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PRODUCTION OF DURIAN (*Durio zibethinus*) POWDER BY SPRAY DRYING TECHNIQUE

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ABSTRACT

Durian is a tropical fruit crop which is grown in South-East Asian countries. The fruit is thorny, perishable, nutrient rich and having a characteristic odor. Fruits are seasonal and bear alternatively. Usually, Durian restricted in restaurants, public places public transport including taxies and flights due to its odor and bulky thorny husk. At present, there are hardly any widely accepted preservation techniques for this fruit. Therefore, it requires new preservation methods. This study was aimed to optimize the method of producing Durian powder by spray drying and to find the optimum pulp water temperature, Maltodextrin percentage for the highest powder yield and better physicochemical properties. Twenty-seven samples were prepared by blending Durian flesh with three different water temperatures (0, 27 & 40 ^{0}C) and three Maltodextrin levels (10%, 20% & 30%). Then, the samples were spray dried under 100 ^{0}C output temperature and maximum fan speed. Powder weight & physicochemical properties (Total soluble solids, ascorbic acid, solubility, rehydration time, hygroscopicity and moisture) were statistically analyzed by using two-way ANOVA test. It was found that pulp can be transformed to powder by spray drying. The highest powder weight was recorded at 0 ^{0}C water temperature and 20% Maltodextrin combination due to less caramelization of complex sugars. Moreover, the ascorbic acid content was high due to minimum degradation under low temperature. Therefore, 0 ^{0}C water temperature and 20% Maltodextrin level were recommended for the spray drying of to obtain best quality powder.

Keywords: Durian, Powder properties, Pulp water temperature, Spray drying

INTRODUCTION

Durian is a tropical perennial tree belongs to family Bombacaceae. It's fruiting is seasonal and has a short postharvest life of 2 to 5 days at ambient conditions (Ho and Rajeev, 2015; DOA, 2015). On other hand, continuous and steady supply of fruits limited due to low extent of cultivation up to an altitude of 600 m, lack of commercial cultivation and alternative bearing habit of this crop (DOA, 2015; Ali, 2010). This limited production leads to a difficulty in supply for higher demand in the local market. Moreover, the odor and bulky thorny husk of the fruit crop created restricted usage in some restaurant, public places, taxies, public transport and hotels and exportation via air freight (Small and Catling, 2011). Some individual have been adapted to this revolting odor and some regard this as a fragrance. In Sri Lanka, post-harvest technology has not yet been developed for this fruit crop and no value added products are available in the market yet. Malaysia is the one and only country that has been exporting Durian as its dry foam (Brown, 1997). Furthermore, this thorny and bulky raw fruits' export shipping and freight is very expensive (Ali, 2010).

According to Sagar and Kumar, (2010) and Yousefi *et al*., (2011), a wide range of dehydrated food products are made using spray drying technique to produce long shelf life and light weight dry powders and agglomerates. Moreover, the spray dryers can dry a suspension within single step rapidly than other drying methods which is the advantageous method for time saving and minimal processing (Chegini and Ghobadian, 2007; Quek, 2007; Murugesan and Orsat, 2011; Phisut, 2012). However, spray drying protocol and optimum operating parameters of many fruits has been well established except Durian. Therefore, this study was conducted to produce high quality Durian powder by spray drying technique and investigate the impact of pulp making water temperature and Maltodextrin percentage on spray dried powder yield and physicochemical properties.

MATERIALS AND METHODS

Plant materials and chemicals

This research was conducted in a laboratory of Food Research Unit, Department of Agriculture, Gannoruwa. Organically grown, naturally fallen ripened fruits (TSS-21 Brix, moisture -55 %) from locally collected trees at Dangamuwa, Kalanigama, Ginigathhena were used for the study. Comercially available Food grade Maltodextrin 10 DE was used in the study.

Experiment sample preparation

The fresh flesh sample was obtained by removing hull and seeds. Then, the pulp was prepared by blending the flesh using domestic blender for 2 minutes time at third speed (R.P.M 18,000) level. Flesh was blended with water or ice cube according to the proportion indicated in Table 1. Pulp was filtered using a stainless steel strainer (40 square/ inch^2) and mixed with Maltodextrin properly according to the percentage given in Table 2.

Table 1. Experiment details of pulp making

Water temperatures	Blending materials (per sample)	Number of samples
0 ^{0}C	200 g + 200 g ice cube	9
27 ^{0}C	200 g + 200 ml tap water	9
40 ^{0}C	200 g + 200 ml hot water	9

Table 2. Different Maltodexrin levels used for the study

Water temperatures	Maltodextrin (MD) levels w/v		
	10 %	20%	30 %
0 ^{o}C	40 g MD + Pulp 400 ml	80 g MD + Pulp 400 ml	120g MD + pulp 400 ml
27 ^{o}C	40 g MD + Pulp 400 ml	80 g MD + Pulp 400 ml	120g MD + pulp 400 ml
40 ^{o}C	40 g MD + Pulp 400 ml	80 g MD + Pulp 400 ml	120g MD + pulp 400 ml

Prepared pulp (400 ml) sample was diluted by adding 400 ml of tap water at 27^{0}C or 400 ml of hot water at 40 ^{0}C or 400 g ice cube in to 800 ml sample to adjust the compatible thickness to spray dryer according to the treatment plan, and subjected for spray drying. Experiment was conducted in Complete Randomized Design (CRD) with three replicates.

Spray drying

Prior to start spray drying, the spray dryer was switched on 20 minutes after adjusting inlet air temperature to 270 ^{0}C to obtain 100 ^{0}C output air temperatures for best efficient water evaporation. The fan speed was also adjusted to maximum speed. The sample was fed into spray dryer after output temperature reached to 100 ^{0}C, with medium atomizer speed (20,000 RPM) and measured weight by using analytical balance (RADWAG, Model No AS 220.R2) after end of spray drying process. This procedure was followed for remaining 26 samples belongs to each treatment combination. All samples were packed with laminated aluminum bags (6-inch × 4 inch, 200 gauges) to prevent moisture absorption. Thereafter, total soluble solids, ascorbic acid, solubility, rehydration time, hygroscopicity and moisture % were analyzed as physicochemical properties.

Physicochemical Analysis

Total soluble solids

One gram of powder sample was dissolved in 9 ml of distilled water and transferred one drop of solution on to a glass prism of a refractometer (0-90%, Atago, model AL-21 Japan) by using a plastic rod and sample data were recorded as ^{0} Brix.

Ascorbic acid content

Five gram of powder was weighed and dissolved in 20 ml 3% HPO_3 and the solution was filtered by using Whatman number 5 filter paper. Then 5 ml HPO_3 sample aliquot was titrated with early standardized dye (2, 6 dichorophenol-indophenol) to a pink end point which should persist for at least 15 sec. Each and every replicate reading was added to a formula which was described by Rangana (1977).

$$\text{Mg of ascorbic acid per 100 g or ml} = \frac{\text{Titer} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Aliquot of extract taken for estimation} \times \text{Weight or volume of sample taken for estimation}}$$

Solubility percentage

One gram of powder was added to 100 ml distilled water and mixed for 5 minutes at maximum speed on the stirrer Filtered with Whatman number 5 filter paper. Filtered solution (15 ml) was filled to a previously weighed crucible and oven dried in an oven at 105 °C for 5 hours. Then, the solubility was calculated by using the Eastman & Moore method described by Goula and Adamopoulos, (2010).

$$\text{Solubility \%} = \frac{\text{Weight of recovered solid (g)}}{\text{Weight of sample (g)}} \text{ X } 100$$

Rehydration time

Two gram of powder was added to 50 ml of distilled water in the 1,000 ml beaker at 26 ^{0}C temperature. Then the solution was agitated on magnetic stirrer at 900 rpm, and the time was recorded to require for the material to be completely re-hydrated and expressed as the rehydration time of powder (Goula & Adamopoulous, 2004; Goula & Adamopoulous, 2008) and calculated average rehydration time in second for three replicates of every treatment combination.

Hygroscopicity percentage

One gram of powder was weighed into previously weighed petri dish and exposed to air relative humidity of 79.5 ± 2 %. Then, the sample was repeatedly weighted at 30 minutes intervals until it reached a constant weight. The final constant sample was oven dried at 105 ^{0}C for 4 hours. Then hygroscopicity calculation was done as equation described by GEA Niro research laboratory method (Goula and Adamopoulos, 2010).

$$\text{Hygroscopicity (\%)} = \frac{(\text{\% WI} + \text{\% FW})}{100 + \text{\% WI}} \text{ X } 100$$

Where,

% FW = Percentage of Free water = ((c-b)/c-e)) × 100

% WI = ((c-b)/(b-a)) × 100

a = weight of plate (g)

b = weight of plate + powder (g)

c = weight of plate + powder in equilibrium (g)

e = oven dry weight (g)

Moisture content

Moisture content of the dried sample was determined by using the oven dried method by placing two gram of powder to weighted crucible (Diameter- 54 mm), dried for 4 hours at 105 ^{0}C. Oven drying process was repeated until it attained constant weight and moisture content of the sample was obtained using following equation.

$$\text{Moisture percentage} = \frac{W1\text{-}W2}{W1\text{-}W0} \times 100$$

Where
W1: weight of crucible + sample before drying
W2: weight of crucible + sample after drying
W0: weight of crucible

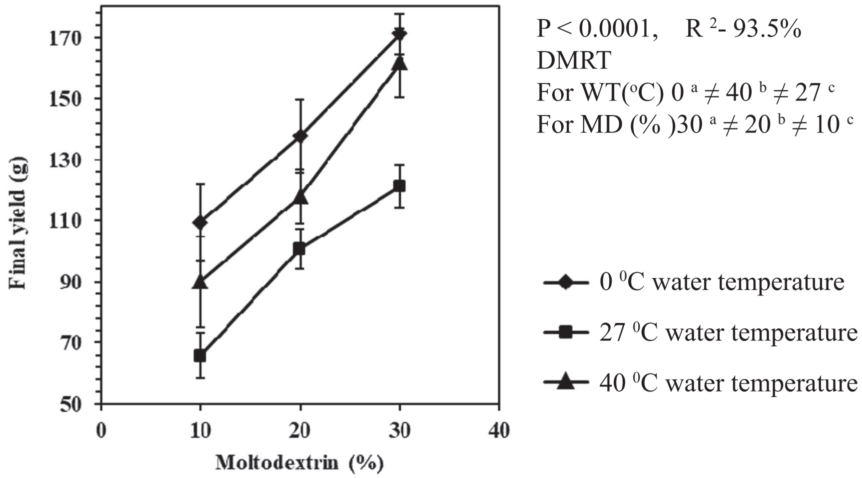
Data analysis

All data were analyzed statistically using SAS system 9.0. Two-way ANOVA and Duncan Multiple Range Test were used to analyze the data and mean separation was conducted at $p = 0.05$.

RESULTS AND DISCUSSION

Effect of pulp making water temperature on final powder yield

Figure 1 shows the different trend lines with nine different treatment combinations. All powder yield was significantly ($p < 0.05$) increased with the increasing of Maltodextrin percentage. According to the statistical analysis, Maltodextrin percentage increment significantly ($p < 0.05$) contributed to increase the output powder yield. Water temperature 0 ^{0}C and 27 ^{0}C showed the highest and lowest powder yield, respectively and 40 ^{0}C pulp making water temperature treatment showed moderate powder yield. According to the analysis, all three water temperatures significantly ($P < 0.05$) contributed to result different powder output yields.



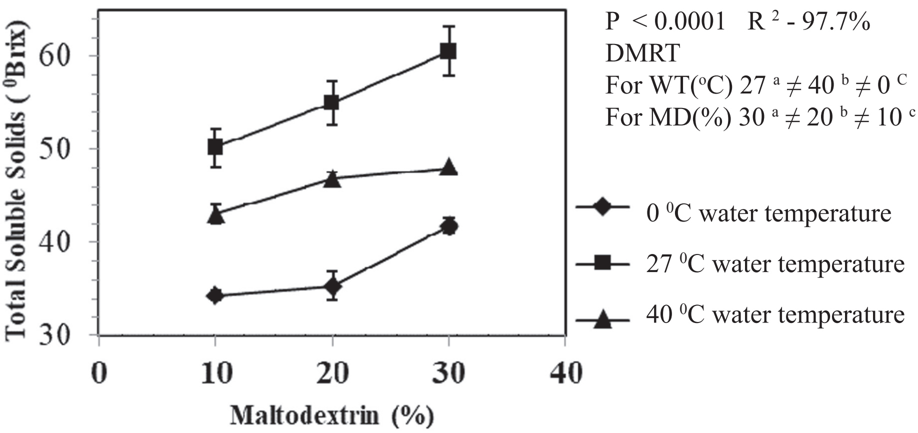
Values are presented as the mean of three replicates, p <0.05 - statistically significant

Figure 1. Output powder yield of different water temperature & Maltodextrin percentage treatment combinations of pulp

According to the above results, Maltodextrin percentage directly affected on the final powder yield. This was confirmed by previous study explanation, the total solids of the pineapple spray powder were increased with the increasing of Maltodextrin percentage (Jittanit *et al*., 2010). Therefore, powder weight was increased by increasing Maltodextrin percentage. Moreover, the pulp making water temperature was affected to enzyme activity of the pulp such as polygalacturonase, pectinase, kinase, amylase and hydrolases (Imsabai *et al*., 2002). According to Voon *et al*., (2006) the firm texture of pulp was preserved at 4 ^{0}C storage due to the low enzyme activity under the low temperature. Usually the optimum temperature level for optimum enzymatic reaction was around 28 ^{0}C and it will result more simple sugars of fruits (Voon *et al*., 2006). The sucrose breakdown (in to glucose and fructose) rate of was slower than the starch conversion rate (into sucrose) at 4 ^{0}C storage. In 0 ^{0}C and 40 ^{0}C temperature levels enzymatic reaction got limited and preserved large organic compounds such as starch, complex sugars such as sucrose and reduced the volatilization of some compounds. Hence, the preserved starch, complex sugar, polysaccharide particles and preserved chemicals (i.e., ascorbic acid) increase the final powder yield at 0 ^{0}C and 40 ^{0}C pulp making temperatures than 27 ^{0}C temperature treated pulp.

Effect of pulp water temperature on total soluble solids (TSS) of powder

Figure 2 shows the different trends with nine different treatment combinations. Overall TSS of the powder was significantly (p < 0.05) increased with increasing of Maltodextrin percentage. Furthermore, mean separation value of different Maltodextrin % showed that the Maltodextrin percentage increment significantly (p < 0.05) contributed to increase the powder TSS (^{0}Brix). The highest and lowest TSS were obtained by the 27 ^{0}C and 0 ^{0}C pulp making water temperatures, respectively and 40 ^{0}C pulp making water temperature treatment showed moderate TSS. According to statistical analysis, water temperatures were significantly contributed to total powder TSS.



Values are presented as the mean of three replicates, p <0.05 - statistically significant

Figure 2. Powder TSS of different water temperature & maltodextrin percentage treatment combinations of pulp

According to the results (Figure 2) all three pulp making water temperature treatments and three Maltodextrin levels were significantly (p < 0.05) affected on TSS contents of the powder. All three temperature treatments, TSS were increased with the increasing Maltodextrin per cenatge. It may be due to its higher solubility. Similar findings were reported by Jittanit *et al*., (2010) for TSS of pineapple powder. Pulp making water temperature of 27 ^{0}C was optimized the enzyme (polygalacturonase) activity and converted complex sugars into more soluble simple sugars (Imsabai *et al*., 2002; Voon *et al*., 2006). Therefore, 27 ^{0}C pulp making water temperature treatment was showed the highest TSS in powder. Water temperature of ^{0}C were preserved more sucrose by reducing enzyme activity and showed lowest TSS than other two treatments. Furthermore, the 40^{0}C pulp making water temperature showed moderate TSS due to moderate enzymatic activity than two other treatments.

Effect of pulp making water temperature on ascorbic acid content of powder

In all treatments, ascorbic acid contents were significantly (p <0.05) decreased with increasing of Maltodextrin percentage. Temperatures of water 0 ^{0}C & 40 ^{0}C had same effect on ascorbic acid content in powder and the 27 ^{0}C pulp making water temperature resulted significantly lower ascorbic acid content compare to other two treatments.

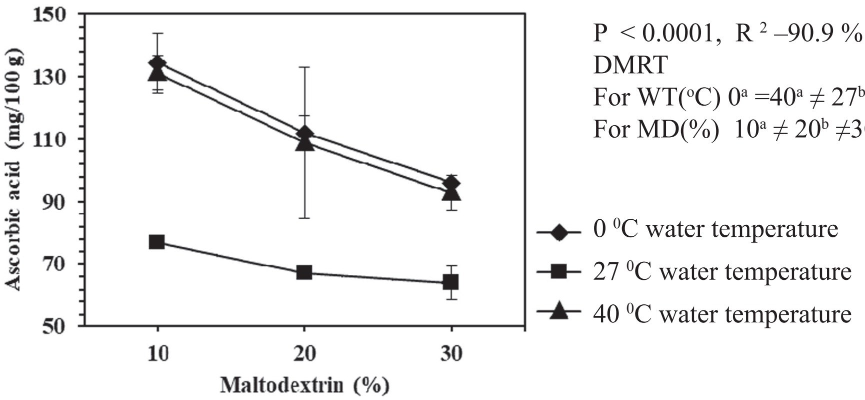


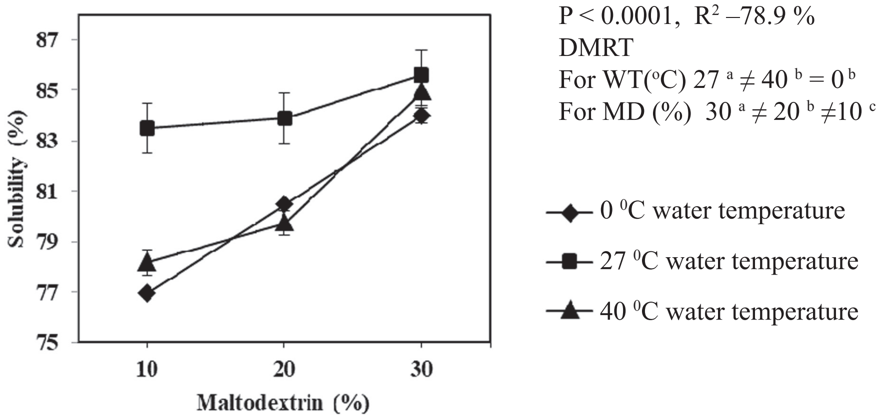
Figure 3. Powder ascorbic acid contents of different water temperature & Maltodextrin percentage treatment combinations of pulp

Note: Values are presented as the mean of three replicates, p <0.05 - statistically significant

Decrease of ascorbic acid content with increasing of Maltodextrin percentage was a significant (p <0.05). In the 0 ^{0}C and 40 ^{0}C pulp making water temperatures had a great impact to preservation of ascorbic acid in the spray dried powder than 27 ^{0}C pulp making water temperature (Paul, 2012). The ascorbic acid is more sensitive to heat. Therefore, the 0 ^{0}C pulp making water temperature was the best to preserve ascorbic acid in spray drying process. Moreover, the fruit ascorbic acid content is gradually decreases from harvesting to ripening due to resulting of more simple sugars with higher enzyme activity. Kalt, (2006) stated that the vitamin C degrades very rapidly and it is the best indicator of freshness.

Effect of pulp making water temperature and Maltodextrin percentage on solubility (%) of powder

According to Figure 4, solubility % of all treatments were significantly (*p* <0.05) increased with increasing of Maltodextrin percentage. Pulp making water temperature of 27 ^{0}C showed higher solubility percentage than the temperature of 0 ^{0}C & 40 ^{0}C.



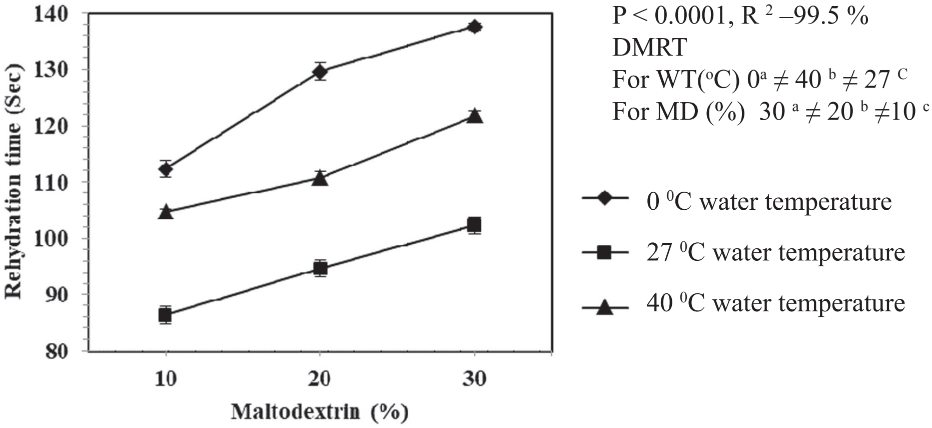
values are presented as the mean of three replicates, p <0.05 - statistically significant

Figure 4. powder solubility (%) of different water temperature & Maltodextrin percentage treatment combinations of pulp

Similar, results were obtained by Grabowski *et al*., (2006) for sweet potato powder with increasing Maltodextrin (%). Pulp making water temperature of 27 ^{0}C had great positive influence on solubility percentage than other two water temperatures. It may be due to optimized enzyme activity at 27 ^{0}C, which produce more soluble simple sugars. The 0 ^{0}C & 40 ^{0}C pulp making water temperatures were showed low solubility (%) due to limited enzyme activity and more insoluble sugars.

Effect of pulp making water temperature on rehydration time of powder

According to Figure 5, powder rehydration time is significantly different in all three water temperatures (*p*<0.05) and it was significantly (*p* <0.05) increased with increasing of Maltodextrin percentage. Temperatures of 0 ^{0}C and 27 ^{0}C pulp making temperatures showed the highest and lowest powder rehydration time, respectively, and 40 ^{0}C pulp making water temperature treatment showed moderate powder rehydration time.



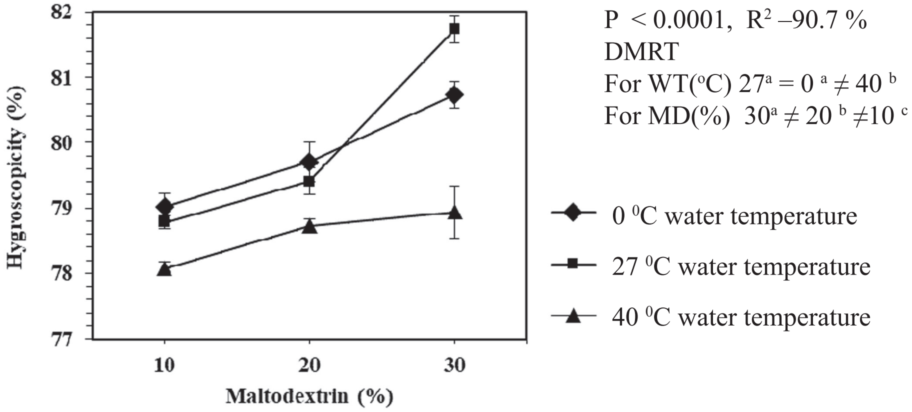
Values are presented as the mean of three replicates, p <0.05 - statistically significant

Figure 5. Rehydration time of different water temperature & Maltodextrin percentage treatment combinations of pulp

According to the study of Masters, (1979) and Phisut, (2012) the powder particle size was increased with the Maltodextrin concentration increment and those large particles were led to increased viscosity of fruits' powder particles. High viscosity of pulp due to high Maltodextrin concentration resulted larger droplet size when atomizing and finally it affected larger powder particles. Those large powder particle sizes take more time for rehydration than small size particle. The literature showed encapsulating ability of mango powder increased with the increasing Maltodextrin percentage and those capsules increase the rehydration time (Cano-Chauca *et al*., 2005). The solubility percentage at 0 ^{0}C & 40 ^{0}C water temperatures than 27 ^{0}C water temperature explained the influence of low solubility rate on rehydration time.

Effect of pulp making water temperature on hygroscopicity of powder

According to Figure 6 hygroscopicity percentage of all treatments significantly (p <0.05) increased with increasing the Maltodextrin percentage. Pulp making water temperatures 0 ^{0}C & 27 ^{0}C showed higher hygroscopicity comparing to 40 ^{0}C pulp making water temperature. All treatment combinations got hygroscopicity values than 25% level. According to the statistical analysis, effect of 0 ^{0}C & 27 ^{0}C pulp making water temperatures on hygroscopicity have no significant difference and 40 ^{0}C pulp making water temperature showed significantly lower effect on hygroscopicity percentage.



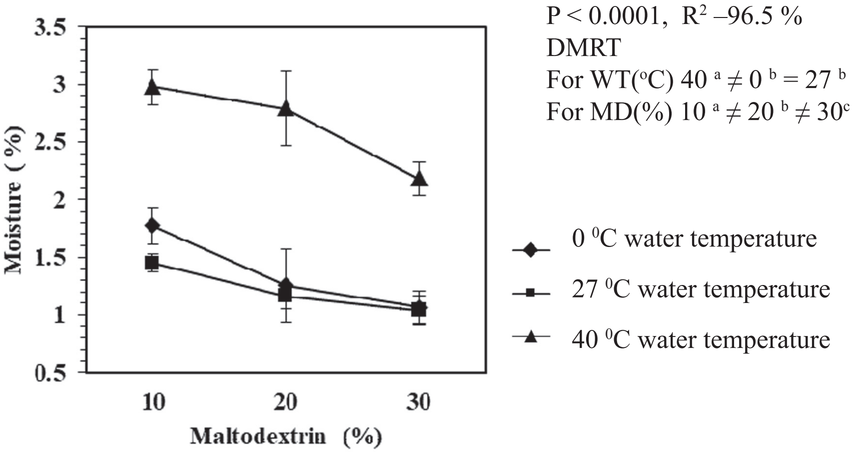
Values are presented as the mean of three replicates, p <0.05 - statistically significant

Figure 6. Powder hygroscopicity of different water temperature & Maltodextrin percentage combinations of pulp

Goula and Adamopoulos, (2010) highlighted that treatment combination of spray dried powder obtained more than 25 % hygroscopicity and its categories as extremely hygroscopic. However, 40 ^{0}C pulp making water temperatures showed low hygroscopicity (%) due to presence of higher powder moisture percentage than other two treatments (Figure 7). The hygroscopicity (%) were increased with increasing maltodextrin % due to decreasing the moisture (%) in acai powder (Cai and Corke, 2000; Tonon, 2008).

Effect of pulp preparing water temperature on moisture percentage of powder

According to the Figure 7, all powder moisture percentages were significantly (p <0.05) decreased with increasing Maltodextrin percentage. Temperatures of 27 ^{0}C and 0 ^{0}C showed the same effect to moisture % of powder and temperature of 40 ^{0}C had significantly high moisture % in the final powder than two other temperatures.



Values are presented as the mean of three replicates, p <0.05 - statistically significant

Figure7. Powder moisture (%) of different water temperature & Maltodextrin percentage treatment combinations of pulp

According to the study, Moisture contents were decreased. Phisut, (2012) stated that, with increasing Maltodextrin (%) encapsulating ability will increase and it elevated total solid content. Increasing encapsulation was prevented the moisture absorption and reduces the surface stickiness of powder particles. It confirmed by study of Jittanit *et al*., (2010) and Tonon, (2008), that the moisture content of spray dried watermelon, acai berry and pineapple powders was decreased when the increasing of moltodextrin percentage (Quek *et al*., 2007).

CONCLUSIONS

This Study has confirmed that pulp can be transformed to powder by spray drying. Quality parameters of powder ascorbic acid, moisture (%) also significantly altered with 0 ^{0}C pulp making temperature. Moreover, the 0 ^{0}C pulp making water temperature and 20% Maltodextrin level obtained the best results compared to commercial production due to higher output powder yield. Increasing Maltodextrin percentage increases final powder output weight, TSS, solubility, rehydration time and hygroscopicity of powder. Thus, it can be concluded that pulp making water temperature and Maltodextrin percentage has a great impact on different physicochemical properties of powder. Further studies are needed to produce value added products by using powder and to its marketability.

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