CRYSTALLIZATION OF PINEAPPLE SKIN JUICE EXTRACTION BY USING SPRAY DRYING TECHNIQUE

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Abstract— Pineapple contains bromelain which known to be natural source of bioactive compound that gives benefits to health purposes. However, high moisture content of the fruit makes it easily perishable and difficult to store and handle. In order to overcome this issue, spray drying technique is implement to convert liquid food products into powder form because the dried powder products will have a longer shelf life at ambient temperature, easy to handle and low cost of transportation. In this research, the juice extracted from the skin of pineapple was spray-dried and the characterization of the resulting powder was determined. The combined crystallization and drying of pineapple skin juice extraction was performed in a pilot-scale spray dryer with a varying parameters of operating conditions. The spray drying process is unique because it includes both particle formation and drying. Optimization of spray drying process was carried out using different inlet temperatures of 130°C, 140°C and 150°C and maltodextrin concentrations of 15%, 20% and 25 % w/w. The effect of different parameters on physicochemical properties such as powder yield, pH, moisture content, bulk density and soluble solid content was analyzed. This research demonstrates that the effect of inlet temperature and carrier agent concentration play a vital role in determining the physicochemical properties of fruit extract powder.

Keywords*—Pineapple skin juice, spray drying, maltodextrin, physicochemical properties*

I. INTRODUCTION

Pineapple have important sources of vitamins and carbohydrates. It is one of the famous Malaysia tropical fruit and the demand is increasing throughout the year. Nowadays, people are educated and well aware with good eating habit for healthy lifestyle thus the trend of the food intake has changed from high calories meal to healthy diet enrichment. This situation make the fresh fruit demand increased in the global market. However, the demand for fresh consumption of fresh fruit like pineapple is quite difficult because pineapple has a high moisture and sugar content. This has causes the pineapple fruit to have a short shelf life and easily perishable thus the availability of them is limited throughout the year. The preservation of fresh fruit is the method implement in order to handle the excessive demand throughout the year. The method of drying is used in this preservation to reduce the moisture content and water activity in the fresh fruits. By reducing the moisture content and water activity in the fruit, it will leads to decrease in enzyme activity and microbial growth thus maintain the quality in fruit.

In this fast economic development years, many techniques of drying have invented such as spray drying, freeze drying, vacuum drying, oven drying and others are used to achieve better product quality in the industries. This study is specifically to transform the fresh pineapple skin juice into dry particulates by using spray drying techniques. Among all the techniques mentioned, spray drying is the most suitable technique used to form powders from fresh pineapple skin juice. By transforming fruit juices into powder form, it is not just another method of drying for perishable fruits, but also it also enhancing the value of the product development as instant powders or flavoring agents which can be incorporated into beverages or food products.

Spray drying is a method of drying that involves hot and dry air which evaporate the solvent and transformed the finely atomized droplets into powder form. This is the most used method of drying for many heat-sensitive materials such as pharmaceuticals and foods.

The product of spray-dried powder has a huge advantages such as low moisture content and water activity, higher quality and minimize storage for easier transportation.

However, different operating parameter of spray dryer systems resulting in different quality of spray-dried powder. Hence, the objective of this research is to study some of the factors such as inlet temperature and concentration of carrier agents affecting the properties of obtained spray-dried powder.

The inlet temperature of the drying air is the key factor that affects the quality of the obtained powders (Rodríguez-Hernández, G.R, R., & et. al., 2005). Inlet temperatures can gives effect to properties of the spray-dried powder such as powder yield, moisture content, bulk density and soluble solid content.

Despite having a lot of advantages in spray-drying method, there is also challenge during spray drying process such as issue of stickiness of powder cause by the natural properties of the fruit. This problem is common in handling fruit with high sugar content like pineapple. Such issue resulting in operational problem and low product yield. Thus, this problem can be encounter by using a carrier agent in the spray drying method to avoid a huge amount of deposition on the drying chamber wall. The most common carrier agent is widely used is Maltodextrin which helps to reduce the stickiness of the powder.

The glass transition temperature (Tg) of the feed rises with the addition of maltodextrin thus result in higher difference in product temperature and the glass transition temperature of feed (Bhandari & Howes, 2005).

Maltodextrin concentration also affect the quality of spray-dried powder. At low concentration of maltodextrin, the powder tends to be stickier.

Based on research study on the effect of maltodextrin concentrations on spray-dried powder presented by Quek et al. (2007), the feed of watermelon juice without maltodextrin resulted in very low powder yield accumulated at the collector. The powder produced were very sticky and mostly are deposited onto the drying chamber. The addition of higher content of maltodextrin to the juice mixture obtained a higher yield compared to lower content of maltodextrin.

Thus, maltodextrin is a useful material in spray drying process which results in improving the yield of powder of spray-dried watermelon juice.

Maltodextrin facilitate drying by reducing the stickiness of spray-dried product. This can be achieve because maltodextrin has the ability to alter the surface stickiness low molecular weight sugars. (Quek et. al, 2007)

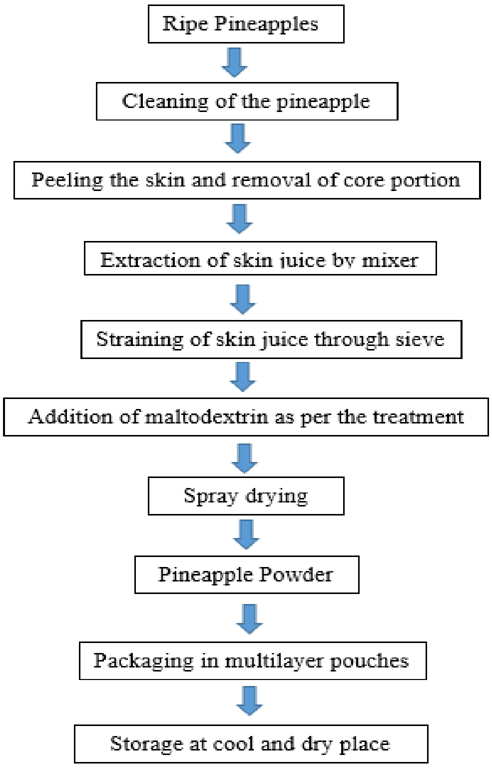
Therefore, this research is a series of experimental study to investigate the spray drying of locally available pineapples with a view to optimize parameters of spray drying process to obtain a high quality powder. The specific objective of this study is to investigate the effect of inlet temperature and concentration of maltodextrin addition on the yield and quality of spray-dried pineapple powders from fresh local pineapples.

II. METHODOLOGY

Materials

Local pineapples such asYankee used in this study was purchased from local Giant supermarket located at Seksyen 7, Shah Alam.

Maltodextrin was obtained from the faculty food laboratory.



Pretreatment process and extraction of pineapple skin juice

The pineapples selected were free from any kind of dark spots and bruises. The fresh pineapples were washed and cleaned. The external part of pineapple such as crown, skin and eyes were removed. Only the skin peel were used in this study and was cut into small slices. The small slices of skin peel were blended in the Tefal® Perfect Mix blender at maximum speed until it fully blended and hydraulically pressed for the extraction of juice by using a standard metallic kitchen sieve with fine mesh used to remove any solids and fibrous materials. Meanwhile, before further processing, the juice extraction was kept at 4ºC.

Addition of Maltodextrin

Preparation of maltodextrin is done by dispersing the maltodextrin with pH 5.2 into 50 gram of hot water. Then, 200 gram of the fresh pineapple extraction is mixed with the solution by using the blender. In order to prepare maltodextrin content of 15, 20, and 25%, the amounts of maltodextrin were 37.5, 50, and 62.5 grams filled into the hot water. The total weight combination of hot water and pineapple juice is 250 gram. The ratios of pineapples (based on total soluble solids) and maltodextrin content of 15, 20, 25%, can be converted at 65:35, 50:50 and 40:60 by weight respectively. The aqueous mixtures were then stored in a refrigerated chamber at 4°C until further used.

Figure 1: LabPlant Spray Dryer

Spray Drying

Optimization of inlet temperature and maltodextrin concentration

The spray drying process performed by drying the samples of juice extraction prepared previously using a small scale LabPlant spray dryer. In order to determine the best parameters of feed for spray drying, the concentration and temperature inlet need to be optimize.

Different inlet temperature were carried out for the spray drying process and the temperatures are at 130 - 150°C with interval of 10°C and the outlet temperature set at 85°C by adjusting the flow rate of air. The pump speed initially set at level '3'. Then, the process were further carried out with concentrations of maltodextrin optimize at 15-25% w/w with interval of 5% w/w at fixed optimized inlet temperature.

Eventually, after the spray drying process, the powders obtained from the vessel were immediately collected, weighed and store in an airtight bottle. The highest yield of powders were determined by the mass of the spray dried powder and chosen as the optimized powder.

Analysis of Powder Yield

The drying yield obtained at the collecting vessel after the spray drying process was determined as the % of the powder collected to the gram of liquid juice in the initial feed.

The spray-drying yield was calculated according to Eq. (1) as followed:

$$Yield\ (\%) = \frac{Obtained\ spray\ dried\ powder\ (g)}{feed\ mixture\ of\ juice\ and\ maltodextrin\ (g)} \times 100$$

Moisture Content

The moisture content analysis for the pineapple skin powder is determined by using a Sartorius MA 35 moisture analyzer by adding three gram of powder in the moisture analyzer at 105°C for 10 mins. The results were recorded for all the experiment runs.

Bulk Density

The measurement of bulk density was determined according to Sahin-Nadeem et al., (2013) method. Two grams powder was taken into 10 mL graduated cylinder and recorded the volume changes. The ratio of mass of the sample to the volume is the estimated bulk density.

pH measurement

The pH value of the pineapple skin juice powder was measured using a digital pH meter…..

III. RESULTS AND DISCUSSION

The parameters such as inlet temperature and maltodextrin concentration in the spray drying process of pineapple skin juice were varied in the experiment in order to study the optimized parameter that yield the highest quality of spray-dried pineapple skin powder. The powder yield, pH value, soluble solid content, moisture content and bulk density of the spray-dried powders were analyzed.

Table 1: Powder recovery of spray-dried pineapple skin juice

Temperature (˚C)	MD Content (%)	Power Yield (g)	Powder Yield (%)
130	15	18.68	7.5
	20	19.66	7.9
	25	21.55	8.6
140	15	18.88	7.6
	20	26.15	10.5
	25	23.12	9.2
150	15	15.01	6.0
	20	19.90	8.0
	25	21.15	8.5

Table 2: Physicochemical properties of spray-dried powder

Inlet Temper -ature (˚C)	MD Content (%)	pH Value	Soluble Solid Content	Moisture Content (%)	Bulk Density (g/ml)
130	15	5.22	1.37310	7.73	0.69
	20	5.12	1.37330	7.63	0.67
	25	5.08	1.37389	7.57	0.65
140	15	5.11	1.37442	6.33	0.63
	20	5.21	1.37531	6.22	0.62
	25	5.19	1.37588	6.15	0.60
150	15	5.14	1.37545	6.25	0.60
	20	5.16	1.37620	6.12	0.58
	25	5.09	1.37740	6.07	0.57

Moisture Content

Figure 3 shows the effect of temperature to the moisture content (%) for each of the inlet temperature at different maltodextrin concentration. It shows that the increased in the inlet temperature leads to decrease in moisture content. This is somehow same as the result according to the data described by Goula et al. (2009), which state that an increase in air inlet temperature leads to a decrease in moisture content. This is because of the higher rate of heat transfer into the particles when there is greater temperature difference between the medium and the feed particles, which eventually provides the driving force for moisture removal.

Powder Yield

One of the key component of process performance is powder yield.

Fig. 2 shows the achieved values of residue yield ranging from 6 to 10.5%.

The inlet temperature temperatures can affect the powder yield of the spray-dried products where higher process yield occurs at higher inlet temperatures. Usually at higher inlet temperatures, the efficiency of heat and mass transfer processes during spray drying is higher thus producing greater process yield. However, process yield can sometimes be reduced at higher inlet temperatures because of the melting of powder and cohesion wall. This phenomenon caused lower production of the spray-dried powder. (G.R. Chegini, 2007).

According to Figure 2, it can be seen that at the same maltodextrin concentration with higher inlet temperature, the amount of powder yield is increase but somehow there are also reduced amount of powder yield as the temperature goes higher. Based on the findings, at all of the three concentrations of maltodextrin, the powder yield is reduced when it is spray dried at the highest inlet temperature of 150˚C. The trend of reduced powder yield along the increasing maltodextrin content may due to less efficiency of method used for the powder collection. The spray-dried products was collected at the cyclone and the decreased in powder yield at inlet temperature of 150°C may because of the sticking of pineapple skin droplets on the drying medium chamber during spray drying process. (Sahin-Nadeem et al., 2013).

Bulk Density

Referring to Fig. 4, the increase of maltodextrin concentration lead to the decrease of bulk density. This is necessarily true because addition of maltodextrin could reduce the amount of sticky particles.

The higher content of maltodextrin could increase the volume of trapped air in the particles due to skin formation of maltodextrin and the particles may contain air bubbles that formed as a result of deposition of air that was present in the feed mixture. Thus, the increase in the volume of trapped air resulted in the decrease of density of the spray-dried powder particles, which eventually gives result of powder bulk density. Based on result reported by Goula & Adamopoulos (2010), bulk density in tomato juice powder has decreasing trend as the maltodextrin concentration is increased.

Bulk density of spray-dried powder also depends on the inlet temperature. Based on Fig. 4, the bulk density of powder decrease with the increase on the inlet temperature. Referring to the research studied by Tonon et al. (2008) shown that inlet temperature has effect on the bulk density of acai juice powder which caused the bulk density to decrease at higher inlet temperature. This phenomenon happen because of the greater evaporation rates occur at higher inlet temperature and resulted in more porous and fragmented dried products. Walton (2000) reported that the particles of spray dried powder have a high tendency to be hollow when there is a decrease in bulk density that resulted at higher inlet temperature. The phenomenon called inflation-ballooning is common in materials that have skin forming ability.

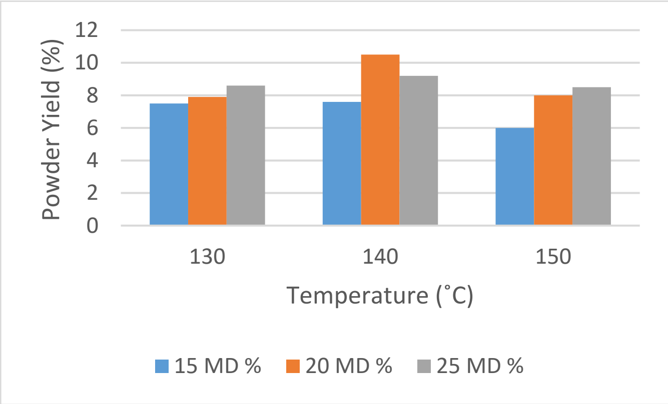


Figure 2: Effect of Temperature on Powder Yield

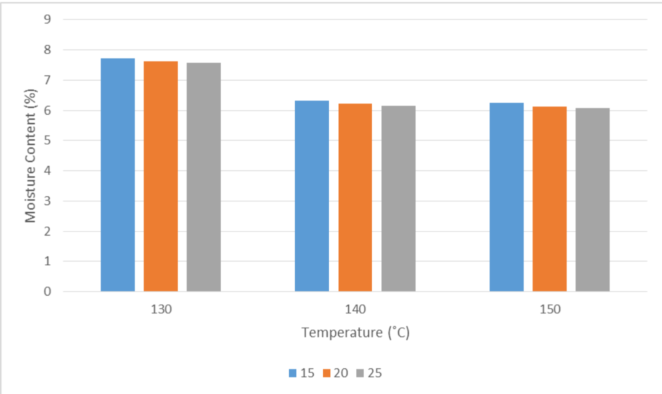


Figure 3: Effect of Temperature and MD content on Moisture Content

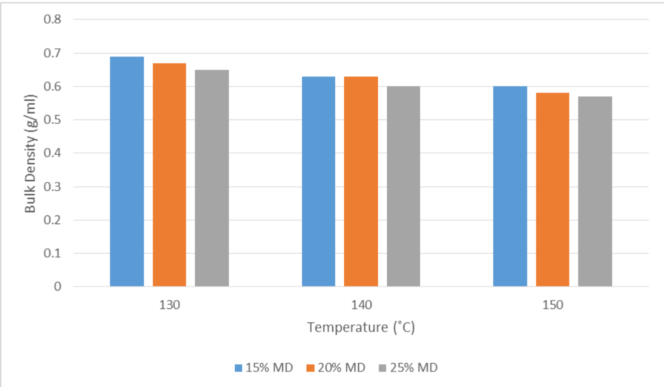


Figure 4: Effect of Temperature and MD content on Bulk Density

IV. CONCLUSION

Crystallization of pineapple skin juice by using spray drying technique with different parameters such as inlet temperatures and maltodextrin concentration was developed. The effect of both parameters on the spray-dried powder properties was studied to determine at which parameter produce the highest quality and yield. Maltodextrin used as carrier agents to facilitate in drying process by reducing the stickiness of the powder.

It was observed that different drying parameter gives impact to the powder quality. Based on the result obtained, powder yield increase with an increase in inlet temperatures and maltodextrin concentration. The increasing drying temperatures and maltodextrin content resulted in the lower moisture product. Higher inlet temperatures also causes reduction in bulk density.

From the results, the spray-dried product obtain ranging from 7 to 10% and much lower than those reported by other researchers. This may happen due to dehumidified air is used in the medium which gives lower air temperatures in the drying chamber (Goula and Adamopoulos, 2005). It was found out that pineapple skin juice with addition maltodextrin of 20% and spray dried at temperature 150C achieved the highest yield of optimum quality powder of 10.5% with 6.22% of moisture content and 0.6 g/ml bulk density.

V. ACKNOWLEDGMENT

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