic: maltodextrin (4: 6 % w/v) were appropriated for spray drying of dried watermelon powder from its juice. The spray-dried product of arabic gum-maltoxetrin-watermelon juice was considered to be the good technique to dry watermelon juice on the result of phytochemical determination, physical and chemical properties and antioxidant activity. Value addition of watermelon 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 watermelon produce.

Keywords: *Watermelon juice, spray drying, dried powder, inlet air, out let air, speed flow rate carrier agent*

I. INTRODUCTION

Watermelon (*Citrullus lanatus*) botanically considered as the fruit is belonging to the family Cucurbitaceae (Edwards et al., 2003). It is a large, sprawling annual plant with coarse, hairy pinnately-lobed leaves and yellow flowers. It is grown for its edible fruit, which is a special kind of berry botanically called a pepo. The watermelon fruit has deep green smooth thick exterior rind with grey or light green vertical stripes. Inside the fruit is red in colour with small black seeds embedded in the middle third of the flesh. Watermelons range in shape from round to oblong. Rind colours can be light to dark green, with or without stripes. Flesh colours can be dark red, red or yellow. Watermelons can be stored for 14 days at 15°C. Watermelons should not be stored with apples and bananas as the ethylene produced during storage from these fruits hastens softening and development of off flavour to watermelons. Watermelon contains more than 91% water and up to 7% of carbohydrates. It is a rich source of lycopene and citrulline. Watermelon rind contains more amounts of citrulline then flesh. Additionally, watermelon has a number of essential micronutrients and vitamins (Reetu and Maharishi Toma, 2017). Watermelon contains high levels of lycopene that is very effective in protect cells from damage and lower the risk of heart disease. Watermelon extracts help to reduce hypertension and lower blood pressure in obese adults. Watermelon fruit is also a good source of potassium. Potassium is an important component of cell and body fluids that helps controlling heart rate and blood pressure. Thus, it prevents against stroke and coronary heart diseases (Le et al., 2005).

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). The spray-dried fruit powder provides more stability to the nutrients and other active substances present in the fruit (Krishnaiah et al. 2014). Also, spray-dried powder can be readily reconstituted, has low water activity and is suitable for transport and storage at room temperature (Kha et al. 2010). This lowers the storage and transportation costs as compared with the raw fruits.

Not many researches mentioned to processing of watermelon juice. A study was conducted using Büchi mini spray dryer B-191 to produce spray-dried watermelon powders using two different maltodextrin concentrations (3% and 5%) as the encapsulating agent and four different inlet temperatures (145 °C, 155 °C, 165 °C and 175 °C) (Quek, Siew Youn et al., 2007). Fruit juice from watermelon was spray dried with 20% maltodextrin and studied for physicochemical, phytochemical and antioxidant properties (Sangeeta Saikia et al., 2014). The effect of the inlet temperature on the quality of watermelon powder after spray drying was evaluated (Yue Shi et al., 2018). Watermelon juice 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 watermelon juice 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 carrier agent were examined.

II. MATERIAL AND METHOD

2.1 Material

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

Figure 1. Watermelon fruit

2.2 Researching method

2.2.1 Effect of inlet and outlet air spray drying temperature to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, yield, solubility, hygroscopicity, total plate count, sensory score in spray-dried powder

Different inlet: outlet air drying temperature (140^{o}C: 75^{o}C, 150^{o}C: 80^{o}C, 160^{o}C: 85^{o}C, 170^{o}C: 90^{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), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score.

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

Different speed flow rate (6, 12, 18, 24 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), **yield (%), solubility (%),** hygroscopicity (%), total plate count (cfu/g), sensory score.

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

Different ratio of drying carrier agent by arabic gum: maltodextrin (2:8, 4:6, 6:4, 8:2% 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), carotenoid (mg/ 100g), bulk density (g/ml), yield (%), solubility **(%),** hygroscopicity (%), 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. 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 (Sangeeta Saikia et al., 2014). The solubility (%) was determined according to the method described by Chau et al. (2007). 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 spraydried powder samples were placed in pre-weighed glass vials and placed in a desiccator 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.

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 inlet/ outlet spray drying temperature to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, yield, solubility, hygroscopicity, total plate count, sensory score in spray-dried powder

The main advantages of this type of drying process are its high yield and a reduction of the product of exposure time to high temperatures. This, in turn, reduces the thermal damage caused to the product (Samantha Serra Costa et al., 2015). 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 air drying temperature increased.

From table 1, the optimal inlet/ outlet spray drying temperature should be 160^{o}C: 85^{o}C so we choose this value for further experiments. A study was conducted using Büchi mini spray dryer B-191 to produce spray-dried watermelon powders using two different maltodextrin concentrations (3% and 5%) as the encapsulating agent and four different inlet temperatures (145 °C, 155 °C, 165 °C and 175 °C). The spray-dried watermelon powders were analysed for moisture content, dissolution, water activity, colour, lycopene and β-carotene. Results demonstrated that as inlet temperature increased, the moisture content and dissolution decreased. However, there were no significant changes in the water activities of the spray-dried powders for all the inlet temperatures investigated. Colormetric analyses showed that the L*, a*, b*, hue and chroma values changed with the inlet temperatures. The results were well correlated to the lycopene and β-carotene contents of the spray-dried powders (Quek, Siew Youn et al., 2007). 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. 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. 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).

3.2 Effect of speed flow rate to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, 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 (G.R. Chegini and B. Ghobadian, 2007). Different speed flow rate (6, 12, 16, 24 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 1. Effect of inlet/ outlet spray drying temperature (140^{o}C: 75^{o}C, 150^{o}C: 80^{o}C, 160^{o}C: 85^{o}C, 170^{o}C: 90 ^{o}C) to moisture content (%), water activity (a_w), total phenolic (mg GAE/g), ascorbic acid (mg/ 100g), carotenoid (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 (^{o}C)	**140^{o}C: 75^{o}C**	**150^{o}C: 80^{o}C**	**160^{o}C: 85^{o}C**	**170^{o}C: 90^{o}C**
Moisture (%)	5.38 ± 0.02^{a}	5.36 ± 0.02^{ab}	**5.35 ± 0.02^{ab}**	5.34 ± 0.02^{b}
Water activity (a_w)	0.31 ± 0.01^{a}	0.30 ± 0.03^{a}	**0.30 ± 0.01^{a}**	0.29 ± 0.01^{a}
Total phenolic (mg GAE/g)	53.14 ± 0.01^{c}	53.88 ± 0.01^{b}	**54.11 ± 0.00^{a}**	53.21 ± 0.03^{bc}
Ascorbic acid (mg/ 100g)	24.48 ± 0.01^{ab}	24.50 ± 0.01^{ab}	**24.54 ± 0.01^{a}**	24.37 ± 0.00^{b}
Carotenoid (mg/ 100g)	18.92 ± 0.02^{b}	19.04 ± 0.02^{ab}	**19.22 ± 0.00^{a}**	19.01 ± 0.02^{ab}
Bulk density (g/ml)	0.35 ± 0.01^{a}	0.34 ± 0.03^{ab}	**0.32 ± 0.01^{b}**	0.34 ± 0.01^{ab}
Yield (%)	77.34 ± 0.02^{b}	77.93 ± 0.02^{ab}	**78.12 ± 0.01^{a}**	77.89 ± 0.02^{ab}
Solubility (%)	62.06 ± 0.01^{b}	63.94 ± 0.02^{ab}	**65.40 ± 0.02^{a}**	63.72 ± 0.01^{ab}
Hygroscopicity (%)	12.68 ± 0.02^{a}	12.31 ± 0.00^{ab}	**12.04 ± 0.01^{b}**	12.27 ± 0.00^{ab}
Total plate count (cfu/g)	$1.2x10^{1}\pm0.00^{a}$	$1.2x10^{1}\pm0.01^{a}$	**$1.2x10^{1}\pm0.01^{a}$**	$1.2x10^{1}\pm0.02^{a}$
Sensory score	7.60 ± 0.01^{b}	7.64 ± 0.01^{ab}	**7.75 ± 0.01^{a}**	7.68 ± 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 2. Effect of different speed flow rate (6, 12, 18, 24 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), yield (%), solubility (%), hygroscopicity (%), total plate count (cfu/g), sensory score in spray-dried powder

Speed flow rate (ml/ min)	**6**	**12**	**16**	**24**
Moisture (%)	5.35 ± 0.02^{a}	5.35 ± 0.01^{a}	**5.36 ± 0.01^{a}**	5.36 ± 0.01^{a}
Water activity (a_w)	0.30 ± 0.01^{a}	0.30 ± 0.02^{a}	**0.31 ± 0.02^{a}**	0.31 ± 0.02^{a}
Total phenolic (mg GAE/g)	54.11 ± 0.00^{b}	54.22 ± 0.03^{ab}	**54.29 ± 0.03^{a}**	54.17 ± 0.01^{ab}
Ascorbic acid (mg/ 100g)	24.54 ± 0.01^{b}	24.59 ± 0.01^{ab}	**24.64 ± 0.00^{a}**	24.57 ± 0.03^{ab}
Carotenoid (mg/ 100g)	19.22 ± 0.00^{b}	19.34 ± 0.02^{ab}	**19.45 ± 0.00^{a}**	17.28 ± 0.00^{ab}
Bulk density (g/ml)	0.32 ± 0.01^{b}	0.32 ± 0.03^{a}	**0.33 ± 0.03^{a}**	0.33 ± 0.03^{a}
Yield (%)	78.12 ± 0.01^{d}	80.46 ± 0.01^{c}	**82.77 ± 0.01^{b}**	83.89 ± 0.02^{a}
Solubility (%)	65.40 ± 0.02^{d}	67.09 ± 0.00^{c}	**69.35 ± 0.02^{a}**	68.24 ± 0.01^{b}
Hygroscopicity (%)	12.04 ± 0.01^{a}	11.95 ± 0.02^{ab}	**11.90 ± 0.02^{b}**	12.00 ± 0.03^{ab}
Total plate count (cfu/g)	$1.2x10^{1}\pm0.01^{a}$	$1.2x10^{1}\pm0.01^{a}$	**$1.2x10^{1}\pm0.01^{a}$**	$1.2x10^{1}\pm0.00^{a}$
Sensory score	7.75 ± 0.01^{b}	7.81 ± 0.01^{ab}	**7.93 ± 0.00^{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%).

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

Arabic gum: Maltodextrin (% w/v)	**2:8**	**4:6**	**6:4**	**8:2**
Moisture (%)	5.35 ± 0.02^{a}	**5.35 ± 0.01^{a}**	5.36 ± 0.01^{a}	5.36 ± 0.01^{a}
Water activity (a_w)	0.30 ± 0.01^{a}	**0.30 ± 0.03^{a}**	0.30 ± 0.02^{a}	0.31 ± 0.02^{a}
Total phenolic (mg GAE/g)	54.37 ± 0.03^{ab}	**54.40 ± 0.01^{a}**	54.34 ± 0.01^{ab}	54.29 ± 0.03^{b}
Ascorbic acid (mg/ 100g)	24.74 ± 0.02^{ab}	**24.79 ± 0.02^{a}**	24.73 ± 0.00^{ab}	24.64 ± 0.00^{b}
Carotenoid (mg/ 100g)	17.49 ± 0.01^{ab}	**17.69 ± 0.01^{a}**	19.52 ± 0.03^{ab}	19.45 ± 0.00^{b}
Bulk density (g/ml)	0.30 ± 0.03^{b}	**0.31 ± 0.03^{ab}**	0.32 ± 0.02^{ab}	0.33 ± 0.03^{a}
Yield (%)	83.90 ± 0.01^{b}	**84.40 ± 0.01^{a}**	83.28 ± 0.01^{c}	82.77 ± 0.01^{d}
Solubility (%)	69.88 ± 0.01^{ab}	**70.85 ± 0.03^{a}**	70.41 ± 0.01^{ab}	69.35 ± 0.02^{b}
Hygroscopicity (%)	11.84 ± 0.02^{ab}	**11.60 ± 0.02^{b}**	11.76 ± 0.02^{ab}	11.90 ± 0.02^{a}
Total plate count (cfu/g)	$1.3x10^{1}\pm0.01^{a}$	**$1.3x10^{1}\pm0.01^{a}$**	$1.3x10^{1}\pm0.01^{a}$	$1.2x10^{1}\pm0.01^{a}$
Sensory score	8.06 ± 0.03^{ab}	**8.15 ± 0.03^{a}**	7.97 ± 0.03^{ab}	7.89 ± 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%).

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. 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 (Pimolmart Rattanaburee et al., 2017).

3.3 Effect of ratio of drying carrier agents to moisture content, water activity, total phenolic, ascorbic acid, carotenoid, bulk density, yield, solubility, hygroscopicity, 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. Gum Arabic is natural plant exudates of Acacia trees, which consists of a complex heteropolysaccharide with highly ramifed 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)

From table 3, ratio of arabic gum: maltodextrin (4: 6 % w/v) was appropriate for application. In another research, fruit juice from watermelon was spray dried with 20% maltodextrin and studied for physicochemical, phytochemical and antioxidant properties. In watermelon powder, decrease in total phenolic content and total flavonoid content was observed (Sangeeta Saikia et al., 2014). 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 watermelon juice 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. Razzaq A et al., (2017) reported that fresh apricot pulp (100 mL) with 15 g of Arabic gum, diluted by additon of distll water to adjust Brix at 20° was processed through a lab scale spray dryer with inlet temperature at 190°C. These drying parameters were observed as the best drying conditons for maximum producton of Apricot powder (9.1%). 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. 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).

IV. CONCLUSION

Watermelons are very good source of important nutritive components and contained a very high concentration of nutrients for human consumption. It also contains different components of medicinal values. Additionally, watermelon rind and seed is a rich source of an important amino acid and minerals. These exceptional qualities of watermelon and its products warrant us to use it for health benefits. The process of spray drying consists of the transformation of a product in fluid form to the solid state in the form of powder. This is done through the dispersion of droplets from the product inside a chamber, in contact with hot air. In this process, substances known as carriers or encapsulating agents can be added, aiming at facilitating or even allowing the drying of certain products. Spray drying of watermelon 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 watermelon juice, creating new varieties of products and make available throughout the year. Spray drying can be used to convert watermelon juice 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.

REFERENCES

1. Cai, Y.Z. and Corke, H. (2000). Production and properties of spray dried Amaranthus betacyanim pigments. *J. Food Sci.* 65: 1248–1252.
2. H. Carrillo-Navas, D. A. Gonzalez-Rodea, J. Cruz-Olivares, J.F. Barrera-Pichardo, A. Roman-Guerrero and C. Perez-Alonso (2011). Storage stability and physicochemical properties of palmyra palm juice juice microcapsules by spray-drying. *Revista Mexicana de Ingeniería Química* 10(3): 421-430.
3. Chau, C.F., Wang, T.Y. and Wen, L.Y. (2007). Different micronization methods significantly improve the functionality of carrot insoluble fibre. *Food Chem.* 100: 1402–1408.
4. Chegini, G. R., & Ghobadian, B. (2005). Effect of spray drying conditions on physical properties of orange juice powder. *Drying Technology* 23: 657–668.
5. G.R. Chegini and B. Ghobadian (2007). Spray dryer parameters for fruit juice drying. *World Journal of Agricultural Sciences* 3 (2): 230-236.
6. G.R. Chegini, J. Khazaei, B. Ghobadian, and A.M. Goudarzi (2008). Prediction of process and product parameters in an orange juice spray dryer using artificial neural networks. *Journal of Food Engineering* 84: 534– 543.
7. Edwards AJ, Vinyard BT, Wiley ER, Brown ED, Collins JK, Perkins-Veazie P (2003). Consumption of watermelon juice increases plasma concentrations of lycopene and β-carotene in humans. *Journal of Nutrition* 133: 1043-1050.
8. C.C. Ferrari, S.P.M. Germer and J.M. de Aguirre (2012). Effects of spray-drying conditions on the physicochemical properties of blackberry powder. *Drying Technology* 30: 154-163.
9. Gallo, L., Llabot, J. M., Allemandi, D., Bucalá, V., & Piña, J. (2011). Influence of spray-drying operating conditions on *Rhamnus purshiana* (*Cáscara sagrada*) extract powder physical properties. *Powder Technology* 2018: 205–214.
10. Gharsallaoui, G. Roudaut, O. Chambin, A. Voilley and R. Saurel (2007). Applications of spray-drying in microencapsulation of food ingredients: An overview. *Food Research International* 40: 1107–1121.
11. Goula, A. M., & Adamopoulos, K. G. (2008). Effect of maltodextrin addition during spray drying of tomato pulp in dehumidified air: I. Drying kinetics and product recovery. *Drying Technology* 26(6): 714–725.
12. Jagannath, J. H., Napjappa, C., Das Gupta, D., & Bawa, A. S (2006). Studies on the stability of an edible film and its use for the preservation of carrots (*Daucus carota*). *International Journal of Food Science and Technology* 41: 498-506.
13. Kha, T.C., Nguyen, M.H. And Roach, P.D. (2010). Effects of spray drying conditions on the physicochemical and antioxidant properties of the Gac (*Momordica cochinchinensis*) fruit aril powder. *J. Food Eng.* 98: 385–392.
14. Khalid Muzaffar, Gulzar Ahmad Nayik, Pradyuman Kumar (2018). Production of Fruit Juice Powders by Spray Drying Technology. *International Journal of Advance Research in Science and Engineering* 07(03): 59-67.
15. Krishnaiah, D., Nithyanandam, R. And Sarbatly, R. (2014). A critical review on the spray drying of fruit extract: Effect of additives

on physicochemical properties. *Crit. Rev. Food Sci. Nutr.* 54: 449–473.

16. P. Mishra, S. Mishra and C.L. Mahanta (2014). Effect of maltodextrin concentration and inlet temperature during spray drying on physicochemical and antioxidant properties of alma (*Emblica officinalis*) juice powder. *Food Bioproduct and Processing* 92: 252–258.
17. Phisut, N. (2012). Spray-drying technique of fruit juice powder: Some factors influencing the properties of products. *Int. Food Res. J.* 19: 1297–1306.
18. Pimolmart Rattanaburee, Thanaporn Amnuaikit, and Jindaporn Puripattanavong (2017). Physicochemical properties of spray-dried young coconut juice. *International Journal of Pharma Medicine and Biological Sciences* 6(2): 43-47.
19. Quek, Siew Young & King Chok, Ngan & Swedlund, Peter. (2007). The physiochemical properties of spray-dried watermelon powders. *Chemical Engineering and Processing: Process Intensification* 46: 386-392.
20. Reetu and Maharishi Toma (2017). Watermelon: A valuable horticultural crop with nutritional benefits. *Popular Kheti* 5(2): 5-9.
21. Rocha, A. M. C. N., & Morais, A. M. B. B. (2002). Polyphenoloxidase activity and total phenolic content as related to browning of minimally processed ‘Jonagored’ apple. *Journal of the Science of Food and Agriculture* 82: 120-126.
22. Rodriguez-Hernandez, G.R., Gonzalez-Garcia, R., GrajalesLagunes, A. and Ruiz-Cabrera, M.A. (2005). Spraydrying of cactus pear juice (*Opuntia streptacantha*): Effect on the physicochemical properties of powder and reconstituted product. *Drying Technology* 23: 955–973.
23. Ruiz Cabrera Miguel Angel, Lucía Carolina Espinosa-Muñoz, Carlos Aviles-Aviles, Raúl González-García, Mario Moscosa-Santillán, Alicia Grajales-Lagunes and Miguel Abud-Archila (2009). Spray-drying of palmyra palm juice juice using lactosemaltodextrin blends as the support material. *Brazilian Archives of Biology and Technology* 52(4): 1011-1018.
24. Samantha Serra Costa, Bruna Aparecida Souza Machado, Adriana Regina Martin, Fabio Bagnara, Sandro Andre Ragadalli and Aline Rabello Costa Alves (2015). Drying by spray drying in the food industry: Micro-encapsulation, process parameters and main carriers used. *African Journal of Food Science* 9(9): 462-470.
25. Sangeeta Saikia, Nikhil Kumar Mahnot and Charu Lata Mahanta (2014). Effect of spray drying of four fruit juices on physicochemical, phytochemical and antioxidant properties. *Journal of Food Processing and Preservation* 1: 1-9.
26. Tuyet T. A. Tran and Ha V. H. Nguyen (2018). Effects of spray-drying temperatures and carriers on physical and antioxidant properties of lemongrass leaf extract powder. *Beverages* 4(84): 1-14.
27. Walton, D. E. (2000). The morphology of spray-dried particles. A qualitative view. *Drying Technology* 18(9): 1943–1986.
28. Zbicinski, C. Strumillo and A. Delag (2002). Drying kinetics and particle residence time in spray drying. *Drying Technology* 20: 1751-1768.
29. Yue Shi, Jing Wang, Yubin Wang, Huijuan Zhang, Yue Ma, Xiaoyan Zhao and Chao Zhang (2018). Inlet temperature affects spray drying quality of watermelon powder. *Czech J. Food Sci.*, 36(4): 321–328.