Effect of Inlet Temperature in Pineapple and *Centella Asiatica L.* Spray Drying

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***Abstract*—Spray drying is one of the method to convert fruit juice into powder form to improve shelf life and easy transportation but it tend to become sticky due to high sugar content especially in Moris pineapple. The effect of addition of CAL with maltodextrin as carrier agent and inlet air temperature towards physicochemical of pineapple powder were studied. The spray dryer model used was a laboratory scale dryer and samples were run at different inlet temperatures of 130°C, 150°C, and 170°C. Maltodextrin was used as a carrier agent at different concentrations of 20%, 30% and 40% (w/v) while CAL at 5%, 10% and 15% (v/v) respectively. The pineapple powder were then analyzed for pH, sugar levels, moisture content, bulk density, antioxidant activity, product yield and colour. pH powder slightly increased from 3.80-3.96 to 3.81-4.02. Sugar level decreased significantly after spray drying from 19.0-29.9°Brix to 6.6-9.7°Brix. At higher inlet temperatures and increment of maltodextrin content, the moisture content of pineapple powder decreased from 6.03-6.12% to 5.28-5.48%. The highest bulk density is 0.58 g/ml at 130°C and 40% concentration. Product yield increased with increasing of inlet temperature from 5.57% to 8.89%. The colour of powder produced is light green yellowish affected by CAL juice. The antioxidant activity showed best at 130°C where it obtained positive value. As a conclusion, the best condition of spray drying to be at 170°C and 40% maltodextrin concentration due to its low moisture content, high bulk density and product yield. The addition of CAL also does affect the physicochemical properties due to it contain high moisture content, dark green in colour, pH value at 5.5 and high antioxidant level.**

Keywords— spray drying, pineapple, Centella, maltodextrin

I. INTRODUCTION

Pineapple or also known as Morris pineapple cultivars are most popular as freshly consumed fruits in Malaysia. Seventy percent of the fresh pineapple fruit produced in Malaysia is from 'Nanas Moris'.The fruit is conical, deep-yellow, with deep eyes which require a thick cut to remove the peel completely and it is less fibrous. It is juicy and sweet, of fine flavor with a small and tender core. Fruits are spiny, golden yellow in color and emit pleasant aroma and flavor when ripe. Total soluble solid (TSS) varies from 10^{o} to 14^{o} Brix depending upon the stage of maturity and season, have range of pH 4 to 4.5 and its water content is 80% to 90% [1]. The bioactivity of this fruit is due to the presence of compounds such as polyphenols and ascorbic acid or also known as Vitamin C, which contribute to the antioxidant activity of the fruit extract [2].

In order to convert pineapple juice in liquid state to powder form which in solid state, spray drying method has been used. Spray drying is a method used widely in food processing industries especially in production of fruit juice powder and it is operated according optimum process state to form powders with good quality and low water activity [3]. There are many advantages of fruit juice in powder form instead of in liquid condition such as lowering weight and volume, easier handling and transportation, minimize packaging and much longer shelf life. However, there are some issues in the spray dryer production, the dried powder usually contain large amount of simple sugars which may cause stickiness. The particles intend to stick to one another and to the dryer and remain at the cyclone wall which will further formed thick wall deposits, while very little product comes out at the dryer's exit [4].

There are several of spray drying parameters that affect the quality of spray dried product. The factors are types of carrier agent used, temperature of inlet air, carrier agent concentration, flow rate of slurry feed, drying air flowrate and types of atomizer [5]. Maltodextrin is a carrier agent commonly used in fruit juice spray drying. Maltodextrins are products of enzymatic disintegration of gluco-sidic bonds of starch and are classify by dextrose equivalent (DE) value of less than 20 [6]. It can minimize stickiness and affect the physicochemical properties of pineapple powder.

Centella Asiatica L. (CAL) are going to be studied to add with maltodextrin as food additive in processed powder. CAL, or locally known as pegaga, is an aromatic smelling herb of the family *Umbelliferare.* It is a slender, creeping plant, rooting at the nodes, growing in the damp areas in different tropical countries. The demand of CAL in food and beverages industry has improving due to its good to human health such as antioxidant, wound treating and improving memory [7]. Various vital bioactive compounds that exists in CAL such as triterpene saponins, phenolic compounds, vitamins, minerals, free amino acids, and polyacetylenic compounds. Triterpene saponins occurring in CAL include primarily two triterpene glycosides which are asiaticoside and madecassoside and corresponding aglycones which are asiatic acid and madecassic acid [8].

The outcome of this study is to produce pineapple powder using maltodextrin with addition of CAL as the food additives and also to investigate the effect of inlet temperature and carrier agent concentrations towards the physicochemical properties of pineapple powder.

II. METHODOLOGY

2.1 Material

Moris pineapple were peeled and cut into a small pieces. Then, tap water was used to wash pineapple and CAL. The proportion to prepare the pineapple juice and CAL juice is 1:2 to ratio with distilled water and blend using brand Tefal model BL8011 about 3 minutes. The pineapple and CAL puree were then pushed through a sock sieve to extract the juice.

2.2 Juice Preparation for Spray Drying

Pineapple juice was measured to 250 ml. Then, 5% (v/v) of CAL added into pineapple juice. 50 grams of maltodextrin for 20% (w/v) was added with mixture of pineapple and CAL juice. The mixture stirred by using magnetic stirrer at 30°C for 10 minutes. Once dissolved, pH and sugar level were measured by using pH meter model FiveGo brand Mettler Toledo and refractometer model A1908 respectively. This procedure were repeated at 10% and 15% (v/v) for CAL concentration while 30% and 40% (w/v) for maltodextrin concentration.

2.3. Spray Drying Settings

The mixture of pineapple, CAL juice and maltodextrin were spray dried by using brand Lab Plant model SD-Basic at inlet temperature of 130°C and pump speed 4 for each of different maltodextrin concentration. The flowrate for each batch of juice was measured the time taken for each batch volume of juice to finish spray dry. The outlet temperature reading for each batch of juice were recorded. This steps were repeated with 150°C and 170°C inlet temperature.

2.4. Powder Physicochemical Analysis

2.4.1 pH value

A 1 gram of powder was dissolved in 10 ml of distilled water. Then, the pH solution was measured by using pH meter.

2.4.2. Sugar level

Refractrometer was used to measure the sugar level of powder solution by put 2 drop of solution at the slit of refractrometer and Brix value was read through eyepiece.

2.4.3. Moisture content

A 5 grams of powder were weighed in moisture pan and distributed the powder evenly to maximize the surface area for evaporation. Then, moisture pan was transferred into moisture analyzer brand Sartorius model MA 35 and close its cover. The heating is set at 105°C for 10 minutes. The moisture content in percentage is recorded.

2.4.4. Product yield

Weight of powder yield and weight of a batch of juices is measured by using weigh balance. The product yield is calculated by using this formula:

Yield (%) = Weight of Powder / Weight of Juice X 100%

2.4.5.Bulk density

2 gram of pineapple powder was freely poured into a 10 ml glass graduated cylinder and the samples were repeatedly tapped manually by lifting and dropping the cylinder under its own weight at a vertical distance of 10 cm high until negligible difference in volume between succeeding measurements was observed. Given the mass m and the apparent (tapped) volume V of the powder, the powder bulk density was computed as m/V (g/mL).

2.4.6. Colour

Colour of powder sample were measured by using chromameter brand Konica Minolta model CR-400. A bulk of powder were spread on petri dish. Then, the lens of chromameter was put on top of the powder and the colour analysis were printed out from printer.

2.4.7. Antioxidant Analysis using DPPH Method

2.4.7.1. Extraction of Antioxidant

100 mg of powder were extracted with 10 ml of 80% methanol for 30 minutes on a hot plate. Then, the extracted was centrifuged using brand Sartorius model Sigma 3-18K at 5000 rpm for 15 minutes to separate all suspended solid.

2.4.7.2. Preparation of DPPH solution

3.94 mg of 2,2-diphenyl-1-picrylhydrazyl (DPPH) solid was weighed and dissolved it with pure methanol in 100 ml volumetric flask. 0.1 mM of DPPH solution were prepared and the solution was left for 30 minutes in dark room and covered with aluminium foil.

Temperature (°C)	Conc. MD (w/v)%	Conc. CAL (v/v)%	pH		Sugar Level (°Brix)	
			Juice	Powder	Juice	Powder
130	20	5	3.87	3.75	19.1	6.6
	30	10	3.95	4.02	23.3	8.0
	40	15	3.88	3.95	29.3	8.8
150	20	5	3.80	3.81	19.0	7.3
	30	10	3.96	3.87	23.3	9.1
	40	15	3.90	4.01	29.1	9.7
170	20	5	4.02	3.95	19.1	7.7
	30	10	3.86	3.90	24.7	8.4
	40	15	3.85	3.96	29.9	9.4

2.4.7.3 Absorbance Reading

1 ml of extracted solution is added with 3 ml of DPPH methanol solution and shake vigorously. The mixture was left to stand for 30 minutes in dark place before reading the absorbance at 517 nm by using UV-Vis Spectrophotometer brand Agilent Technologies model Cary 60 UV-Vis. Methanol was used as the blank. For control, 1 ml methanol is added with 3 ml of DPPH methanol solution. Each of the absorbance reading were taken and the percentage of antioxidant activity were calculated by using this formula:

$$\text{Antioxidant Activity (\%)} = \text{Absorbance}_{control} - \text{Absorbance}_{sample} / \text{Absorbance}_{control} \times 100\%$$

III. RESULTS AND DISCUSSION

3.1 Spray Drying Operation

Spray dryer were operated at three different inlet temperature at 130°C, 150°C, 170°C and three different maltodextrin concentration 20%, 30% and 40% at constant pump speed 4 for all samples run. For each sample run, time for juice samples to completely pump into spray dryer were taken and volumetric flowrate of juice were calculated. Outlet temperature were also recorded.

At pump speed 4, it shows that the average flowrate of juice pumped into spray dryer for all sample run is 11 ml/min. The feed flowrate plays an important part to produce a good quality of powder. Higher flow rates of feed suggest in a shorter contact time between the feed and drying air and making the heat exchange least efficient and in this manner caused the lower water evaporation. When higher feed rates were utilized, a dripping inside the main chamber was observed, when the slurry feed was drop directly to the chamber and that was not fully atomized resulting lower yield [9]. Same results obtained when orange juice were sprayed dry at different feed flowrate at 15, 20, 25 and 30 ml/min found that bulk density and product yield decreased while moisture content increased with increasing of feed flowrate [10].

The outlet temperature shows increment with increasing of inlet temperature by 12°C and 3°C. The outlet temperature indicates the maximum temperature of the product achieved and the thermal exposure of the sample during spray drying [11]. This result is supported by the study of lulo pulp spray drying, where outlet temperature increased with increasing of inlet temperature [12]. Outlet temperature has a significant effect on the powder properties. In the same study, it shows that higher outlet temperature reduced moisture content and increased process yield.

3.2 Physicochemical Analysis

3.2.1 pH and Sugar Level

pH and sugar level of juice and powder were measured to determine its changes after spray drying process. Tablem1 shows the pH and sugar level of pineapple juice and pineapple powder.

Table 1: pH and Sugar Level for Pineapple Juice and Powder

From the pH value obtained, most of the powder shows an increment from pineapple juice even though the increments are not consistent. This increment occurred due to addition of CAL that have pH 5.4. Maltodexrin also affect the pH value of powder that has pH 4.7 [13].

The results from sugar level are occurred due to most of the soluble solid which is sugar were evaporated along with water throughout spray drying process and also some the soluble solid were suck out through exhaust flow at cyclone. Same study found that °Brix value of pineapple juice transform to spray dried powder were decreased from 14.8°Brix to 2.93°Brix [14].

3.2.2 Moisture Content

Moisture content is important parameters for spray-dried powders, indicating overall drying performance. A good spray drying process necessary to have low moisture content at below 5% to ensure it have longer shelf life and to minimize the activity of microorganism in the fruit powder. Moisture content were measured by using moisture analyzer brand Sartorius model MA 35 at temperature 105°C for 10 minutes. Figure 1 shows the moisture content for each sample run.

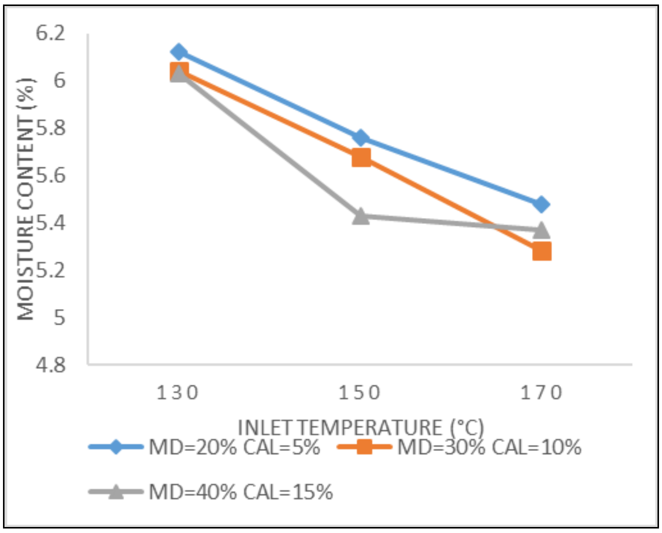

Figure 1: Moisture Content Plot for Pineapple Powder

Moisture content were slightly decreased with increasing of inlet temperature. This is due to the faster heat transfer between the product and drying air. At higher inlet air temperatures, there is a greater temperature gradient between the atomized feed and drying air and it results the greatest driving force for water evaporation [9]. Thus, powders with less moisture content were formed. Same observation obtained the moisture content of pineapple powder spray dried at range at 140°C to 200°C at 10% of maltodextrin reduced from 1.5% to 1.22% [15].

It is also shows that moisture content were decreased with increasing of maltodextrin concentration at the same inlet temperature. Increased content of the carrier agent reduced the free water amount for evaporation. The moisture content reduced from 5.5% to 4.6% while at 150°C, the moisture content reduced from 4.9% to 4% with increasing of maltodextrin concentration from the recent study [4]. Moisture content obtained from that study also much lower. This is due to addition of CAL into feed solution that has high moisture content which is 87.7% [7].

3.2.3 Bulk Density

Bulk density is one of the important criteria of good quality of spray dried powder. Powders with higher bulk density have a greater packaging volume for the same amount of material. Figure 2 shows bulk density plot for each powder sample.

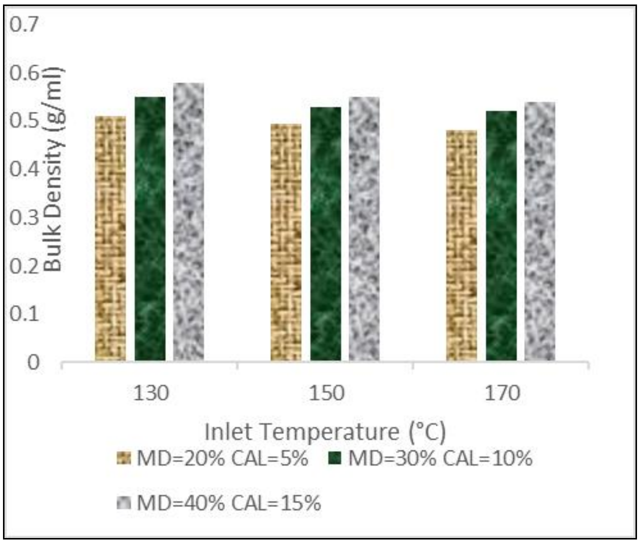

Figure 2: Bulk Density Plot for Pineapple Powder

Bulk density shows a slightly decreasing trends with increasing of inlet temperature. This can be explained by faster evaporation rate results in more porous or fragmented particles due to inflation of particle are formed [16]. In general, porous or fragmented particle shows low particle density, which leads to relatively low bulk density. This is also affected by the moisture content which reduced its bulk density, because water is denser than most dry food solids. From previous study, spray drying of black mulberry juice at 110°C to 150°C where increasing inlet air temperature caused a reduction in bulk density. At 110°C, the bulk density is 0.52 g/cm^3 reduced to 0.48 g/cm^3 at 150°C [6].

This results also shows that bulk density increased with increasing of maltodextrin concentration. This was explained by the increase in the total solid content of the feed. A study of spray drying of pomegranate juice where increasing of maltodextrin concentration increased the bulk density of powder [17].

3.2.4 Product Yield

Product yield is an important indicator for the industry since higher yield means more benefit. Figure 3 shows product yield plot for pineapple powder.

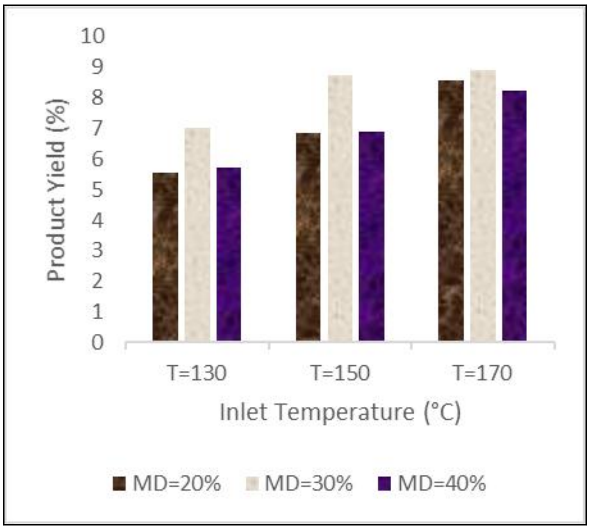

Figure 3 Product Yield Plot for Pineapple Powder

From this plot, product yield shows increment trend with increasing of inlet temperature for all concentration. This phenomena is due more efficient heat and mass transfer processes occur at higher temperatures and also high temperature is decreasing the probability of hitting inadequate drying particles to the wall of the drying chamber [18].

At same temperature with different concentration, the product yield obtained inconsistent. The highest yield for all temperature is at 30% concentration. This is due to higher maltodextrin concentration reduced the wall deposition, reduce stickiness and increased the yield percentages by increasing the glass transition temperature [19].

3.2.5 Colour

Color is one of the major parameter of dried food product. L* value defines the lightness of sample, a* denotes redness and greenness and b* denotes the yellowness and blueness. Table 2 shows the colour properties for powder samples.

Table 2: Colour Properties of Powder

Inlet Temperature (°C)	Conc. MD (w/v)%	Conc. CAL (v/v)%	Colour		
			*L	*a	*b
130	20	5	95.6	-4.0	8.8
	30	10	94.7	-4.5	9.9
	40	15	93.9	-4.7	11.0
150	20	5	94.8	-4.4	10.4
	30	10	94.7	-4.1	10.4
	40	15	92.5	-3.3	9.8
170	20	5	96.6	-2.6	8.1
	30	10	95.4	-2.5	8.5
	40	15	92.2	-5.4	13.2

Based on result, all of powder samples have high lightness, a* is negative value and *b in positive values. It shows that the powder is light green yellowish in colour. High value in lightness are affected by the high concentration of maltodextrin white in colour. The negative *a value mostly due to from CAL juice. Same observation obtained in CAL spray drying study, where its colour properties are 91.76 *L, -1.20 *a and 12.36 *b [20].

3.2.6 Antioxidant Analysis

Antioxidant analysis is crucial to determine how much antioxidant level from juice can be retained after spray drying process. From the analysis, the antioxidant activity of pineapple juice and CAL juice are at 75.58% and 78.9% respectively. Table 3 shows the antioxidant activity for powder samples.

Table 3: Antioxidant Activity of Powder

Inlet Temperature (°C)	Conc. MD (w/v)%	Conc. CAL (v/v)%	Antioxidant Activity (%)
130	20	5	30.54
	30	10	12.5
	40	15	-12.43
150	20	5	-52.12
	30	10	-73.56
	40	15	-54.23
170	20	5	5.25
	30	10	-4.98
	40	15	-5.15

Based from the results, there were inconsistent antioxidant activity from powder samples. Most of the powder samples have negative value of antioxidant activity and did not turn colour from purple to yellowish after addition with DPPH solution. The varied results could be due to the reaction of the various phenolic compounds present in the fruit juices to the heat applied during the drying process. Although, phenolic compounds are generally heat liable, individual phenolic compounds have different degree of tolerance to heat and the structural degradation and rearrangement hence in turn affect its content and activity. The conformational change in phenolics could either render them more soluble and extractable in the extracting solvent or make them less soluble thus affecting their quantification [21].

IV. Conclusion

Spray drying of the juice samples had both positive and adverse effects on the final product's quality and antioxidant activity. The physicochemical properties such of the final product varied depending on the condition of spray drying such as inlet temperature and concentration of carrier agents. The analysis shows that the best condition of spray drying to be at 170°C and 40% maltodextrin concentration due to its low moisture content, high bulk density and product yield. The addition of CAL also does affect the physicochemical properties of powder such as moisture content, colour and pH value. The recommendation for future work from this study is to analyze the physicochemical properties of powder with using other condition of spray drying such as types of carrier agent, feed flowrate and types of atomizer. The antioxidant activity also can be analyze by using other method such as Folin-Ciocalteu's reagent and Ferric reducing power assay.

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