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Spray Drying Parameters Affecting to Dried Powder from Palmyra Palm (*Borassus flabellifer*) Juice

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Abstract.

Palmyra palm juice from palm tree (*Borassus flabelliffer*) is a seasonal and low priced drinking juice. This juice has a commercial and medicinal value. The aim of this work was to study the feasibility of spray drying of palmyra palm 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 (140°C: 85°C), speed flow rate (12 ml/ min), arabic: maltodextrin (5: 5 % w/v) were appropriated for spray drying of dried palmyra palm powder from its juice. The spray-dried product of arabic gum-maltoxetrin-palmyra palm juice was considered to be the good technique to dry palmyra palm juice on the result of phytochemical determination, physical and chemical properties and antioxidant activity. Value addition of palmyra palm 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 palmyra palm produce.

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

I. INTRODUCTION

Palmyra palm (*Borassus flabellifer* L.) belonging to the family Palmae. The coconut like fruits are three sided when young, becoming rounded or more or less oval, 12-15 cm wide, and capped at the base with overlapping sepals (Morton, 1988). It is referred to as tree of life with several uses including food, beverage, fibre, medicinal and timber (Ghosh et al., 2012; A. K. Chaurasiya et al., 2014). Traditionally the different parts of the plant such as root, leaves, fruit, and seeds are used for various human disorders. Leaves are used for thatching, mats, baskets, fans. Flowers of *B. flabellifer* were investigated for analgesic and antipyretic effects, anti-inflammatory activity, haematological, biochemical parameters, and immunosuppressant property. The different parts of the plant are being used for medicinal properties like antihelminthic and diuretic (Veda Priya Gummadi et al., 2016). Various by-products like palm sugar and gur (molasses) are also prepared from the juice extracted from tree trunk. The juice contains sugars, proteins, lipids, vitamin A, B-complex, vitamin C and others minerals (Barhet al., 2008). It has also been reported to possess immunosuppressant properties (Revesz et al., 1999). The palm sugar can be produced from the palm juice by boiled down into syrup or crystallized into a palm sugar (Rao *et al.*, 2009). Toddy is also another fermented product produced from palm juice. The juice that has been collected without lime being added to the receptacle is called toddy. The immature soft juicy seed nuts are used as a soft natural drink to protect against hot summer. The soft orange-yellow mesocarp pulp of the ripe fruit is sugary, dense and edible, rich in vitamin A and C. The fruit pulp of *B. flabellifer* has been used in traditional dishes and the sap, has been used as a sweetener for diabetic patients. Borassus also contains bitter compound called flabelliferrins, which are steroidal saponins (Sandhya et al. 2010; Veda Priya Gummadi et al., 2016). Ripe fruit pulp can be processed into soft beverages, jam, toffee, delicious food items and sweets. These fruits are suitable candidates for popularization through value addition and income generation and thus livelihood security to the marginal farmers (Anuradha Srivastava et al., 2017). However, the commercialization of dried powder is still scanty.

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.

Several researches mentioned to processing of palmyra palm juice. Optimizing process conditions for palm (*Borassus flabelliffer*) wine fermentation using Response Surface Methodology was examined (Ghosh, S. et al., 2012). A study examined palm vinegar fermentation and applies response surface methodology to determine an optimal composition of palm vinegar fermentation media (Satyabrata Ghosh et al., 2014). A study investigated the physicochemical and functional properties of plamyra fruit pulp (Vijayakumari et al., 2014). Palmyra palm juice is similar to young coconut juice. In another study, physicochemical properties, antioxidant activity and phytochemical determinations of young coconut juice (YCJ) from *Cocos nucifera* L. (Arecaceae) and spray-dried maltodextrin (MD) mixed YCJ powder (MD-YCJ powder) were evaluated (Pimolmart Rattanaburee et al., 2017). A study aimed to investigate the best condition of the fermentation of palmyra palm sap to be ethanol using co-culture of Saccharomyces cerevisiae and Pichia stipitisin different variables such as pH, initial inoculum and sugar concentration to get the best ethanol fermentation yield (Widjaja, Tri et al., 2017). A research specifically extracted Palmyra Palm fruit pulp, assess the proximate composition and develop value-added products from the fresh pulp like palm spread, palm cream and palm toffee (Moses Kwaku Golly et al., 2017). However there was no any research mentioned to spray drying of palmyra palm juice. Palmyra palm 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 palmyra palm 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 palmyra palm 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. Palmyra palm fruit and its juice harvesting

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 (120°C: 75°C, 130°C: 80°C, 140°C: 85°C, 150°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), 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 (4, 8, 12, 16 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 (4:6, 5:5, 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), 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

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 1, the optimal inlet/ outlet spray drying temperature should be 140^{o}C: 85^{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. 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 (4, 8, 12, 16 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.

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).

Table 1. Effect of inlet/ outlet spray drying temperature (120^{o}C: 75^{o}C, 130^{o}C: 80^{o}C, 140^{o}C: 85^{o}C, 150^{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)	120^{o}C: 75^{o}C	130^{o}C: 80^{o}C	140^{o}C: 85^{o}C	150^{o}C: 90^{o}C
Moisture (%)	5.38 ± 0.01^{a}	5.36 ± 0.03^{ab}	**5.35 ± 0.01^{ab}**	5.34 ± 0.01^{b}
Water activity (a_w)	0.31 ± 0.00^{a}	0.30 ± 0.01^{a}	**0.30 ± 0.02^{a}**	0.29 ± 0.02^{a}
Total phenolic (mg GAE/g)	49.52 ± 0.03^{b}	49.59 ± 0.03^{ab}	**49.63 ± 0.01^{a}**	49.57 ± 0.01^{ab}
Ascorbic acid (mg/ 100g)	24.48 ± 0.00^{ab}	24.50 ± 0.00^{ab}	**24.54 ± 0.03^{a}**	24.37 ± 0.00^{b}
Carotenoid (mg/ 100g)	17.65 ± 0.01^{b}	17.73 ± 0.01^{ab}	**17.80 ± 0.01^{a}**	17.69 ± 0.00^{ab}
Bulk density (g/ml)	0.35 ± 0.02^{a}	0.34 ± 0.02^{ab}	**0.32 ± 0.02^{b}**	0.34 ± 0.02^{ab}
Yield (%)	80.12 ± 0.01^{b}	81.24 ± 0.01^{ab}	**82.49 ± 0.03^{a}**	80.36 ± 0.03^{ab}
Solubility (%)	58.60 ± 0.02^{b}	60.13 ± 0.01^{ab}	**62.09 ± 0.01^{a}**	60.23 ± 0.01^{ab}
Hygroscopicity (%)	12.01 ± 0.00^{a}	11.78 ± 0.03^{ab}	**11.60 ± 0.02^{b}**	11.94 ± 0.02^{ab}
Total plate count (cfu/g)	$1.3\text{x}10^{1}\pm0.01^{a}$	$1.3\text{x}10^{1}\pm0.01^{a}$	**$1.3\text{x}10^{1}\pm0.02^{a}$**	$1.3\text{x}10^{1}\pm0.02^{a}$
Sensory score	7.68 ± 0.02^{b}	7.73 ± 0.00^{ab}	**7.80 ± 0.00^{a}**	7.70 ± 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 (4, 8, 12, 16 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)	4	8	12	16
Moisture (%)	5.35±0.01^{a}	5.35±0.02^{a}	**5.36±0.03^{a}**	5.36±0.02^{a}
Water activity (a_w)	0.30±0.02^{a}	0.30±0.03^{a}	**0.30±0.01^{a}**	0.30±0.01^{a}
Total phenolic (mg GAE/g)	49.63±0.01^{b}	49.69±0.01^{ab}	**49.72±0.02^{a}**	49.70±0.02^{ab}
Ascorbic acid (mg/ 100g)	24.54±0.03^{b}	24.58±0.00^{ab}	**24.63±0.01^{a}**	24.60±0.01^{ab}
Carotenoid (mg/ 100g)	17.80±0.01^{b}	17.82±0.00^{ab}	**17.85±0.00^{a}**	17.83±0.03^{ab}
Bulk density (g/ml)	0.32±0.02^{a}	0.32±0.01^{a}	**0.33±0.01^{a}**	0.33±0.00^{a}
Yield (%)	82.49±0.03^{d}	82.73±0.02^{c}	**82.94±0.02^{b}**	83.00±0.01^{a}
Solubility (%)	62.09±0.01^{a}	62.05±0.02^{ab}	**62.03±0.00^{ab}**	62.01±0.00^{b}
Hygroscopicity (%)	11.60±0.02^{b}	11.62±0.01^{ab}	**11.63±0.01^{ab}**	11.65±0.01^{a}
Total plate count (cfu/g)	1.3x10^{1}±0.02^{a}	1.3x10^{1}±0.00^{a}	**1.3x10^{1}±0.03^{a}**	1.3x10^{1}±0.01^{a}
Sensory score	7.80±0.00^{b}	7.84±0.03^{ab}	**7.89±0.01^{a}**	7.82±0.02^{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)	4:6	5:5	6:4	7:3
Moisture (%)	5.36±0.02^{a}	**5.36±0.01^{a}**	5.36±0.01^{a}	5.36±0.03^{a}
Water activity (a_w)	0.30±0.01^{a}	**0.30±0.03^{a}**	0.30±0.02^{a}	0.30±0.01^{a}
Total phenolic (mg GAE/g)	49.83±0.03^{a}	**49.80±0.01^{ab}**	49.77±0.01^{ab}	49.72±0.02^{b}
Ascorbic acid (mg/ 100g)	24.70±0.02^{a}	**24.69±0.02^{ab}**	24.65±0.00^{ab}	24.63±0.01^{b}
Carotenoid (mg/ 100g)	17.90±0.01^{a}	**17.90±0.01^{a}**	17.87±0.03^{ab}	17.85±0.00^{b}
Bulk density (g/ml)	0.30±0.03^{a}	**0.31±0.03^{ab}**	0.32±0.02^{ab}	0.33±0.01^{b}
Yield (%)	84.43±0.01^{a}	**83.85±0.01^{b}**	83.04±0.01^{bc}	82.94±0.02^{c}
Solubility (%)	62.30±0.01^{ab}	**62.38±0.03^{a}**	62.21±0.01^{ab}	62.03±0.00^{b}
Hygroscopicity (%)	11.52±0.02^{b}	**11.52±0.02^{b}**	11.58±0.02^{ab}	11.63±0.01^{a}
Total plate count (cfu/g)	1.3x10^{1}±0.01^{a}	**1.3x10^{1}±0.01^{a}**	1.3x10^{1}±0.01^{a}	1.3x10^{1}±0.03^{a}
Sensory score	8.11±0.03^{ab}	**8.42±0.03^{a}**	7.95±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%).

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 (5: 5 % w/v) 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 palmyra palm 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

Borassus flabellifer is a medicinal plant with innumerable medicinal qualities for all parts. Spray drying of palmyra palm 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 palmyra palm juice, creating new varieties of products and make available throughout the year. Spray drying can be used to convert palmyra palm 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.

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