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Effect of Gum Arabic Concentration on Powder Recovery and Physicochemical Characteristics of Spray-Dried Tamarind Pulp Powder

Khalid Muzaffar and Pradyuman Kumar

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

Abstract—*The present study was aimed to evaluate the powder recovery and various physicochemical properties of spray dried tamarind pulp powder as affected by concentration of Gum Arabic as a drying aid. Increase in concentration of Gum Arabic significantly increased powder recovery and powder lightness value. Moisture content and water activity first increased and then decreased with increase in concentration of Gum arabic in the feed material. Decrease in moisture content at higher concentration of Gum Arabic could be related to increase in feed solids and reduction in total moisture for evaporation. Increase in concentration of Gum Arabic showed significant positive effect on water solubility index and glass transition temperature (T_g) and negatively influenced hygroscopicity and bulk density.*

1. INTRODUCTION

Spray drying is the widely used technique in food industries for commercial production of food powders (Quek *et al*. 2007). 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 *et al*. 1993). Tamarind pulp also contains high proportion of low molecular weight components like glucose, fructose and tartaric acid, which can cause stickiness problem during spray drying. To minimize the stickiness problem material based approach including the change of glass transition temperature of feed solution by addition of high molecular weight drying aids is commonly used (Fazaeli *et al*. 2012). The most commonly used drying aids include maltodextrins and Gum Arabic.

The physicochemical properties of powders produced by spray drying depend on the concentration of drying aid used (Chegini *et al*. 2008). So, the aim of this work was to study the effect of Gum Arabic concentration on powder recovery and various physicochemical characteristics of spray dried tamarind pulp powder.

2. MATERIALS AND METHODS

Materials

Fresh and fully ripened tamarind pods were procured from the local market (Sabzimandi, Sangrur, India). Gum Arabic purchased from Loba Chemie Pvt. Ltd. Mumbai, India was used as drying aid.

Sample preparation and spray drying

After the outer shell of tamarind fruit was removed manually, it was soaked in water in the ratio 1:2.5 under optimum conditions of 33 min soaking time and 39 ^{o}C soaking temperature, blended in a laboratory type blender and sieved to separate fiber, rags and seeds from the pulp. The pulp was then passed through muslin cloth to obtain fine pulp. Tamarind pulp was spray dried in a tall type laboratory scale spray dryer (S.M. Scientech, Calcutta, India) using different concentration of Gum Arabic on total solid basis. In all the experiments 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 each experimental run, powder was recovered from the cyclone and cylindrical parts of dryer chamber. The powder was then weighed to determine powder recovery and immediately sealed in laminated pouches to prevent subsequent moisture till further analysis. The powders produced at different concentrations of Gum Arabic were then analyzed for color, moisture content, water activity, hygroscopicity, solubility, bulk density, and glass transition temperature.

Powder recovery

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

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Color measurement

The color parameters (L^*, a^*, b^*) of pulp were determined using a color spectrophotometer (CM-3600d, Konica Minolta).

Moisture content

The moisture content of the powder samples was determined by using an electronic moisture analyzer (Presia Gravimetric AG Dietikon, Switzerland) at 105 ^oC.

Water activity (a_w)

The water activity meter (Aqualab CX2T, Decagon Devices, USA) was employed to determine the water activity of the powder samples.

Hygroscopicity

Hygroscopicity was determined according to the method proposed by Tonon *et al*. (2008).

Water solubility index

The water solubility index of the powder samples was determined according to the method followed by Kha *et al*. (2010).

Bulk density

The bulk density was measured as per the method followed by Goula and Adamopoulus (2010).

Glass transition temperature (T_g)

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

Statistical analysis

Except powder recovery, all the experiments were carried out in triplicates and the results were presented as mean values with standard deviations. Statistical analysis was performed, employing Duncan's Multiple Range Test (DMRT) at 95% confidence level ($p < 0.05$).

3. RESULTS AND DISCUSSION

Powder recovery

With increase in addition level of Gum Arabic from 25% to 55%, the powder recovery also increased from 10.85 to 59.77% (Table 1). The increase in powder recovery with the addition of Gum Arabic is due to the increase in overall Tg of tamarind pulp solids, overcoming the stickiness problem during spray drying.

Color

The color values (L^*, a^* and $b)^*$ values were significantly affected by Gum Arabic concentration (Table 1). It was found that with increase in concentration of Gum Arabic, L^* value significantly increased, however significant decrease was observed in a^* and b^* value, which is due to the concentration effect of the SPI having the inherent whitish color.

Moisture Content and Water Activity (a_w)

The moisture content and water activity of the powders produced with different concentrations of gum Arabic is shown in Table 2. With increase in concentration of gum Arabic both the moisture content and a_w of the powders increased, which may be to the fact that presence of large maltodextrin molecules may make it difficult for water molecules to diffuse (Adhikari *et al*. 2004). At higher concentration of Gum Arabic, moisture content decreased, which may be due to increase in feed solids and a reduction in total moisture for evaporation.

Table 1: Powder recovery and color characteristics of Spray dried tamarind pulp powder using gum Arabic as drying aid

Concentration of drying aid (%)	Powder recovery (%)	Color characteristics		
		L*	a*	b*
25% GA	10.85± 1.33d	62.54±1.55 d	8.14±1.06 a	15.10±0.65 a
35% GA	28.60±3.69 c	67.58±0.84 c	7.59±0.59 a	14.87±0.29 a
45% GA	49.55±4.13 b	73.19±2.59 b	6.10±0.83 b	12.62±0.24 b
55% GA	59.77±2.76 a	77.95±2.02 a	5.14±0.28 b	10.87±0.82 c

Values were expressed as the average of triplicates ± standard deviation. Different letters (a-d) in the same column indicate a significant difference between powders produced with different concentrations of Gum Arabic (SPI), respectively at $p<0.05$ according to Duncan's Multiple Range Test (DMRT).

Hygroscopicity and Water Solubility

The hygroscopicity values of the powders produced with different concentrations of gum Arabic are presented in Table 2. The lowest hygroscopicity values were obtained at higher concentration of the Gum Arabic used, confirming its efficiency as drying aid in reducing the hygroscopicity of spray dried powders. With respect to solubility, the powder samples showed increase in solubility with increase in concentration of Gum Arabic in the feed material. The higher solubility values could be due to high solubility of gum arabic. Our results are in consistent with the findings of Comunian *et al*. (2011) observed during spray drying of chlorophyllide.

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Table 2 Physicochemical properties of spray dried Tamarind pulp powder using Gum Arabic as drying aid

Concentration of Gum Arabic (%)	Moisture content (%)	Water activity	Hygroscopicity (%)	Solubility index (%)	Bulk density (g/ml)	Glass transition temperature (oC)
25%	3.92±0.29b	0.392±0.01b	26.23±1.09a	63.71±0.90d	0.59±0.01a	42.85±1.25d
35%	4.63±0.20a	0.425±0.03a	25.22±0.27b	67.21±0.94c	0.58±0.01a	48.19±2.16c
45%	3.96±0.14b	0.393±0.01b	23.02±0.52b	73.80±1.30b	0.54±0.01b	65.73±1.89b
55%	3.03±0.14c	0.354±0.01c	20.48±1.11c	78.85±0.25a	0.52±0.01c	93.41±1.54a

Values were expressed as the average of triplicates ± standard deviation. Different letters (a-d) in the same column indicate a significant difference between powders produced with different concentrations of Gum Arabic (SPI), respectively at $p<0.05$ according to Duncan's Multiple Range Test (DMRT).

Bulk Density

With increase in concentration of Gum Arabic in the feed solution bulk density decreased (Table 2). This effect could be related to the fact that addition of the drying aid minimizes the thermoplastic particles from sticking and also increases the volume of air trapped into the particles because of the film forming property of the drying aid (Goula and Adamopoulos, 2010). With increase in volume of the trapped air, a decrease in the apparent density of particles occurs and this apparent density primarily determines the powder bulk density.

Glass Transition Temperature (Tg)

The glass transition temperature of spray dried tamarind pulp powders produced with different concentrations of Gum Arabic ranged from 42.85 to 93.41 (Table 2). The T_g values increased with increase in concentration of Gum Arabic, which could be related to high molecular weight of Gum Arabic.

4. CONCLUSIONS

Concentration of Gum Arabic significantly influenced all the investigated properties of spay dried tamarind pulp powder. Concentration of Gum Arabic showed significant positive effect on powder recovery, powder lightness, water solubility index and glass transition temperature (T_g) and negatively influenced hygroscopicity and bulk density. At Higher concentration of Gum Arabic decreased moisture content which could be related to increase in feed solids and reduction in total moisture for evaporation.

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