Comparison of Powder Yield, Color, Thermal and Microstructural Properties of Spray Dried Tamarind Pulp Powder using Three different Drying Aids

Khalid Muzaffar and Pradyuman Kumar

Department of Food Engineering and Technology, Sant Longowal Institute of Engineering and Technology, Longowal, Punjab-148106, India
E-mail: khalidmuzaffar76@gmail.com

Abstract—*The aim of this work was to compare powder yield, color, thermal and microstructural properties of spray dried tamarind Pulp powder using different carrier agents (maltodextrin, gum Arabic and soya protein isolate). No powder was recovered when tamarind pulp was spray dried alone. About 55% of maltodextrin and Gum arabic was required for successful spray drying of tamarind pulp, while small amount (20%) of soya protein isolate (SPI) was needed for the same purpose. With respect to SPI, maltodextrin and Gum Arabic showed higher change in color values because of using higher concentration of maltodextrin and Gum Arabic. Increase in glass transition temperature of the tamarind pulp powder was much more using maltodextrin and Gum arabic. However using SPI, the increase was not as much, which may be due to fact that protein remained mostly on the surface of particles and contributing minimum to the overall/bulk* T_g*. Powder produced with maltodextrin and Gum Arabic showed smoother surface and are more or less spherical in shape. However powders produced with soya protein isolate showed wrinkled particle surface morphology.*

1. INTRODUCTION

Among the number of drying technologies spray-drying is the widely used method for production of fruit juice and pulp powders (Quek et al. 2007). It involves the transformation of feed in liquid state into powder form by atomizing it into hot air. Fruit juice and pulp powders produced by spray drying may present some problems in their properties such as stickiness and hygroscopicity. These problems are due to the presence of low molecular weight sugars and acids which have low glass transition temperature (Bhandari, 1993).To minimize the stickiness problem and to produce of free flowing powder material science based approach including changing the glass transition temperature of feed solution by introduction of high molecular weight drying aids is commonly used (Troung et al. 2005). The most commonly used drying aids include maltodextrins, Gum Arabic and protein isolate. The aim of this research work was to compare the various properties (powder yield, color, glass transition temperature and microstructure) of tamarind pulp powder using different drying aids

2. MATERIALS AND METHODS

Materials

Fresh and fully ripened tamarind fruit pods were purchased from Sangrur (India). Maltodextrin (DE 20) and Gum Arabic purchased from Loba Chemie Pvt. Ltd. Mumbai, India while soya protein isolate purchased from Nutrimed Health Care Private Ltd. Delhi, India, respectively were used as drying aids.

Tamarind Pulp Preparation

After deshelling and soaking in water in the ratio 1:2.5, Pulp was extracted from tamarind fruit pods under optimum conditions of 33min soaking time and 39^{o}C soaking temperature (Muzaffar and Kumar, 2015).

Spray Drying of Tamarind Pulp using different drying aids

Desired concentrations of each drying aid in powder form were added to the pulp on total solid basis to prepare the feed solutions. The solutions were fed into a tall type laboratory scale spray dryer (S.M. Scientech, Calcutta, India). In all the experimental runs inlet air temperature, feed flow rate, feed temperature, compressor air pressure and blower speed were kept at 160 ^{o}C, 500 ml/h, 25.0±0.5 ^{o}C, 0.06 MPa and 2300 rpm, respectively. After the completion of the experiment, the sample was collected from the cyclone and cylindrical parts of dryer chamber by lightly sweeping the chamber wall as proposed by Bhandari et al. (1997). The powder was then weighed to determine powder yield, packed in laminated

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pouches–and stored in desiccator containing silica gel till further analysis.

Powder yield

Powder recovery was calculated as the percentual ratio between the total mass of the product recovered after spray-drying experiment and the amount of total solids in the feed material.

Color measurement

The color parameters (L^*, a^*, b^*) of powder were determined using a color spectrophotometer (CM-3600d, Konica Minolta) at observation angle of 10 °C and using D65 illuminant. L^* is the lightness (L^*=100 for white and 0 for black), a^* indicates red for a positive value and green for a negative value, b^* indicates yellow for a positive value and blue for a negative value.

Glass transition temperature (T_g)

Differential scanning calorimeter (Mettler Toledo DSC821, Switzerland) was employed to determine the glass transition temperature of the powder samples.

Particle morphology

Particle morphology of spray-dried tamarind pulp powders was evaluated by scanning electron microscopy. The Powders were mounted on SEM stubs using double-sided adhesive tape. The samples were then coated with platinum under vacuum and examined with a Jeol JSM-840 scanning electron microscope (Jeol Ltd, Tokyo, Japan) at an accelerated voltage of 15 kV.

Statistical Analysis

All the analyses were carried out in triplicates and the results were expressed as mean ± standard deviation. Statistical analysis was performed, employing Duncan's Multiple Range Test (DMRT) at 95% confidence level ($p<0.05$).

3. RESULTS AND DISCUSSION

Powder Yield

During spray drying of tamarind pulp without use of any drying aid, all the pulp solids stick to the dryer chamber wall and no powder was recovered. With increase in concentration of each drying aid, powder yield increased (Table 1). About 55% of maltodextrin and gum Arabic was needed for successful spray drying (powder yield > 50%) of tamarind pulp however about 20% of SPI was needed for the same purpose. Increase in powder yield using maltodextrin and gum Arabic as drying aid is due to the increase in overall Tg of tamarind pulp solids (Tonon et al. 2008 and Kha et al. 2010). However greatly enhanced powder yield using SPI as drying aid could be related to preferential migration of protein to air water interface of the atomized droplets, forming a protein rich film and when subjected into hot air, which is converted into glassy skin with high glass transition temperature, preventing the agglomeration and sticky interactions of the particles at the drying chamber of spray dryer (Adhikari et al. 2009). Decrease in powder yield using higher percentage of SPI could be related higher increase in feed viscosity, not leading to proper atomization and causing more solids to paste in the drying chamber.

Color

The color values were significantly affected by concentration of each drying aid (Table 1). It was found that with increase in concentration of each drying aid in the feed material, L value increased, which is attributed to inherent whitish color of the drying aid. With respect to SPI, addition of maltodextrin and gum Arabic showed higher change in color values because of using higher concentration of these drying aids.

Table 1: Powder yield, color and glass transition temperature of tamarind pulp powder using different drying aids.

Concentration of drying aid (%)	Powder yield (%)	Color characteristics			Glass transition temperature (oC)
		L	a	b	
25% MD	9.51±2.19d	63.76±0.87d	8.21±0.34a	14.53±0.25a	39.36±1.23a
35% MD	18.94±3.24c	68.01±0.57c	7.53±0.30b	14.10±0.06a	46.99±1.03b
45% MD	43.39±1.94b	72.28±0.21b	6.15±0.30c	13.30±0.38b	60.70±1.71c
55% MD	52.83±0.37a	79.50±0.16a	4.95±0.18d	12.38±0.16c	85.75±1.44d
25% GA	10.85±1.33h	62.54±1.55h	8.14±1.06e	15.10±0.65e	42.85±1.34h
35% GA	28.60±3.69g	67.58±0.84g	7.59±0.59e	14.87±0.29e	48.19 ±2.04g
45% GA	49.55±4.13f	73.19±2.59f	6.10±0.83f	12.62±0.24f	65.73 ±1.82f
55% GA	59.77±2.76e	77.95±2.02e	5.14±0.28f	10.87±0.82g	93.41±1.01e
12% SPI	17.90±2.49r	52.91 ± 0.72r	10.83 ± 0.37p	25.36 ± 0.63p	34.72±2.43r
20% SPI	55.07±1.98q	61.32 ± 0.97q	9.66 ± 0.47q	24.76 ± 0.48p	41.12±1.36q
28% SPI	48.24±3.21p	68.87 ± 1.24p	9.23 ± 0.22q	21.66 ± 0.40q	52.88±0.98p

Values were expressed as the average of triplicates ± standard deviation.

Different letters (a-d) (e-h) and (p-r) in the same column indicate a significant difference between powders produced with different concentrations of maltodextrin (MD), gum Arabic and soya protein isolate (SPI), respectively at $p \leq 0.05$ according to Duncan's Multiple Range Test (DMRT).

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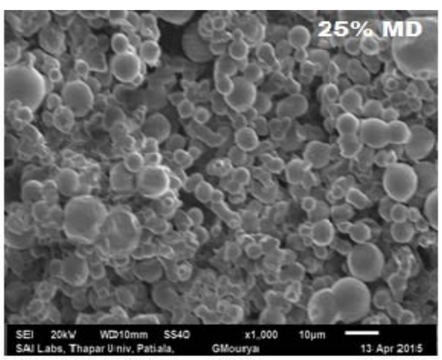
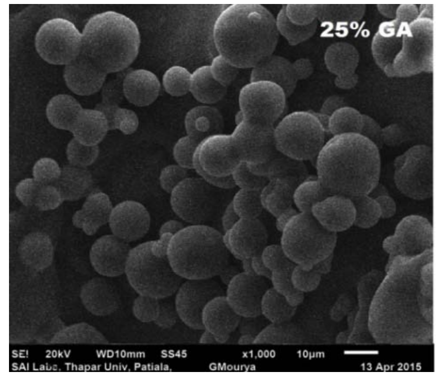
Glass Transition Temperature (Tg)

The glass transition temperature of spray dried tamarind pulp powder increased with increase in concentration of each drying aid, owing to high molecular weight of drying aid. These results are in agreement with the findings of Fang and Bhandari (2012) observed during spray drying of bayberry juice. However T_g of spray dried tamarind pulp powder produced with addition of SPI in the feed material increased not too much, which may be due to fact that protein remained mostly on the surface of particles and contributing minimum to the overall/bulk T_g (Adhikari et al. 2009).

Morphology

Micrographs of spray dried tamarind pulp powders produced with different drying aids is shown in Fig 1. The micrographs of the powders produced with maltodextrin and gum Arabic were almost similar, present round particle morphology. Similar results were found by Ferrari et al. (2012) and Tonon et al. (2008) for spray dried blackberry and acai pulp powder respectively. However micrographs of tamarind pulp powders produced with SPI showed indented and wrinkled particle surface. This could be related to the fact that due to surface activity, the protein forms a thin stable and elastic layer on the particle surface in which protein molecules are bound together by hydrophobic interactions and had low lateral mobility (Jayasundera et al. 2009) The increased flexibility of the SPI protein layer might allow low shrinkage of the particles during drying without rupturing the protein film (Tang and Li, 2013)





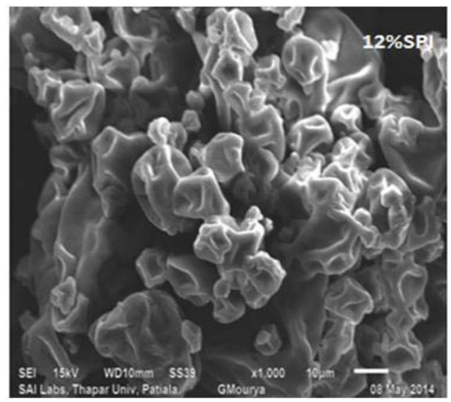


Figure 1: Micrographs of tamarind pulp powder using maltodextrin, Gum Arabic and soya protein isolate as drying aids

4. CONCLUSION

With respect to powder yield, soya protein isolate proved to be an efficient drying aid than maltodextrin and gum Arabic in spray drying of tamarind pulp. All the drying aids increased the lightness of the resulting powder due to inherent whitish color. Overall glass transition temperature and particle morphology of tamarind pulp powder were well affected by the type of type of drying aid used.

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