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Process technology for production of spray and freeze dried pineapple powder

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Abstract
Ananas Comosus is a most economical tropical fruit in the *Bromeliaceae* family. Pineapple juice was extracted, filtered juice mixed with maltodextrin at different concentrations (0, 1, 2, 3, 4 and 5%) and conducted spray drying and freeze drying experiments. Filtered pineapple juice was fed to the spray dryer at inlet drying air temperature of 140 ºC, constant feed flow rate of 20 ml/min and freeze drying was conducted at below -40 ºC. The quality of pineapple powder was determined by evaluating the physical, chemical and sensory characteristics of powder. The results revealed that, the yield of freeze drying pineapple powder was highest (14.72%) at a maltodextrin concentration of 5%. It was also observed that, the moisture contents of the powders was in the range of 4.5- 5.8%, increasing in maltodextrin concentration resulted lowering the moisture content of powder. The water solubility of the pineapple powder varied with maltodextrin concentration and ranged between 58-95 sec. The pH varied from 4.4 to 4.8, the pH of the reconstituted juice was higher than the fresh pineapple juice, the pH of the reconstituted pineapple juice was higher than that of fresh juice, and the rise in pH of the reconstituted juice may be due to the addition of maltodextrin. Ascorbic acid and total acidity varied from 12.78 to 20.32 mg/100mg and 0.5 to 1.1% respectively. Freeze dried powder contain high ascorbic acid than spray dried powder. Highest rating of overall acceptability was given for freeze dried pineapple powder as compared to spray dried powder. Among freeze dried experiments, highest rating sensory score was obtained by powder without addition of maltodextrin followed by 1% and 2% Maltodextrin concentration.

Keywords: Pine apple, spray drying, freeze drying, powder recovery, sensory evaluation

Introduction
Pineapple [*Ananas comosus* (L.) *Merr. Family: Bromeliaceae*] is queen of the tropical fruits due to its excellent flavor and taste, third most important tropical fruit in the world after Banana and Citrus. Production of pineapple in India during 2016–2017 was about 1.7 million tones (Anonymous, 2018 [1]). In terms of area and production, Assam and West Bengal rank first followed by Karnataka, Bihar and Manipur states. The pineapple fruits are low in saturated fat, cholesterol and sodium, rich in vitamin-C, potassium, magnesium, dietary fiber and other minerals (Hossain *et al*., 2015) [2]. Pineapples are filled with vitamin-C and fiber, which are important for the immune and digestive systems, regulate the gland and aid in goiter. In addition, fresh pineapple juice is used to remove intestinal worms, throat and other infections (Hossain *et al*., 2015) [2].

Pineapples are usually used in kitchens, apart from freshly consumed, converted into juices, jams, ice cream *etc*. Fresh fruits are difficult to ship and the juice which is having high content of ascorbic acid cannot last longer. Although the market includes many pineapple products, the food industry is still developing new pineapple products. The new product has the advantage of increasing the fresh pineapple demand which therefore helps to reduce the losses due to micro organisms, chemical substances and enzyme reactions during the harvest season.

Fresh fruit can be transformed into dry particulates using different dehydration methods, such as freeze drying, solar, spray drying, vacuum during and oven drying (Botha *et al.*, 2012 [3]; Bala *et al.*, 2003 [4]; Gabas *et al.*, 2007 [5]; Jittanit *et al.*, 2010 [6]). Due to prolonged shelf life at ambient temperature, easiness of use and minimum cost of transportation, the pineapple juice powder is an interesting product; it can be used as a flavoring agent or as instant juice powder. Drying of the fruit juice with high content of sugar, such as pineapple is difficult because of its thermo plasticity and hygroscopicity. It can be overcome by adding some carriers such as maltodextrin (MD) and Arabic gum. The drying carriers or adjuncts are high molecular weight compounds that have high glass transition temperature (Tg) hence, they can raise the Tg value of juice and the subsequent powder [7].

The present study was taken up to optimize the process parameters for production of pineapple juice powder by freeze drying and spray drying.

Materials and Methods

Research work has been conducted at the Process Engineering Laboratory, Department of Agricultural Process and Food Engineering, College of Agricultural Engineering, Bapatla, Andhra Pradesh.

Pineapple fruits

Freshly harvested, fully ripened pineapples fruits used for the study were procured from local fruit market. Fruits were cleaned with water to remove dirt adhering on surface, peeled, cut and hydraulically pressed to squeeze out the juice. Pineapple juice extracted using juicer having sediments and fiber *etc*. The clear pineapple fruit juice was obtained by filtering through muslin cloth.

Carrier agent

Maltodextrin can significantly reduce dried products hygroscopicity (Goula and Adamopoulos, 2008 [8]). Hence the carrier agent maltodextrin of 0, 1, 2, 3, 4 and 5% w/v was mixed with the pineapple juice to reduce the hygroscopicity. Freeze drying and spray drying methods were used to obtain pineapple powder.

Freeze Dryer

Dehydration of pineapple fruit juice was carried out using freeze dryer (Make: Delvac pumps, model: LYODEL-55), which is having 750 mm depth, 550 mm width and 350 mm height. The lowest temperature in the freeze dryer is -55 (± 5 ˚C). Freeze drying experiments were conducted at -40 ˚C at different maltrodextrin concentrations of drying agent (0, 1, 2, 3, 4 and 5%).

Spray Dryer

Laboratory scale toll type spray dryer (Make: S.M. Science Tech., India, Model: SMST-15) was used for drying of pineapple juice. Experiments were conducted with spray dryer inlet temperature of 140 °C and 20 ml/min constant flow rates at different maltodextrin concentrations (0, 1, 2, 3, 4 and 5%).

Physico-chemical properties

Pineapple juice powder obtained was kept at ambient temperature in glass bottles to avoid moisture absorption. Later, the powder was used to determine the physical and chemical properties of pineapple powder and sensory analyses. Each sample was replicated three times and its mean value was taken.

Powder recovery

Powder recovery was expressed as the final product's weight percentage compared to the total l feed material (Sansone *et al.*, 2011) [9].

$$\text{Powder recovery, \%} = \frac{\text{Weight of the pineapple powder,g}}{\text{Weight of feed,g}} \times 100$$

Moisture content

The moisture content of pineapple powder was determined by AOAC (1984) [10] method, the moisture content was calculated and expressed by the following formula as percent (w.b.).

$$\text{Moisture content, \%, w. b} = \frac{(\text{Intial weight,g} - \text{Final weight,g})}{\text{Intial weight,g}} \times 100$$

Total soluble solids (TSS)

TSS of juice was determined by using refractometer (Make: ATAGO, Model: ATG53). A drop of juice was placed on the optical refractometer prism to measure the total soluble sample solid, and reading was expressed as Brix.

Water solubility of powder

The solubility of pineapple juice powder in water was determined according to the Eeastman and Moore method (1984) [11]. One gram of pineapple juice powder was added to 50 ml distilled water in a beaker, mixed with the help of magnetic stirrer and recorded the soluble time.

pH

Pineapple juice pH was measured using a digital pH meter of the (HI-98107, Hanna).

Color evaluation

The color was measured by using a colourimeter (Lovibond PFX-995 Tintometer). Small volume of sample was filled in the 10 mm optical glass chamber and placed into the chamber channel. The color readings (Red (R), Yellow (Y) and Blue (B)) were noted (AOAC, 2000) [12].

Ascorbic acid

The ascorbic acid was estimated by AOAC, 2005 method [13].

Titratable acidity

Pineapple juice titrable acidity has been established by AOAC (2005) [13]

Sensory evaluation

For consumer acceptance and preference, sensory evaluation of pineapple juice was performed using 10 untrained panelists chosen at random. Physical appearance, Aroma, taste and overall acceptability and texture of the samples were rated using a 9-point hedonic scale. Sensory analysis was carried out at ambient conditions [14].

Results and Discussion

Yield of pineapple powder

Pineapple juice powder yield obtained at different spray and freeze drying experiments and observed that, the powder yield varied in the range of 10.1-14.72% in freeze drying, where as in spray drying it was in the range of 10.86-12.56% (Fig.1). Powder yield observed to be increased with increase in maltodextrin concentration. Pineapple powder was not obtained in spray drying at 0, 1 and 2% maltodextrin concentration due to less flow properties and sticky nature of fruit juice. Maximum powder yield was obtained at 5% maltodextrin in both freeze and spray drying methods. Maximum powder yield was obtained in freeze drying as compared with freeze drying.

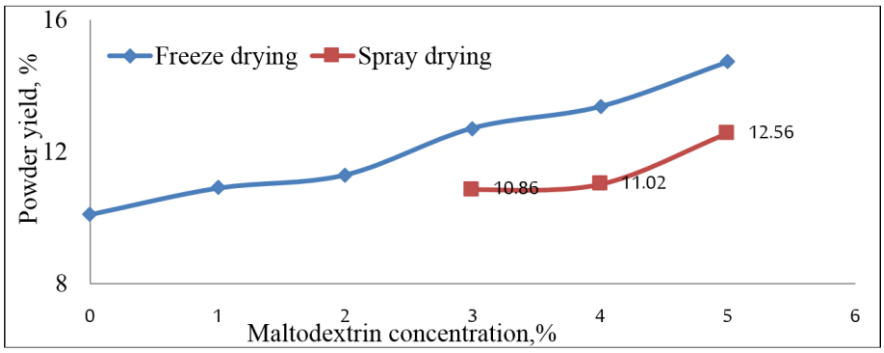

Fig 1: Effect of maltodextrin on pineapple powder yield

Physical properties of pineapple powder

Pineapple powders were obtained at different concentrations of maltodextrin was packed in glass bottles and stored at room temperature, then the samples were taken out and their physical properties like moisture content and solubility were measured.

Water solubility of pineapple juice powder

Freeze dried pineapple powder solubility varied from 95 sec to 68 sec whereas in spray drying it varied from 78 sec to 58 sec (Fig. 2). Solubility was maximum for freeze dried pineapple powder obtained without addition of matrodextrin and minimum at 5% maltodextrin of spray dried powder. Freeze dried powder took more time to dissolve in water as compared to spray dried powder. The solubility of the pineapple powder depends on the maltodextrin concentration, raising the maltodextrin level will reduce the powder hygroscopicity resulting in a reduced soluble time. These results are in accordance with Abadio *et al*., 2004 [15].

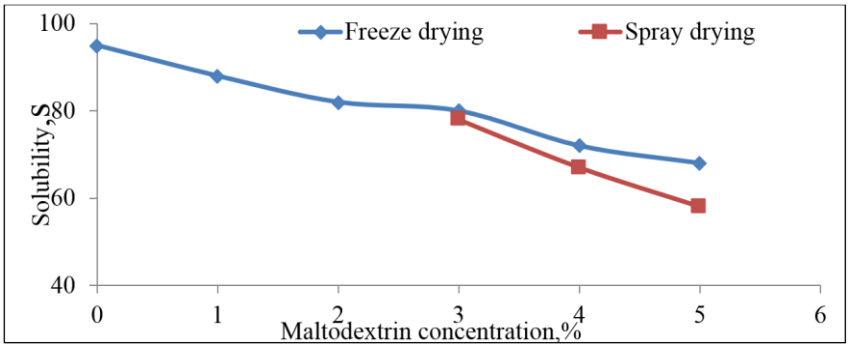

Fig 2: Water solubility of pineapple powder

Moisture content of pineapple powder

Variation in moisture content of pineapple juice powder was studied and reported in Fig.3. Spray dried powder moisture content varied from 4.5-5.8% whereas in freeze dried powder it varied between 4.7 and 5.8%. It was found that, in freezing dried powder, the maximum moisture content was recorded in a sample without addition of maltodextrins and minimum moisture content was recorded in spray dried powder at 5% maltodextrin. It was also revealed that, moisture content was decreased by an increase in the concentrations of maltodextrin. The results obtained are in accordance with results reported by Adhikari *et al.*, 2004 [16], Shrestha *et al.*, 2007 [17].

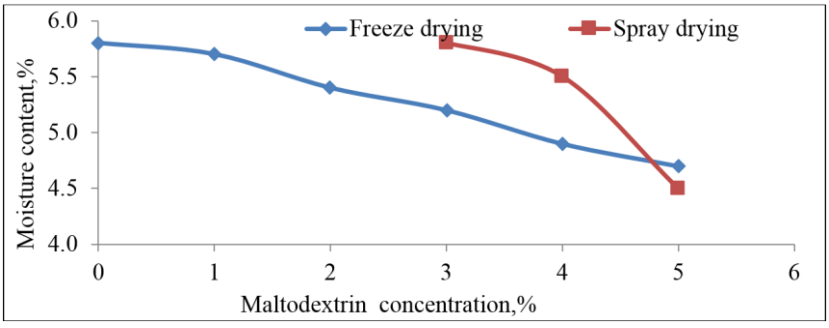

Fig 3: Variation of moisture content at different concentrations of maltodextrin

Chemical Properties of pineapple powder

Spray and freeze dried pineapple powders were obtained at different concentrations of maltodextrin was packed in glass bottles and stored at room temperature. Then the samples were taken out and their chemical properties like total soluble solids, pH, colour, total acidity and ascorbic acid were measured.

Variation in Total Soluble Solids (TSS)

Variation of total soluble solids at different concentrations of maltodextrin was shown in Fig. 4. Total soluble solids of raw pineapple juice at different concentrations of maltodextrin varied from 13 to 19 ˚Brix prier to drying. Reconstitutes spray dried pineapple powder juice TSS varied between 13-17 ˚Brix and freeze dried pineapple powdered juice TSS varied from

12-18˚Brix. TSS of reconstituted freeze dried powder was high as compared to reconstituted spray dried powder juice. It was reported that addition of maltodextrin has increased the total soluble solids (Phisut *et al.*, 2012) [18].

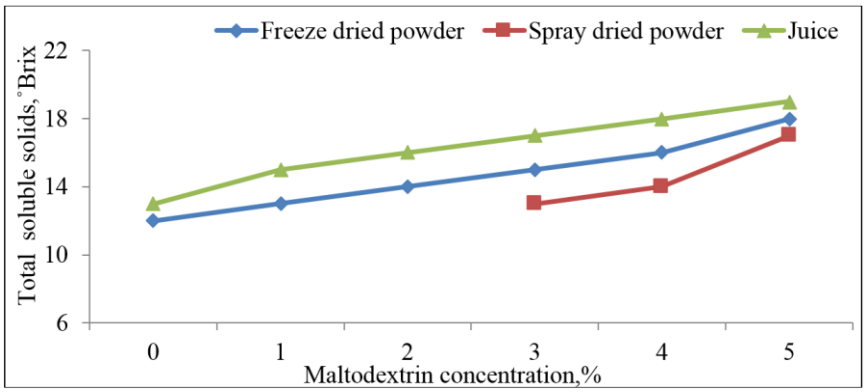

Fig 4: Variation of total soluble solids of reconstituted pineapple juice

Variation in pH

Pineapple juice pH prior to drying at different concentrations of maltodextrin varied from 4.4 to 4.8 (Fig.5). Reconstituted spray dried pineapple powdered juice pH varied from 4.7 to 4.8 whereas in freeze dried pineapple powdered juice it varied from 4.5 to 4.8. The pH of reconstituted pineapple juice was higher than the fresh pineapple juice. The pH of reconstituted juice was increased because the addition of maltodextrin which is having pH of 4.7 (Jittanit *et al.*, 2010) [6].

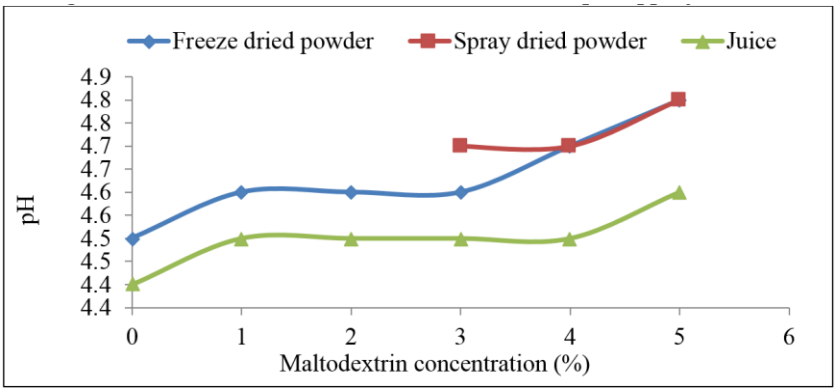

Fig 5: Variation in pH of pineapple juice

Variation in Color

The highest color retention was noticed in the pineapple juice powder obtained at freeze drying without addition of maltodextrin (Table 1). The R, Y and B values of freeze and spray dried pineapple powder decreased with increase in maltodextrin concentrations. The change in the color is due to addition of maltodextrin which is having inherent whitish color (Khalid *et al.*, 2016) [19]. Higher concentrations of drying agent will generally resulted in lower R, Y and B values because an increase in the ratio of drying agent to sample would led to dilution of material.

Variation in Total acidity

Total acidity of was pineapple juice varied from 0.7 to 1.3% where as reconstituted spray and freeze dried pineapple powdered juice varied from 0.5 to 0.7% and 0.6 to 1.1% respectively (Fig.6). Reconstituted freeze dried powdered juice have high total acidity compared to spray dried pineapple powdered juice. The acidity values have decreased with the maltodextrin concentration due to the reduction of organic acids percentage (Holivania *et al.*, 2014) [20].

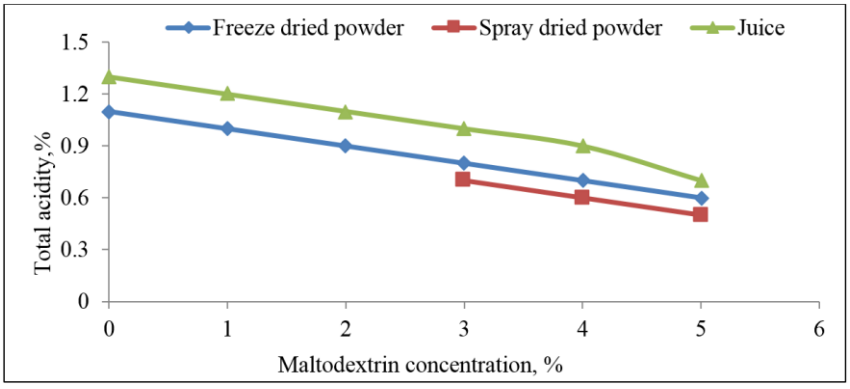

Fig 6: Variation in total acidity of pineapple powder

Variation in Ascorbic acid

Variation of ascorbic acid of pineapple powdered juice at different maltodextrin concentrations was studied; it was observed from the Fig. 7 that, the ascorbic acid content of raw juice varied in the range of 14.56 to 22.67 mg/100 mg where as reconstituted spray and freeze dried pineapple powdered juice varied from 13.45 to 20.32mg/100mg and 12.98 to 15.45 g/100mg, respectively. Raw juice contains high ascorbic acid content as compared to reconstituted juice of freeze and spray dried powder. Freeze dried powdered juice contain high ascorbic acid than spray dried powdered juice. The maltodextrin addition decreased the ascorbic acid concentration. (Holivania *et al*., 2014) [20].

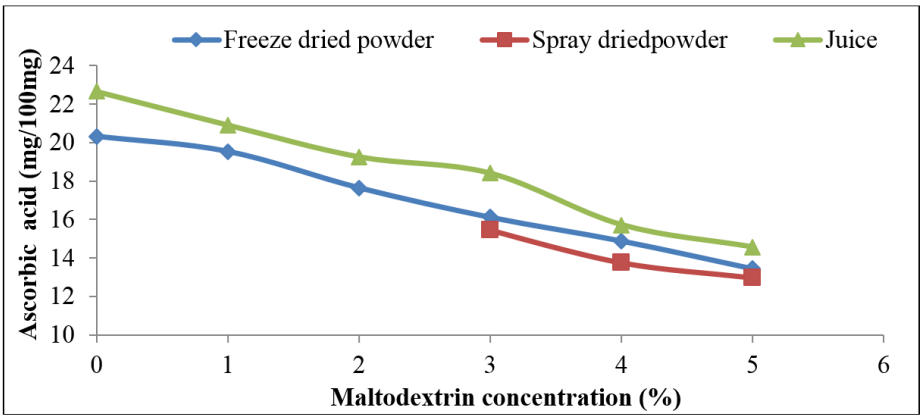

Fig 7: Variation of ascorbic acid at different concentrations of pineapple powder

Table 1: Effect of maltodextrin concentrations on the color profile

Drying method	Maltodextrin concentration (%)	R	Y	B	N
Freeze drying	0%	3.0	14.8	2.3	0.0
	1%	2.7	12.7	2.0	0.0
	2%	2.3	10.2	1.7	0.0
	3%	2.0	9.8	1.2	0.0
	4%	1.7	8.5	0.9	0.0
	5%	1.2	7.2	0.7	0.0
Spray drying	3%	1.6	9.6	1.0	0.0
	4%	1.1	8.1	0.7	0.0
	5%	0.8	6.9	0.5	0.0

Table 2: Sensory test results of spray and freeze dried pineapple powder

Drying method	Maltodextrin content (%)	Appearance	Color	Aroma	Taste	Overall liking
Freeze drying	0	8.5	8.7	8.6	7.9	8.4
	1	8.4	8.6	8.4	7.7	8.3
	2	8.3	8.5	8.2	7.6	8.3
	3	8.2	8.3	8.2	7.2	7.9
	4	8	8.1	8	7.1	7.8
	5	7.9	7.8	7.8	6.8	7.6
Spray drying	3	7.8	8.1	7.3	6.9	7.5
	4	7.5	7.9	7.2	6.7	7.3
	5	7.1	7.3	7	6.4	6.9

Sensory evaluation

Sensory characteristics like texture, appearance, aroma, taste and overall acceptability of the powder were rated by using a 9-point hedonic scale. It was observed from the Table 2 that, highest rating of overall acceptability (8.4) obtained for freeze dried powder than spray dried powder. Among freeze dried powder samples highest overall acceptability obtained to powder obtained without addition of maltrodextrin. Minimum overall liking score obtained at 5% maltodextrin concentration for both freeze and spray dried powder. The acceptance score is decreased with increasing maltodextrin concentration. Original taste and color decreases with addition of maltodextrin concentration. Spray drying experiments were conducted at high temperatures at high temperatures (140˚C) while freeze drying at low temperatures. High temperatures might have decreased the sensory characteristics of the Pineaple powder.

Conclusion

It is concluded that the freeze dried pineapple juice having high powder yield, total soluble solids, color, ascorbic acid and low moisture content as compared with spray dried powder. Sensory analysis revealed the highest rating of overall acceptability (8.4) obtained for freeze dried powder than spray dried powder

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