Effect of Temperature on the Physicochemical Properties of Tamarind (Tamarindus Indica) Powder

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***Abstract*—The aim of the present investigation is to study the effect of temperature on the physicochemical properties of tamarind powder that produced by a double drum dryer. The temperatures varied from 120 to 140 ℃, whereas other parameters like drum clearance (0.0254 mm) and drum rotation speed (0.75 rpm) were kept constant. Drying yield, moisture content, pH value, total acidity, bulk density and solubility were analyzed for the powder samples. Higher temperature decreased the moisture content of the powder, but help to the drying yield increased. While the pH values and the bulk density decreases as temperatures rise. Contrary to the total acidity and the solubility increases as temperatures rise.**

***Index Terms*—tamarind (tamarindus indica), drum dryer, physicochemical properties**

I. Introduction

Tamarind (Tamarindus indica) is a leguminous tree in the family Fabaceae indigenous to tropical Africa. Due to the versatile applications of tamarind, cultivation has spread around the world in tropical and subtropical zones. In Thailand, tamarind is an economic crop with an annual production of over 100,000 tons. Besides, several renowned exotic Thai dishes have tamarind juice as an essential ingredient for the inimitable sour taste [1].

Preparation of fresh tamarind pulp for cooking or other use, such as a spa or drink is also rather onerous, another factor rendering the fresh pulp less attractive. A viable solution to address these issues is through transforming fresh tamarind paste into its powder form using a drum dryer.

A typical drum dryer consists of two hollow cylinders (or drums) rotating in opposite directions, which are heated internally by high-temperature steam. In operation, a thin film of solution is first coated on the outer surface of the heated drums and then the removal of the film of dry products by applying the doctor blade. Drum drying is a technique commonly used in the food industry to produce food powders, e.g. low moisture baby foods and fruit powders, particularly for production of heat-sensitive products in which short-time high temperature drying is permissible [2].

The prior reporting found that the significant effect of temperature on the physicochemical properties of the drum dried powder. The quality of tamarind powder is good because the product temperature is rarely raised above 140 ℃ [3]. Drum dried tamarind juice powders can be added to food systems for a variety of functional benefits [4]. Ideally, drum dried tamarind juice powder should reconstitute instantly or serve as a vitamin c-rich additive. There are numerous reports on drying of tamarind fruit. However, there is limited information of how drying conditions may influence the physicochemical properties of tamarind fruit powder. The present study investigates the effect of temperature on drum drying of tamarind juice and evaluates the physicochemical properties of the powder produced.

II. Materials and Methods

A. Raw Material

In this research, the experimental tamarind flesh was acquired from a local market in Thailand's northeastern province of Nakhon Ratchasima. The experimental maltodextrin (MD) with a dextrose equivalent of 10-12, pH of 4.5-6.5 and moisture content of 5.0-6.0% was from Nutrition SC Co., Ltd. in Nakhonpathom province, Thailand. In addition, octenyl succinic anhydride (OSA) with pH of 4.0-6.0 and moisture content of 4.0-8.0% was obtained from Questex Co., Ltd. in Thailand's Sumutprakarn province, while gum arabic (GA) with pH of 4.0-5.0 and moisture content of 11.0-12.0% was acquired from Chemipan Co., Ltd. in Thailand's capital Bangkok.

B. Tamarind Puree Preparation

Prior to the experiment, the tamarind flesh was seeds removed and mixed with hot water at 80 ℃ in a ratio of 1:5 (w/w). The mixture was kneaded into tamarind paste

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and then filtered through a two-layer cheesecloth for tamarind juice. The TSS (total soluble solids) of the tamarind juice was determined and adjusted to 11 °Brix. MD, OSA and GA were incorporated at 61.21, 28.79 and 10.00 (%), respectively. The optimum concentration of MD, OSA and GA was determined in our previous study [5].

C. Drum Drying Operation

The tamarind puree was feed into the gap between drum at 2 cm pool level deep and 20 cm pool level width. The outer surface temperatures ranged from 120 to 140°C. The drum rotation speed was set at 0.75 rpm and the drum clearance was set at 0.254 mm. The dried material was removed as a thin film from the drum surface by two doctor blades, one for each drum. Dried flakes were immediately stored in a plastic bag and sealed. The flakes were then ground into powder using blender (Philips, HR2061, Indonesia) for 50 s at high speed. Then tamarind powder was sifted through a sieve size of 80 mesh and kept in a sealed laminated aluminium foil for further analyze properties of tamarind powder.

D. Physicochemical Properties Analysis

1) Drying yield

The measurement of tamarind drying yield was performed using the weight difference between the pre-dried tamarind juice and the resultant tamarind powder [6]. The drying yield of tamarind was estimated using equation (1).

$$Drying\ yield = \frac{M_a}{M_b} x\ 100 \tag{1}$$

where M_a and M_b are respectively the weights (kg) of dry solids of tamarind powder and tamarind juice being fed into the dryer.

2) Moisture content

The determination of moisture content of tamarind was carried out using the convection oven method [7], by which the samples were dried in an oven at 105°C for 24 h. The moisture content of tamarind could also be estimated using equation (2).

$$Moisture\ content = \left(\frac{W_2 - W_3}{W_2 - W_1}\right) x\ 100 \tag{2}$$

where W_1 is the initial weight of moisture can (kg), W_2 is the weight of moisture can and pre-dried tamarind (kg), and W_3 is the weight of moisture can and dried tamarind (kg).

3) pH value

The pH values of the tamarind juice was determined using digital pH meter (Mettler Toledo, SevenEasy, Switzerland) [8].

4) Total acidity

To determine total acidity, a 250 ml Erlenmeyer flask with 5 ml of tamarind samples mixed with 10 ml of distilled water was utilized. In addition, 3 drops of 1% phenolpthalein were added to the mixture as an indicator. The resulting mixture was then titrated with a standard solution 0.1 N of NaOH until the endpoint, at which the solution color changed to light pink [9]. The total acidity of tamarind could be estimated using equation (3).

$$Total\ acidity = \frac{V\ x\ N\ x\ Eq.wt}{U \times 1000} x100 \tag{3}$$

where V is the volume of NaOH used in the titration until the endpoint (ml), N is the normality of NaOH, Eq.wt is the Equivalents weight of tartaric acid (=75), and U is the volume of the sample in the titration (ml).

5) Bulk density

Determination of the bulk density of tamarind powder, a cylinder of known volume was filled with 80 mesh passed of tamarind powder by pouring with gravity at a distance of 0.1 m from the cylinder. The filling continued until the tamarind powder overflowed prior to sweeping to the uppermost level of the cylinder [10]. The bulk density of tamarind powder could be estimated with equation (4).

$$Bulk\ density = \frac{m}{v} \tag{4}$$

where m is the mass of tamarind powder (g) and v is the volume of the cylinder (ml).

6) Solubility

To determine the solubility of tamarind powder, 1 g each of tamarind powder samples was suspended in 10 ml water at 30°C in a centrifuge tube. The suspension was stirred intermittently for 30 min prior to centrifugation at 3,000 rpm for 10 min. The supernatant was then drained into a moisture can and dried in an oven at 105°C for 24 h. [11]. The solubility of tamarind could be estimated using equation (5).

$$Solubility = \frac{M_s}{M_p} x\ 100 \tag{5}$$

where M_s is the weight of dry solids of the supernatant (kg) and M_p is the weight of tamarind powder (kg).

E. Statistical Analysis

The experiments were carried out in triplicate and the data was analyzed statistically using SPSS software version 14.0 (SPSS Inc., Chicago, USA) with analysis of variance (ANOVA) and the means were separated using Duncan's multiple range test ($p \leq 0.05$). All the data are presented as the mean with the standard deviation.

III. Results and Discussion

A. Tamarind Juice Composition

The physicochemical properties of tamarind juice shown in Table I. It can be seen that the tamarind juice has a high moisture content, because it’s a semi-liquid or puree. The pH has a low value, which inhibits microbial growth. While the total acidity has a high value, which an important feature of inimitable sour taste.

TABLE I. PHYSICOCHEMICAL PROPERTIES OF TAMARIND JUICE.

Properties	Values*
Moisture content (%)	88.28 ± 0.02
pH value (25 °C)	2.84 ± 0.01
Total acidity (%)	14.25 ± 0.05

* Means ± standard deviation of triplicate analysis.

B. Statistical Analysis

The statistical analyses for the properties of tamarind powder shown in Table II. The results indicated that the alteration of the temperature had a significant ($p<0.05$) effect on the all properties of tamarind powder. Therefore, the temperature is an important factor that direct impact for drying tamarind powder.

TABLE II. STATISTICAL ANALYSIS OF TAMARIND POWDER.

Temperature (°C)	Drying yield (%)	Moisture content (°C)	pH value (-)	Total acidity (%)	Bulk density (g/ml)	Solubility (%)
120	32.16[a]	10.40[a]	3.17[a]	7.50[a]	1.23[a]	70.75[a]
130	56.91[b]	3.70[b]	3.16[b]	7.77[b]	1.09[b]	78.69[b]
140	77.06[c]	2.33[c]	3.14[c]	8.22[c]	0.78[c]	80.66[c]

[a-c] Different letters in the same column indicate significant differences.

C. Properties Analysis

1) Drying yield

Drying yield is one of the major concerns for drum drying process as it is closely related to the production cost and efficiency. Drying yield of tamarind powder varied from 32.16 to 77.06%. The drying yield of the powder increased with an increased in the temperature. This is probably due to the heat and mass transfer processes increasing affect reduction in stickiness and deposition of powder particles on the walls of roller when higher temperature as a result more drying yield. as shown in Fig. 1.

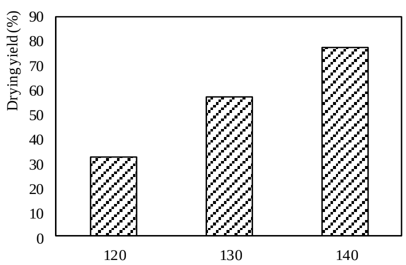

Figure 1. The drying yield of tamarind powder.

2) Moisture content

Moisture content is an important property of powder, which is related to the drying efficiency. Moisture content of a product plays an important role in determining its storage stability [12]. Moisture content of tamarind powder varied from 10.40 to 2.33%. The moisture content of the powder decreased with an increased in the temperature, which may be the due to heat makes more water evaporate as shown in Fig. 2.

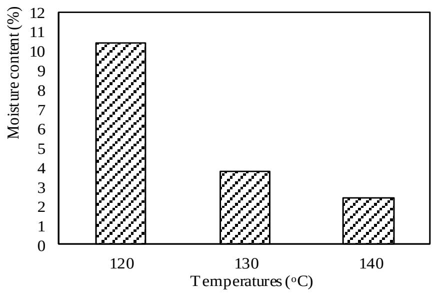

Figure 2. The moisture content of tamarind powder.

3) pH values

pH of tamarind powder varied from 3.14 to 3.17. The pH value of the powder decreased with an increased in the temperature as shown in Fig. 3, because the acid in tamarind juice is very susceptible if heated for a long time. Acid may be destroyed by heat during drying processing. In this sense, the film of tamarind puree dry rapidly at higher of temperature, thereby shortening the drying time [13].

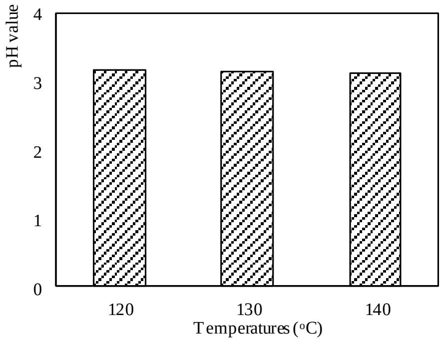

Figure 3. The pH value of tamarind powder.

4) Total acidity

Total acidity a key aspect of tamarind sauces because the inimitable sour taste. Total acidity of the powder increased with an increased in the temperature as shown in Fig. 4. Whereas total acidity was found to be higher in the powder sample produced with the higher temperature. Powder sample at 140 ℃ showed the highest acidity (8.22%) and sample at 120 ℃ showed the lowest (7.50%) acidity value.

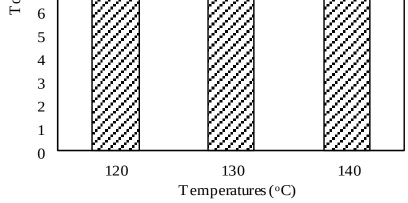

Figure 4. The total acidity of tamarind powder.

5) Bulk density

Bulk density of the powders is one of the most important parameters which are measured. This is important in the terms of transportation, warehousing and packaging. The bulk density of the powder decreased with an increased in the temperature as shown in Fig. 5. While the highest bulk density was shown by sample at 120 ℃ (1.23 g/ml) and the lowest bulk density was shown by sample at 140 ℃ (0.78 g/ml). There are also reported that spray dried powder with higher moisture content tend to have a higher bulking weight because of the presence of water, which is considerably denser than the dry solid [14].

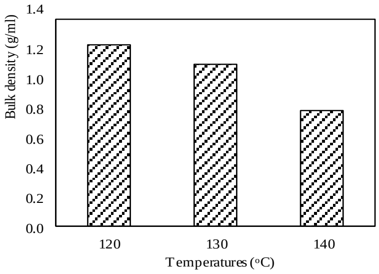

Figure 5. The bulk density of tamarind powder.

6) Solubility

Solubility is a factor that is necessary for drying products, which is related to ease of consumer use. At the highest temperature (140 ℃), sample showed the highest solubility (80.66%), whereas at the lowest temperature (120 ℃), sample showed the lowest solubility (70.75%). The results indicated that the solubility of powders increased with increasing temperatures. The same trend was report for spray dried ginger juice [15], and for spray dried green banana starch [16].

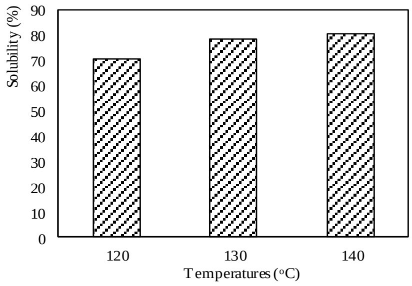

Figure 6. The solubility of tamarind powder.

IV. Conclusion

The present investigation concludes that the temperatures have significant effects on physicochemical properties. By the temperature 140 ℃ gave higher of drying yield, total acidity and solubility as compared to the other temperatures (120 and 130 ℃). While the powder produced using higher temperatures showed lower of moisture content, pH value and bulk density. The best processing conditions for the powder production used a temperature of 140 ℃, which showed better physicochemical properties. The results obtained during the present investigation indicate that good quality powders with optimum moisture content can be produced by drum drying, which demonstrates the great potential for the use of such powders in the food industry.

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References

[1] N. Bhusari, K. Muzaffar, and P. Kumar, “Effect of carrier agents on physical and microstructural properties of spray dried tamarind pulp powder,” *Powder Technology*, vol. 266, pp. 354-364, November 2014.

[2] J. F. Nastaj, “Numerical model of vacuum drying of suspensions on continuous drum dryer at two regions conductive convective heating,” *International Communications in Heat and Mass Transfer*, vol. 27, no. 7, pp. 925-936, October 2000.

[3] W. Jittanit, M. Chantara, T. Deying, and W. Ratanavong, “Production of tamarind powder by drum dryer using maltodextrin and arabic gum as adjuncts,” *Songklanakarin Journal of Science and Technology*, vol. 33, no. 1, pp. 33-41, January-February 2011.

[4] C. K. Pua, N. S. Hamid, C. P. Tan, H. Mirhosseini, R. B. Rahman, and G. Rusul, “Optimization of drum drying processing parameters for production of jackfruit (*Artocarpus heterophyllus*) powder using response surface methodology,” *Food Science and Technology*, vol. 43, no. 2, pp. 343-349, March 2010.

[5] N. Prangpru, T. Treeamnuk, K. Jaito, B. Vanmontree, and K. Treeamnuk, “Comparing the efficiency of two carrier types on drum drying of tamarind juice,” *Thai Society of Agricultural Engineering Journal*, vol. 21, no. 1, pp. 1-7, January-June 2015.

[6] M. Fazaeli, Z. Emam-Djomeh, A. K. Ashtari, and M. Omid, “Effect of spray drying conditions and feed composition on the physical properties of black mulberry juice powder,” *Food and Bioproducts Processing*, vol. 90, no. 4, pp. 667-675, October 2012.

[7] S. Shivmurti and B. K. Kumbhar, “Modeling and optimization for prediction of moisture content, drying rates and moisture ratio,” *International Journal of Agricultural and Biological Engineering*, vol. 2, no. 1, pp. 58-64, January 2009.

[8] Z. Omer and K. Sukru, “Optimization of emulsion characteristics of beef, chicken and turkey meat mixtures in model system using mixture design,” *Meat Science*, vol. 73, no. 4, pp. 611-618, August 2006.

[9] F. Marikar and W. Wijerathnam, “Post-harvest storage of lime fruits (*Citrus aurantifolia*) following high humidity and low temperature in a modified brick wall cooler,” *International Journal of Agricultural and Biological Engineering*, vol. 3, no. 3, pp. 80-86, September 2010.

[10] A. M. Goula and K. G. Adamopoulos, “Effect of maltodextrin addition during spray drying of tomato pulp in dehumidified air: II. powder properties,” *Drying Technology*, vol. 26, no. 6, pp. 726-737, May 2008.

[11] M. Cano-Chauca, P. C. Stringheta, A. M. Ramos, and J. Cal-Vidal, “Effect of the carriers on the microstructure of mango powder obtained by spray drying and its functional characterization,” *Innovative Food Science and Emerging Technologies*, vol. 6, pp. 420-428, May 2005.

[12] A. K. Shrestha, T. Howes, B. P. Adhikari, and B. R. Bhandari, “Water sorption and glass transition properties of spray dried lactose hydrolysed skim milk powder,” *Food Science and Technology*, vol. 40, no. 9, pp. 1593-1600, November 2007.

[13] K. M. Solval, S. Sundararajan, L. Alfaro, and S. Sathivel, “Development of cantaloupe juice powder using spray drying technique,” *Food Science and Technology*, vol. 46, no. 1, pp. 287-293, April 2012.

[14] G. R. Chegini and B. Ghobadian, “Effect of spray-drying conditions on physical properties of orange juice powder,” *Drying Technology*, vol. 23, no. 3, pp. 657-668, March 2005.

[15] S. Phoungchandang and A. Sertwasana, “Spray-drying of ginger juice and physicochemical properties of ginger powders,” *Science Asia*, vol. 36, no. 1, pp. 40-45, March 2010.

[16] D. R. Izidoro, M. R. Sierakowski, C. W. I. Haminiuk, C. F. Souza, and A. P. Scheer, “Physical and chemical properties of ultrasonically, spray-dried green banana (Musa cavendish) starch,” *Journal of Food Engineering*, vol. 104, pp. 639-648, February 2011.

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