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Physicochemical and organoleptic properties of spray-dried pineapple powder: Effect of maltodextrin concentration and inlet air temperature

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Abstract
Fresh fruits and juices are highly perishable and susceptible to mechanical damage during packaging, handling, storage and transportation, which can result in a substantial reduction in quality. Spray drying of fruit juices represents another alternative way to improve the physicochemical stability and increase their shelf life. The present research work focuses on producing pineapple fruit powder using spray drying technique and its objective was to study the effect of different maltodextrin (MD) concentrations and inlet air temperatures on the physicochemical properties and sensory characteristics of final product. Maltodextrin was added to the pineapple juice as a carrier agent in concentrations of 10%, 15% and 20% (w/v) and the powder was produced by dehydrating the juice using a laboratory scale spray dryer at inlet air temperatures 130, 140 and 150 °C at the feed flow rate of 400 mL/h. Quality of powder was evaluated in terms of powder yield, moisture content, solubility, TSS, pH, colour and sensory characteristics. The results showed that MD concentration and inlet air temperature both significantly influenced the physicochemical and sensory properties of powder. The highest yield of powder was produced at spray drying conditions of 130 °C with a 20% MD. It was observed that the higher maltodextrin and lower inlet air temperature produced more pineapple powder; however, the powder produced with 20% MD at 150 °C was also satisfactory. At higher inlet air temperature and maltodextrin content, the moisture content of pineapple powder decreased. Increased concentration of maltodextrin decreased the solubility of pineapple powder. TSS and pH value of the powder increased with addition of maltodextrin while there was no significant effect of inlet air temperature. In the case of colour attributes, a good colour values (L*, a* and b*) and lower colour change was found in 20% MD at 150 °C. Pineapple powder obtained at 20% MD and 150 °C was found to be most acceptable due to attractive appearance; and better colour and taste.

Keywords: Pineapple, spray drying, maltodextrin, inlet air temperature, powder yield

1. Introduction

Pineapple (*Ananus comosus*) is a wonderful tropical fruit having exceptional juiciness, vibrant flavour and immense health benefits, and one of the top fruits in the consumer's preference. Costa Rica represents the world's leading pineapple producing countries with reported production of approximately 2.7 million metric tonne in 2015. India ranks fifth in this list with an annual production rate of 1.9 million tonnes (FAO, 2017) [6]. Pineapple has been considered as a good source of macro and micronutrients which makes it a highly nutritional and valuable product (Scherz and Senser, 1994) [19]. Pineapple is packed with lots of vitamins and minerals like vitamin C, vitamin B_1, vitamin B_6, calcium, potassium, copper and dietary fibres. A group of sulfur-containing proteolytic enzymes (bromelain) in pineapple aid digestion. Bromelain has demonstrated significant anti-inflammatory effects reducing swelling in inflammatory conditions such as acute sinusitis, sore throat, arthritis and gout and speeding recovery from injuries and surgery. Pineapple reduces blood clotting and helps to remove plaque from arterial walls. Pineapple is an excellent cerebral toner; it combats loss of memory, sadness and melancholy. Pineapple fruits are primarily used in three segments, viz., fresh fruit, canning and juices with characteristic requirements of size, shape, colour, aroma and flavour. Owing to the short shelf life, there are always many challenges and difficulties regarding transportation and storage of fresh fruits and juices. Fruit juice powders, by virtue of their reduced weight and volume, are easier to handle, diminish the transportation costs and prolong the shelf life of the juice products (Bhandari, 2013) [3]. Therefore, fruit juice powder is a better alternative to enjoy the feeling of originality and lusciousness like fresh fruits anywhere and anytime. In addition, there are vast multi disciplinary applications of fruit juice powder e.g. pharmaceutical capsules or pills, functional food, water-soluble beverages, colorants and natural flavouring agents, infant or baby food, puffed food, baking food etc.

The chemical composition of fruit juices, mainly due to the low glass transition temperature of the main juice components, that is, organic acids and low molecular weight sugars, make it almost impossible to obtain powder without carriers that are added in a relatively huge quantity (Tonon *et al*., 2010) [22]. What is more, different types of carrier agents might be applied, namely, maltodextrin, gum arabic, waxy starch, inulin and cellulose, among which the most popular is maltodextrin (Phisut, 2012) [15]. Silva *et al*. (2006) [21] pointed out that MD could improve the stability of fruit powder with high sugar content because it reduced stickiness and agglomeration problems during storage. The quantity or concentration of the carrier added into the fruit juices has an influence on the final product's properties (Michalska *et al*., 2017b). Those properties of fruit powders also strongly depended on the drying methods and the parameters applied for their dehydration (Michalska *et al*., 2017a). According to Chopda and Barret (2001) [5], the recommended methods for fruit juice production are, freeze drying, foam mat drying and spray drying, however, the economic aspect should be taken into account.

Spray drying is extensively used in pharmaceutical and food industries in dehydration of liquid foods for conversion into dry powder products (Caparino *et al*., 2012; Kha *et al*., 2010) [4, 10]. Due to its versatility and speed, spray dryer became the most used drying technique. Spray drying involves atomization of feed into a spray and contact between the spray and drying medium resulting in moisture loss leaving a dry powdered product (Moyers and Baldwin, 2008). Spray dryers can dry a liquid product very quickly compared to other methods of drying. Spray drying is commonly used for powder production of milk, coffee, tea, egg, enzymes, whey protein, fruits and vegetables extracts.

In view of the above discussion, the present investigation was taken up to study the effect of different maltodextrin (MD) concentrations and inlet air temperatures on the physicochemical and organoleptic properties of spray-dried pineapple powder.

2. Materials and Methods

2.1 Sample preparation

Freshly harvested pineapples used for the study were procured from the local fruit market at Bapatla, India. They were washed in cold tap water, peeled and cut into small pieces. The juice was extracted using Sujata Powermatic juicer (Mittal Electronics, Delhi) and filtered with new and clean muslin cloth. Then, different samples were prepared for the experiment by mixing 10%, 15% and 20% (w/v) maltodextrin (MD) into juice.

2.2 Spray drying process

The solution was fed to a laboratory scale co-current spray dryer (Model SMST-15, SM Scientech, Kolkata, India) in its drying chamber (500-215 mm) through a peristaltic pump. The inner diameter of atomizer nozzle was 0.5 mm and the feed flow rate was controlled by the pump rotation speed. Drying was conducted at inlet air temperatures of 130, 140 and 150 °C with controlled conditions at the feed flow rate of 400 mL/h. The powder produced was collected in an insulated glass bottle connected at the end of cyclone. After that they were packaged in airtight polyethylene (LDPE) zip bags and stored in a desiccator containing silica gel at 25 °C till further analysis.

2.3 Powder yield

Powder yield was expressed as the weight percentage of the final product compared to the total amount of the materials sprayed (Sansone *et al*., 2011) [18].

$$\text{Yield (\%)} = \frac{\text{Weight of powder (g)}}{\text{Weight of feed (g)}} \times 100$$

2.4 Physico-chemical properties

2.4.1 Moisture content

The moisture content analysis was conducted according to the method of AOAC (2005). One gram of sample was taken and dried in an oven at 70 °C until constant weight and triplicated the analysis and calculated as;

$$\text{Moisture content} = \frac{\text{Weight of water loss}}{\text{Weight of powder sample}} \times 100$$

2.4.2 Solubility

The solubility of pineapple powder was determined using the method of Al-Kahtani and Hassan (1990). The powder sample and distilled water were transferred into a 500 mL beaker with the proportion 37 g of powder per 100 g of distilled water. After transferring the specified amount of powder sample and distilled water into the beaker, a magnetic bar was dropped and then the beaker was located on the stirring hot plate (Model 210T, Fisher Scientific, USA) setting at speed level 5 while the heater was not turned on. The measurement was conducted in the room controlling temperature at 25 °C. The stopwatch was started since turning on the hot plate stirrer and stopped when the powder in the beaker entirely dissolved. This recorded time, namely solubility was indicated in the unit of minute.

2.4.3 Total soluble solids

The total soluble solids (TSS) in pineapple juice samples was determined using digital refractometer (Atago Pocket refractometer PAL-3, Japan) following the method given by AOAC (2005) and expressed in terms of °Brix.

2.4.4 pH

The pH of pineapple juice samples was measured with a digital pH-meter (Systronics micro pH system-362, Ahmedabad, India) according to AOAC (2005) method.

2.4.5 Colour

The colour characteristics of the spray dried pineapple powder were analyzed by using Hunter Lab Colorimeter (Color Flex EZ, USA). The instrument was standardized with white and black ceramic tiles before starting the measurement. Obtained results were expressed as Hunter colour values L*, a* and b* where L* denotes lightness or darkness, a* denotes redness or greenness and b* denotes yellowness or blueness. Powders were packed in polyethylene covers and were measured for colour characteristics. Triplicate samples were analyzed and mean value was reported (Tze *et al*., 2012) [23]

2.5 Organoleptic or sensory properties
Sensory evaluation of pineapple powder was carried out for consumer acceptance and preference using 20 untrained panelists selected at random from the College of Agricultural Engineering, Bapatla. Physical appearance, Aroma, taste and overall acceptability and texture of the samples were rated using a 9-point Hedonic scale where 9 and 1 represent like extremely and dislike extremely respectively (Ranganna, 2001). Sensory evaluation was carried out at ambient conditions in a comfortable and quiet area without disturbance under fluorescent lighting.

3. Results and Discussion
3.1 Pineapple powder yield
Analyzing Fig. 1., it can be observed that both MD concentrations and inlet temperatures have significant effect on the product yield especially higher MD concentrations that led to higher production where the increasing inlet air temperature showed random effect, maximum yield (10.77%) has been found for 20% MD at 130°C. However, the increasing in MD concentrations in pineapple juice significantly increased the process yield. This is similar with the results of Shrestha *et al*., (2007) [20]. On the whole, the product yield of the samples decreased, when inlet air temperature was increased from 130 °C to 150 °C. Such decrease may be happened due to the sticking of the pineapple droplets on the hot surface area of the spray drying chamber (Sahin-Nadeem *et al*., 2013).

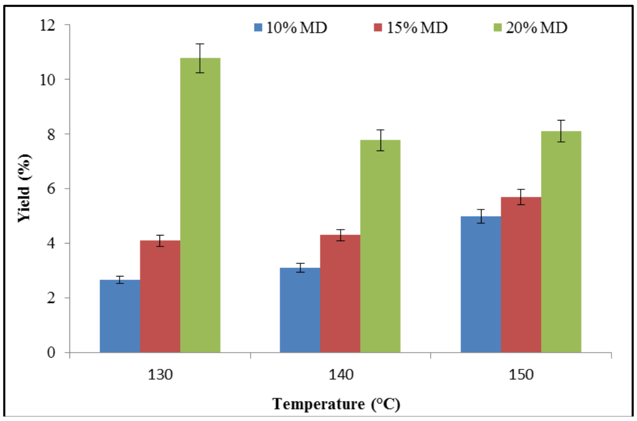

Fig 1: Changes in pineapple powder yield with MD concentration and inlet air temperature

3.2 Physicochemical properties of pineapple powder
3.2.1 Moisture content
Moisture content plays a significant role in determining the quality and shelf life of the fruit juice powder. High moisture content will decrease the quality of the product. The higher the MD concentration and inlet air temperature, the lower the moisture content of the spray-dried pineapple powder as shown in Fig. 2.

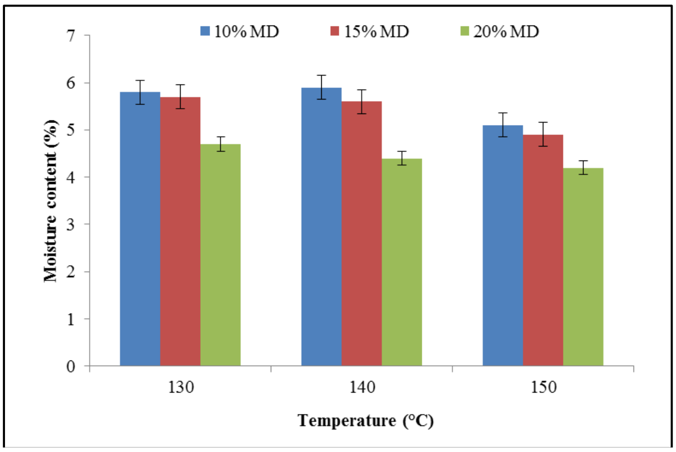

Fig 2: Changes in moisture content of pineapple powder with MD concentration and inlet air temperature

At higher inlet air temperatures, there was a significant changes found on moisture content due to the higher temperature gradient between the atomized feed and the drying air, causing rapid water vaporization with greater rate of heat transfer, ultimately leads to generate powders with lower moisture content (Kha *et al*., 2010) [10]. Higher MD concentrations showed a sound effect to down the moisture trend of spray-dried powder owing to the fact that the addition of MD that increased the total solids of the feed and reduced the amount of water vaporization (Shrestha *et al*., 2007) [20].

3.2.2 Solubility
The solubility of most powdered foods is essential as rehydration process will occur when the dried powder comes into contact with water. A good rehydration process will wet the dried powder quickly and it will dissolve without lump or float in the solution. From Fig. 3, it is shown that the highest solubility is 7.2 for 10% MD at 130 °C inlet air temperature. The solubility of the pineapple powder decreased with increasing the concentration of maltodextrin. This may be due to lower hygroscopicity of pineapple powder obtained at high MD concentration (Phisut, 2012) [15]. On contrast, the solubility of pineapple powder initially decreased up to 140 °C then increased at 150 °C which was consistent with the results for tamarind pulp powder.

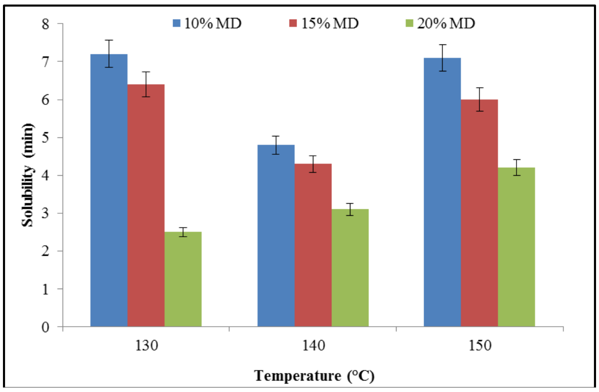

Fig 3: Changes in solubility of pineapple powder with MD concentration and inlet air temperature

3.2.3 Total soluble solids

The total soluble solid (TSS) content of fresh pineapple juice was 11 °Brix. Fig. 4 shows the variation of TSS for each temperature at different concentrations of maltodextrin. The soluble solid content of the pineapple is higher than the fresh pineapple juice. TSS increased with the addition of the maltodextrin in the sample (Phisut, 2012) [15]. The solid soluble content of the pineapple powder does not depend on the inlet temperature as there does not have a constant trend of increasing or decreasing TSS as the inlet temperature increased (Jittanit *et al*., 2010) [9].

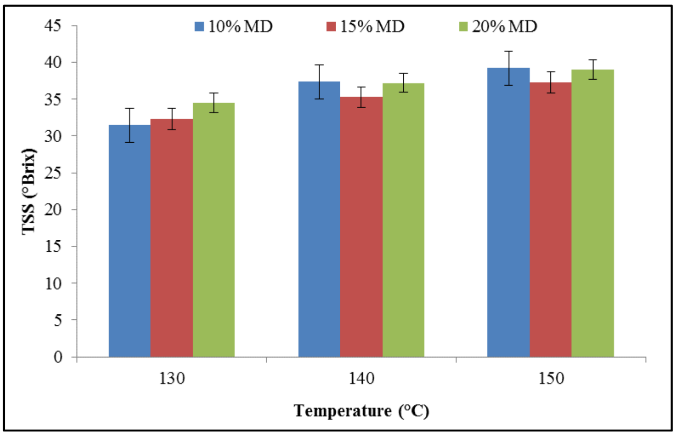

Fig 4: Changes in TSS of pineapple powder with MD concentration and inlet air temperature

3.2.4 pH

pH values of the spray dried pineapple powder slightly increased with increase in the concentration of maltodextrin from 10% to 20% (Fig. 5). There was no significant effect of inlet air temperature on pH of the product. This finding was in agreement with the report of Gonzalez-Palomres *et al*., (2009) for roselle extract powder.

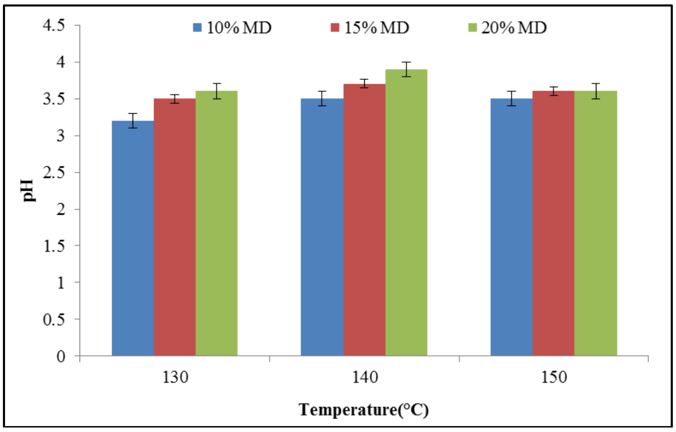

Fig 5: Changes in pH of pineapple powder with MD concentration and inlet air temperature

3.2.5 Colour

The colour of fresh pineapple juice i.e., lightness (L*, +), redness (a*, +) and yellowness (b*, +) were 60.3, 3.1 and 17.8 respectively. It is observed from Fig. 6; the lightness, redness and yellowness of the solutions of pineapple powders were significantly affected by MD concentration as well as inlet air temperatures. Higher inlet air temperature produced lighter product than lower one. In general, the solutions had the less lightness than the fresh sample but the redness and yellowness were higher. For the higher redness and yellowness of the solutions, it may be also as a result of some non-enzymatic browning reactions such as caramelization and Maillard reactions happening during the spray drying process. These reactions could take place because of the high sugar content in the pineapple juice and heat supplied to the juice in the drying chamber (Fennema, 1976) [7].

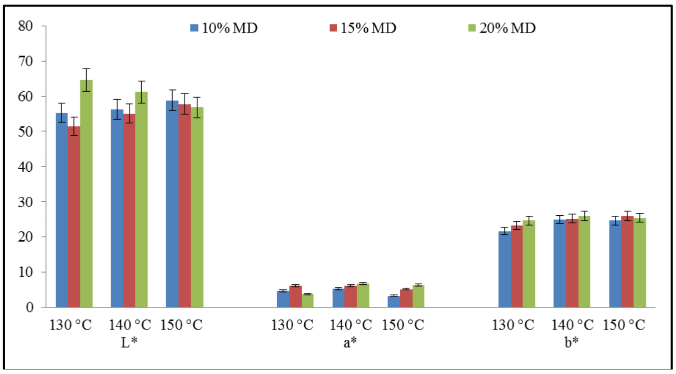

Fig 6: Changes in colour of pineapple powder with MD concentration and inlet air temperature

3.3 Organoleptic properties of pineapple powder

From Fig. 7, it could be observed that highest rating of overall acceptability was given for 20% maltodextrin content under 150 °C inlet drying temperature at constant feed flow rate 20 ml/min.

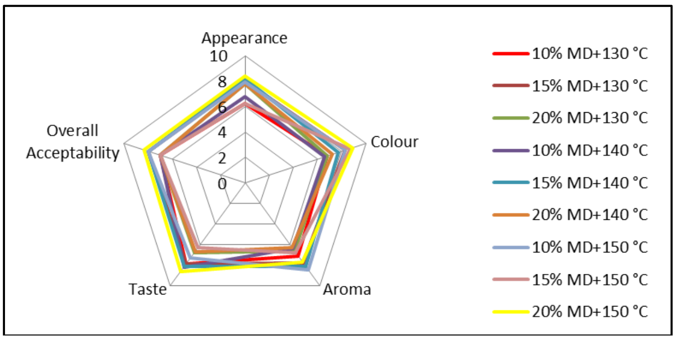

Fig 7: Changes in sensory attributes of pineapple powder with MD concentration and inlet air temperature

4. Conclusions

The research work was carried out to assess the selected quality parameters of spray-dried pineapple powder with the addition of different concentrations of MD at several inlet temperatures. The results showed that inlet temperatures and MD concentrations both have significant influence on the quality of product. It may be concluded that at the inlet temperature of 150 °C and MD concentration of 20%, the spray-dried powders have better quality; reasonably higher yield, higher solubility, lower moisture content, moderate TSS, moderate pH, moderate colour and higher sensorial properties over others. These properties of the powders are very significant to ensure the production of better quality final product. Further investigation is required to analyze the storage effects towards the quality properties to enhance the shelf life of the product.

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