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Effect of spray-dryer operating variables on the fermented beetroot juice powder quality

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Abstract

Rose powder was produced by lab scale spray drying. Powders were analyzed for moisture content, solubility, hygroscopicity, bulk density, color and product recovery. The optimum inlet air temperature (160 ^{o}C) and feed flow rate (120 ml/h) resulted in the product with moisture content (5.3% wb), solubility (86.85%), hygroscopicity (0.259 g/g), bulk density (0.42 g/ml), color (21.03) and product recovery (8.42%). The powder showed a noticeable tendency to stick to internal surfaces of the drying chamber at higher temperatures.

Keywords: Rose powder, spray drying, solubility, hygroscopicity, product recovery

Introduction

Rose is one of the highest-selling flowers in International market. In India it is grown in Karnataka, Tamil Nadu, Bihar, Uttar Pradesh, West Bengal, Maharashtra, Haryana, Gujarat, Punjab, Jammu and Kashmir, Madhya Pradesh and Andhra Pradesh are the major Rose farming states. It is used in every event and has good medicinal value. Rose flowers are available in various sizes, shapes and also in different colors. Roses have unique aroma, hence, is used in many events. Rose petals have many medicinal properties that include stress and depression relief and also it is used to treat acne. The scientific name of the Rose is Rosa and belongs to the family Rosaceae. It is a woody perennial flowering plant. Roses are mostly used in perfumes and in the preparation of rose water, which is used for cooking, cosmetics, medicine and in religious practices. These are rich in volatile essential oils.

They are rich in vitamin C, B and K and thus results in smooth and flawless skin tone when one regularly applied. It moisturizes skin and gave a supple soft skin with a pleasant body fragrance. The antioxidant property in the rose powder discards any skin irritation and soothes skin. It acts as natural cleanser because it removes dirt and excess oil from the pores with the help of its anti-bacterial property. The rose petal powder treats burns and plays the role of natural coolant for the skin. The anti-ageing property in the rose powder prevents from getting wrinkles. The anti-inflammatory property in the roses helps to get rid of the scalp dryness and itchiness. It maintains the pH of the scalp. It increases the blood flow to the hair roots which promotes new hair growth. The rose petals powder contains compounds that improve metabolism in addition to clearing toxins from the body, thereby aiding in weight loss. They can be added to liquid to create rose-infused beverages, jams and jellies.

The objective of our work was to study the spray drying of Rose extract on a lab scale level and to investigate processing conditions, and physical properties of the powder produced

Materials and Methods

Preparation of Fresh Rose Petals Juice

Fresh rose flowers were purchased from a local market and petals of flowers were removed manually immediately. They were washed in clean water to remove dirt. The juice was extracted by using a juicer. Quantity of extracted juice from one kg of rose petals was 470 ml. The juice was sieved through a sieve with 200 meshes to remove pulp and other solids and then transferred into glass bottles.

Spray drying procedure

A lab spray dryer was used in the spray-drying process. Spray drying was carried out at a various inlet air temperature *viz*., 150, 160 and 170 °C and feed flow rate *viz*., 80, 120 and 160 ml/h with constant outlet air temperature of 75 °C and constant air pressure of 2 bar. The total juice solids were adjusted with constant amount 8% of encapsulating agents (maltodextrin).

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The feed solutions were kept under magnetic agitator at room temperature and fed into the drying chamber through a pump. The dryer was washed with water at the desired setting for 10 min before and after the spray-drying process. Then, spray-dried encapsulated powder was collected, weighed and sealed in plastic container.

Spray Drying of Rose Petals Juice

Experimental Design

In this study, response surface methodology was used with two factors three level to investigate the individual and interactive effects of drying process variables such as inlet air temperature and feed flow rate on quality attributes moisture content, solubility, hygroscopicity bulk density, colour, and product recovery.

Determination of physical parameters of Rose Colorant

Moisture content

Moisture content of the sample was determined by using a calibrated Digital Moisture Analyzer (OHAUS, MB45 Moisture Analyzer, New Jersey, UAS) at 100 °C. A sample of one g in triplicate was exposed to the heated infra-red coils of the moisture analyzer and the analysis was completed in an automatic mode within 10 minutes.

Solubility

Solubility was determined using a modified version of the method of Al- Kahtani and Hassan, (1990). A small sample of dry powders of 0.6 g was added to 400 ml of water at 70 °C in a 50 ml beaker. The mixture was stirred using a magnetic stirrer at 7 rpm. Solubility was measured as the time taken to dissolve the dry powders completely.

Hygrscopicity

About 1 g of beetroot powder was spread evenly on Petri dishes (9 cm diameter) to allow for a high surface area between humid air and powder. Samples of each powder were placed in respective seprate dishes in disiccator at 23 °C and 76% relative humidity using HNO_3 solution. Ten minutes interval was selected to get the kinetics of moisture sorption (Al- Kahtani and Hassan, 1990).

Bulk density

Bulk density (g/mL) was determined by gently adding 2 g of powder into an empty 10 mL graduated cylinder. The ratio mass and the volume of powder occupied in the cylinder determine the bulk density value (Goula and Adamopoulos, 2004) [8].

Colour

The color of different samples was measured using a colorimeter (Hunter lab).The results were expressed in b value, which determined the degree of yellowness characteristics of the various rose colorant samples.

Product Recovery

The product recovery was calculated as the mass ratio of the dried powder collected at the end of spray drying process to the initial solid content in the feed.

The product recovery was calculated with following equation by Ahmad (2019) [1].

$$Product\ Recovery, \% = \frac{The\ weight\ of\ obtained\ spray\ dried\ powder}{The\ total\ solid\ weight\ in\ initial\ feed} X\ 100$$

Results and Discussion

In the present investigation efforts were made to optimize the process parameters for micro-encapsulation of rose colorant. Effects of process parameters (inlet air temperature and feed flow rate) on physical properties of rose colorant at constant outlet air temperature of 75 °C and constant air pressure of 2 bar were studied.

Effect of spray drying parameters on physical properties of rose colorant

The effect of process parameters on the physical properties of the spray dried rose colorant have been shown in following point:

Moisture Content

Higher inlet air temperatures resulted in bigger particles, which is related to increased swelling and prevented shrinkage with the increased drying temperature (Chegini & Ghobadian, 2005; Ferrari *et al*., 2012b; Jumah *et al*., 2000; Shishir *et al*., 2016; Tonon *et al*., 2011) [7, 6, 10, 13, 16]. When a particle is subjected to higher temperature, rapid evaporation of moisture occurs at the surface of the particle and promotes the formation of a hard crust prevents particle shrinkage during drying. Additionally, lower inlet air temperature let the particles shrunk uniformly which makes their size smaller.

Figure 1 shows the effect of inlet air temperature and feed rate on the moisture content in rose powder produced from 500 ml rose extract. At inlet air temperature of 150 °C, there was marginal effect on moisture content at different feed flow rates (80, 120 and 160 ml/h).

Similar result was observed at 160 °C. However, at 170 °C, there was large increase in the moisture content of samples produced at 160 ml/h feed rate. There was no evident change in moisture content at 150 °C when feed rate increased from 80 to 160 ml/h. This is because of low drying capacity. However, at 170 °C drying capacity was high which resulted lower moisture content in rose powder. These results coincide with previously published data of Kieviet and Kerkhof (1994) [11]; Jumah (2000) [10]. It has been reported that increased feed rate resulted in higher moisture content due to the increase load in drying chamber. At a feed rate of 80 ml/h, there was trivial change in moisture content when temperature increased from 150 to 160 °C.

However, significant decrease in moisture content was occurred when the temperature increased from 150 to 170 °C. Similarly, at feed rates of 120 and 160 ml/h, increasing the temperature from 150 °C to 170 °C resulted in a large reduction in moisture content. Higher inlet air temperature produced higher drying capacity. Exposure of particles with hotter air lead to dried particles thus, lowers moisture. Jumah *et al.* (2000) [10] reported that higher inlet air temperature caused a decrease in moisture content of sample. The range for moisture content of the spray dried rose colorant varied from 4.3 to 5.6%.

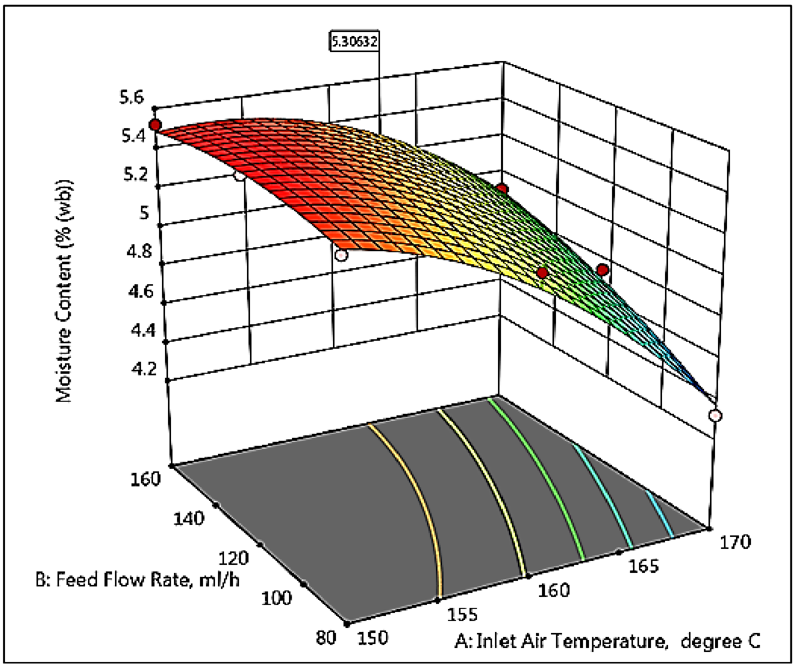

Fig 1: Effect of inlet air temperature and feed flow rate on the moisture content of rose powder

Solubility

The solubility of spray dried rose powders was from 79.4 to 91.3%. The solubility of encapsulated powder increased with an increase in inlet air temperature from150 to 170 °C for any constant feed flow rate the range of 80 to 160 ml/h (Figure 2). It can be inferred that the moisture content of the encapsulated powder decreases with an increment in inlet air temperature which results in an increment in the solubility of obtained encapsulated powder. Increase in drying air temperature generally produces the particles of larger size requiring lesser time to dissolve i.e. encapsulated powders with lower moisture content are more soluble. Whereas an increase in feed flow rate from 80 to 160 ml/h decreased solubility for any constant inlet air temperature within the range of from150 to 170 °C. This is due to higher residual moisture content of the encapsulated powder resulting in lower solubility of encapsulated powder.

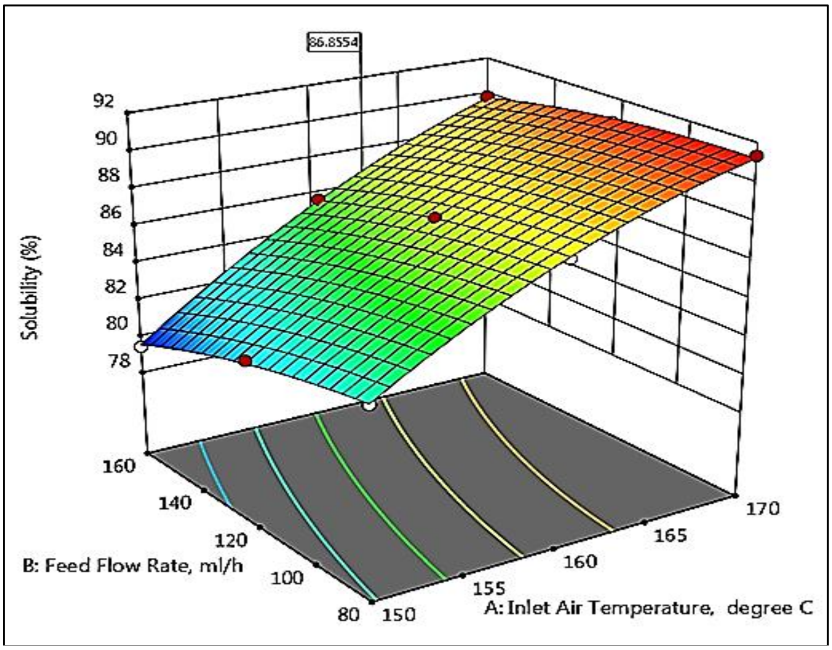

Fig 2: Effect of inlet air temperature and feed flow rate on solubility of rose powder

Hygroscopicity

Figure3 describes the hygroscopicity of spray dried rose powder produced at various process conditions. The range for hygroscopicity of the spray dried rose colorant varied from 0.2 to 0.32 g/g. For any feed flow rate the range of 80 to 160 ml/h, an increase in inlet air temperature from 150 to 170 °C leads to an increase in the hygroscopicity of the juice encapsulated powder. This may be due to the fact that with an increase in the inlet air temperature there is a reduction in the residual moisture content in obtained encapsulated powder which results in an increase in the hygroscopicity. Whereas an increase in feed flow rate from 80 to 160 ml/h decreased hygroscopicity for any constant inlet air temperature within the range of 150 to 170 °C. Lower feed flow rate decreases moisture content which causes greater capacity to absorb ambient moisture which results to decrease in hygroscopicity.

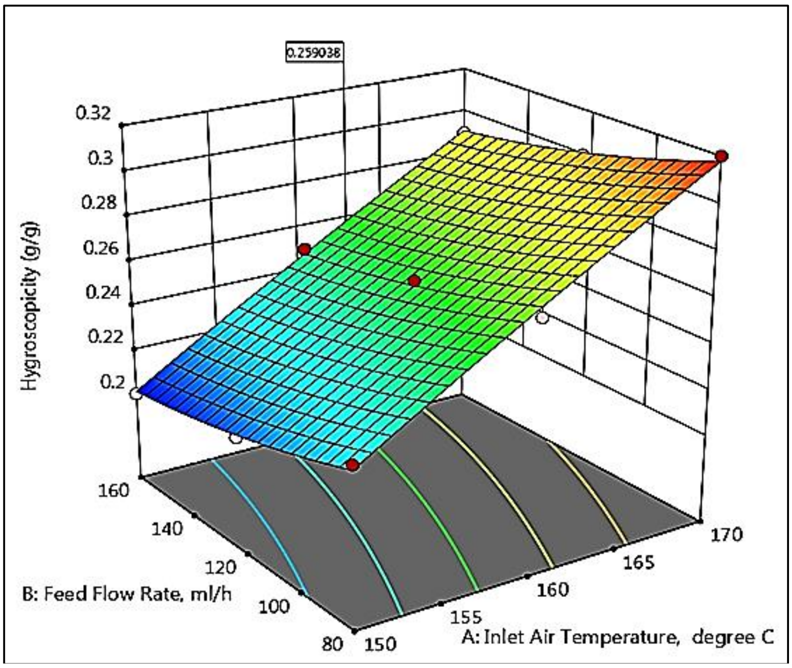

Fig 3: Effect of inlet air temperature and feed flow rate on bulk density of rose powder

Bulk Density

Bulk density is dependent on the size, shape, and surface properties of particles. Powders with a smooth and uniform surface have greater bulk density. Powders with smaller bulk density have a greater packaging volume for the same amount of material (Bicudo *et al*., 2015; Syamaladevi, Insan, Dhawan, Andrews, & Sablani, 2012) [3, 15]. In general, bulk density increases with a decrease in particle size as more particles occupy a given volume, which allows fewer void spaces between particles (Al-Kahtani & Hassan, 1990; Grabowski *et al*., 2006) [2, 9]. High bulk density is desirable to reduce shipping and packaging costs. This study also reported similar results, i.e. an increase in inlet air temperature from 150 to 170 °C leads to a decrease in bulk density g/ml for any constant feed flow rate within the range of 80 to 160 ml/h (Figure 4). The range for bulk density of the spray dried rose colorant varied from 0.32 to 0.47 g/ml.

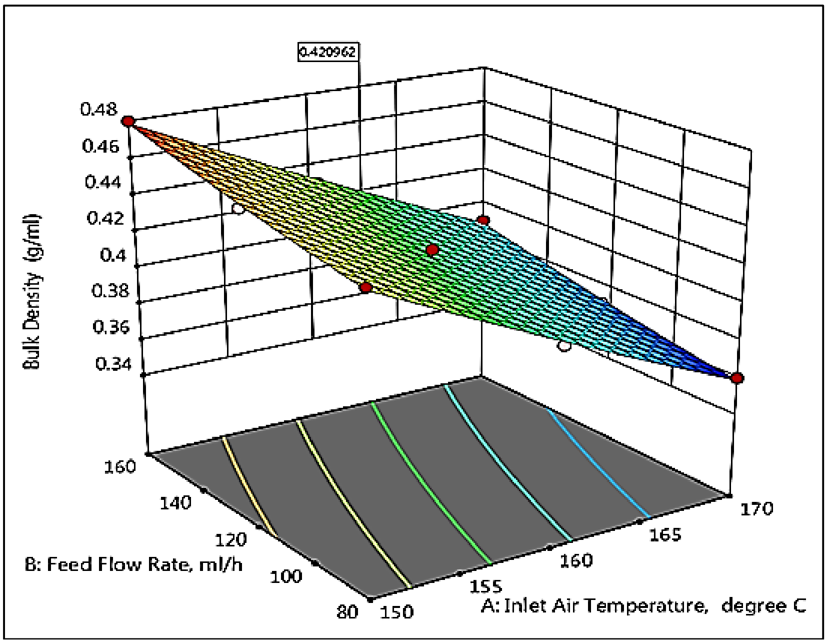

Fig 4: Effect of inlet air temperature and feed flow rate on bulk density of rose powder

Colour ‘a’ value

Colour is a significant factor in food selection and has a direct correlation to acceptability by consumers. The combined effect of inlet air temperature and feed flow rate on colour value is shown in figure 5. An increase in inlet air temperature from 150 to 170 °C reduces in colour value for any constant feed flow rate within the range of 80 to 160 ml/h. This may be due to be the degradation of colour at higher temperature. Whereas an increase in feed flow rate from 80 to 160 ml/h increased colour value for any constant inlet air temperature within the range of 150 to 170 °C. The range for colour ‘a’ value of the spray dried rose colorant in this study varied from 18.41 to 22.68.

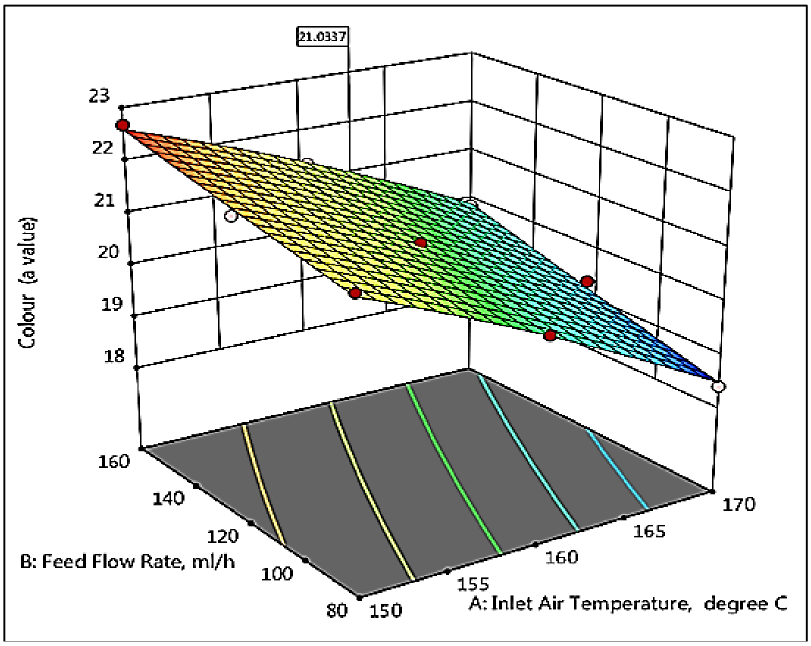

Fig 5: Effect of inlet air temperature and feed flow rate on colour ‘a’ value of rose powder

Product recovery

The powder recovery of spray dried rose powder is shown in Figure 6. The range for product recovery of the spray dried rose colorant varied from 7.85 to 8.92%. The product recovery of encapsulated powder reduced with an increase in inlet air temperature from150to 170 °C for any constant feed flow rate the range of 80 to 160 ml/h. It may be inferred that drying temperature is above their glass transition temperatures which produces stickiness problems. Whereas an increase in feed flow rate from 80 to 160 ml/h increased product recovery from for any constant inlet air temperature within the range of 150to 170 °C due to residual moisture in encapsulated powder.

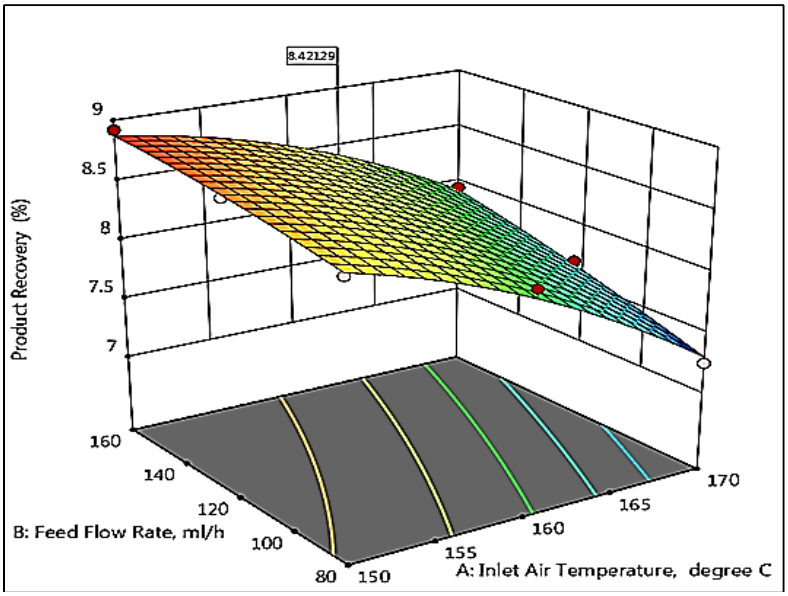

Fig 6: Effect of inlet air temperature and feed flow rate on product recovery of rose powder

Conclusion

The production of spray dried rose powder was successfully carried out in this study. The effect of spray drying conditions on the physical properties of rose powder was elucidated. The higher inlet temperature increased solubility, hygroscopicity and decreased moisture content, colour value, bulk density and product recovery. Whereas higher feed flow rate showed an increase in moisture content, colour value, bulk density, product recovery and a decrease in solubility and hygroscopicity.

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Conflict of interest Statement: The authors declare that there is no conflict of interest.

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