Research Article

Development of a microencapsulated sugarcane juice

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ABSTRACT

Introduction: Sugarcane juice is a popular thirst-quenching drink in many countries due to its typical cane flavor and sweetness. The main problem associated with fresh cane juice is its short shelf life. Raw sugarcane juice is susceptible to the growth of yeast, of spoilage bacteria, and of pathogenic bacteria. Most of the attempts to preserve the sugarcane juice have been focusing on refrigeration, heat treatment, and use of preservatives. Aim: The present study is an attempt to prepare sugarcane juice powder by spray drying. **Materials and Methods:** In this method, an aerosol of sugarcane juice is exposed to hot air and the dried juice is collected in the form of a powder. **Results:** Sugarcane juice powder was prepared from a local species using maltodextrin as bulking agents. Addition of bulking agents such as maltodextrin DE 20 significantly improved the juice powder yield, in addition to improved physical, chemical, and rheological properties of the juice powder. **Conclusion:** Scanning electron microscope images clearly show the variation in particle size and surface characteristics. Maltodextrin formed clear round particles.

KEY WORDS: Microencapsulation, Reconstituted juice, Spray drying, Sugarcane powder

INTRODUCTION

Sugarcane, a native of the warm, climatic tropical regions of Southern Asia and Melanesia belongs to the genus Saccharum and is used in the manufacture of sugar.[1] Historically, sugarcane originated in India and later propagated to many other countries. Today, India stands second in the worldwide production of sugarcane next only to Brazil. Around 46% of the total production of sugarcane in the country goes into the manufacture of white crystalline sugar and the other 42% goes into gur and byproduct production.

Due to the fact that sugarcane juice is rich in carbohydrates, it is often manufactured during the summer season as fresh juice by small scale – roadside vendors. One of the major problems in the extraction of juice using a mechanical crusher and addition of lime juice (or) ginger extract to improve sensory attributes is the general lack of hygiene in the manufacturing process.

Poor hygiene linked with the intrinsic properties of sugarcane juice such as the high carbohydrate and low acid content makes it susceptible to the subsequent growth of pathogenic bacteria. Since the pH of sugarcane juice is >4.6, pathogens such as *Salmonella*, *Staphylococcus aureus*, and *Clostridium perfringens* grow and proliferate with yeast.[2] Vendors, therefore, resort to prepare these sugarcane juices freshly rather than store it after preparation. This prevents fermentation of the crushed juice. Attempts to preserve sugarcane juice in its original liquid form have been widely unsuccessful because the juice is photosensitive and heat sensitive.[3] Partial pasteurization has been relatively successful. This is, however, not commercially viable since it alters the sensory characteristics with respect to the color of the juice.

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The present study is an attempt made at converting the sugarcane juice into a more convenient form to facilitate better handling and a more shelf-stable product. Among the many methods of converting a liquid into solid only freeze-drying and micro-encapsulation using a spray drier are the viable solutions in the case of sugarcane powder production considering the intrinsic properties of sugarcane juice. The authors in this research have explored the possibility of converting the freshly crushed sugarcane juice into a powder form using the micro-encapsulation technique.

MATERIALS AND METHODS

Materials used in the Study

The harvesting operation is critical in sugarcane juice preparation as the harvested sugarcane often contains

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field insects among the dried leaves and green tops of the sugarcane. This has to be removed post-harvest to facilitate quality in the end product. In lieu of this, a local farmer of the Thondamuthur Block was identified and trained to clean the canes right after harvesting using water treated with 5 ppm of sodium hypochlorite. The wash water was replaced periodically to avoid microbial contamination. Chemicals used for the analytical purpose were procured from M/s. Viveka Agencies, Coimbatore a local ingredient vendor.

Sample Preparation

A table-top sugarcane power crusher (Sukra make) containing two stain` steel rollers was used to extract fresh sugarcane juice. The mechanical power crusher ran on a 1 HP motor with a metal screen attachment below the rotating rollers to filter impurities present in the juice. The optimum extraction yield of the cane crusher was about 60%. Maltodextrin (DE 20) was added into the extracted juice as a carrier agent (wall material).

Analysis of Fresh Sugarcane Juice

pH

pH measurement of freshly obtained sugarcane juice was done using a handheld Erma digital pH meter.

Total Soluble Solid (TSS) Content

TSS measurement of freshly obtained sugarcane juice was done using a handheld refractometer of range 0–300Brix calibrated at 30 ± 5°C.

Microencapsulation using Spray Dryer

A lab-scale spray dryer (Labultima model: 222) was used in the experiment for microencapsulation. The spray dryer functions according to the cocurrent flow atomizer principle, i.e., the product sprayed and drying air flow in the same direction. This dryer consists of a glass chamber where the drying takes place and is connected to two cyclone separators. The nozzle used for spraying is a pressure nozzle where the pressure can be varied. The parameters that can be altered are inlet temperature, vacuum present in the chamber, flow rate of the fluid, and the pressure for spraying. By varying the parameters, the optimum conditions were studied. The powder collected in both the cyclones and in the outlet, the breaker is counted as the end product.

Analysis of the Quality of Microencapsulated Sugarcane Powder

The prepared sugarcane juice powder was analyzed for various physiochemical properties such as moisture content, solubility, and re-dispersion time.

Moisture Content

The moisture content of the microencapsulated sugarcane powder was determined using the method described by Ranganna.[4] Samples of 10 g each were taken in triplicate and dried or 16 h in an electric oven at 70°C, cooled in a desiccator and weighed. The process was repeated until the difference between two consecutive weights was ≤0.5–1 mg. The values were recorded, and moisture content was calculated using the following formula:

$$\text{Moisture content } (M_c),\ \% = \frac{W_m}{W_m + W_d} \times 100$$

Where,

M_c = Moisture content (wet basis), %

W_m = Weight of water evaporated, g

W_d = Weight of dry matter, g

Bulk Density

Bulk density of the microencapsulated sugarcane powder was determined using the method described by Bhandari *et al.*, 1992, also known as the tapping method.[5] 2 g of powder was loosely weighed in a 10 ml graduated cylinder. The cylinder was tapped on a flat surface until constant volume of powder was obtained. The bulk density was calculated using the following formula:

$$\text{Bulk Density}\left(g/cm^3\right) = \frac{\text{Weight of microencapsulated powder}}{\text{Volume of the sample}}$$

Solubility

The solubility of the microencapsulated sugarcane powder was determined using the method described by Moreira *et al.,* 2009.[6] 10 g of microencapsulated powder was added into 100 ml of water at room temperature (28 ± 2°C). The mixture was homogeneously mixed using a centrifuge (15,000 rpm for 90 s). The addition of the microencapsulated powder was done gradually till the formation of sediments. The presence of sediments is the indicating factor for the solubility test. The total weight of microencapsulated powder added to the water for the formation was recorded, and the solubility was calculated by the following formula:

$$\text{Solubility, } \% = \frac{\text{Weight of microencapsulated powder}}{\text{Weight of water}} \times 100$$

Reconstitution Time

Reconstitution time is a study of the ability of a microencapsulated powder to release its flavor and aroma when it comes in contact with a solvent. The reconstitution time (in triplicates) was determined using the method described by Rodriguez-Huezo *et al.*, 2006.[7] 1 g of microencapsulated powder was dropped into 40 ml of distilled water. A stopwatch was used to note the time taken for the powder to completely dissolve in the water without any visual traces of the powder.

Imaging

Imaging was done using a Jeol JSM 6390 scanning electron microscope (SEM).

RESULTS

Extraction of Juice

The sugarcanes collected were cleaned using chlorinated water and then fresh sugarcane juice was extracted. The canes gave a juice yield of approximately 55–60%. TSS contents in the juice range from 19 to 21%. pH value ranges from 4.75 to 6.2.

Spray Drying Trials

The juice obtained or prepared was spray dried at temperatures between 160 and 180°C. The aspirator speed was set at 55 Nm3/h. The feed rate was set at 5 ml/h and the yield was between 10.3 and 11%.

Effect of Inlet Temperature on Moisture Content

Moisture content is the amount of moisture or water in the encapsulated powder. Each of the samples, i.e., powders dried at varying temperatures 160, 170, and 180°C were tested for moisture content. Results indicate that the powder dried at 170°C and 15% carrier agent showed the least level of moisture (4.5%). The highest amount of moisture content (6.9%) was recorded in inlet temperature of 160°C and 20% maltodextrin.

Effect of Inlet Temperature on Bulk Density (Tapped)

As per the values attained for the bulk density of powder dried at 160, 170, and 180°C, it can be seen that powder dried at 170°C with 20% maltodextrin and powder dried at 180°C with 15% maltodextrin had the least bulk density (0.41 g/cm^3). The microencapsulated powder having the highest bulk density value (0.55 g/cm^3) was that dried at 160°C with 10% maltodextrin.

Effect of Inlet Temperature on Solubility

Each of the samples, i.e., powders dried at varying temperatures 160, 170, and 180°C was tested for solubility. Results indicate that solubility was highest (20%) at powder dried at 170°C and 20% maltodextrin. The lowest solubility (5%) was recorded in an inlet temperature of 180°C and 10% maltodextrin.

Effect of Inlet Temperature on Reconstitution Time

Each of the powders obtained at different temperatures, i.e., 160°C, 170°C, and 180°C, was tested for their reconstitution time. This test showed that powder dried at 180°C and 15% maltodextrin reconstituted into sugarcane drink in less than a minute (40 s). The longest reconstitution time (90.3 s) was recorded by powder that was dried at 180°C and 10% maltodextrin.

DISCUSSION

Effect of Inlet Temperature on Moisture Content

The overall implication of this that powders having lower moisture content have better flowability. The moisture content of the powder also is a reflection of the water activity of the powder; lower moisture contents would mean that the powder is more shelf-stable with respect to its water activity which will also be low [Figure 1].

Effect of Inlet Temperature on Bulk Density (Tapped)

The results show that the powder dried at 170°C with 20% maltodextrin and powder dried at 180°C with 15% maltodextrin have lower bulk density and hence they have a better compression ratio. This would mean that these powders can be easily packed into most of the commercially available packaging material without difficulty [Figure 2].

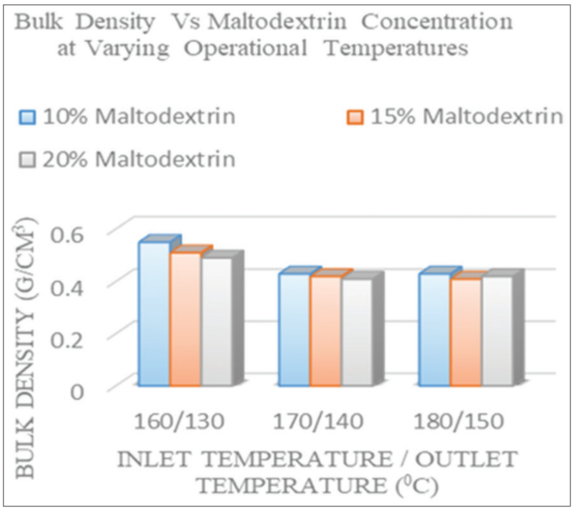

Figure 1: Effect of inlet temperature on moisture content

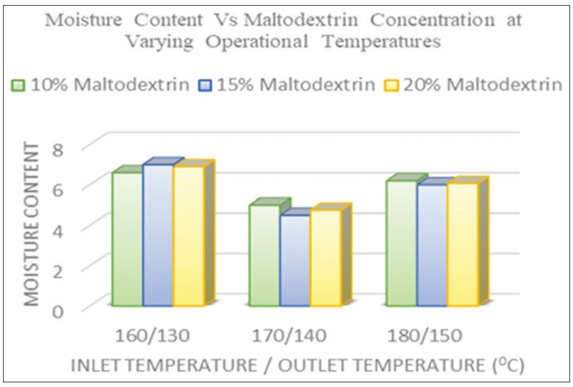

Figure 2: Effect of inlet temperature on bulk density

Effect of Inlet Temperature on Solubility

Results of the solubility test indicate that temperatures above 170°C reduce the solubility of the microencapsulated sugarcane powder thereby increasing the insoluble sedimentation in the reconstituted drink. Temperature <170°C, i.e., 160°C also showed lower solubility percentage in comparison to the optimum operational temperature of 170°C. Hence, operational temperature is a significant parameter controlling the solubility of microencapsulated sugarcane powder [Figure 3].

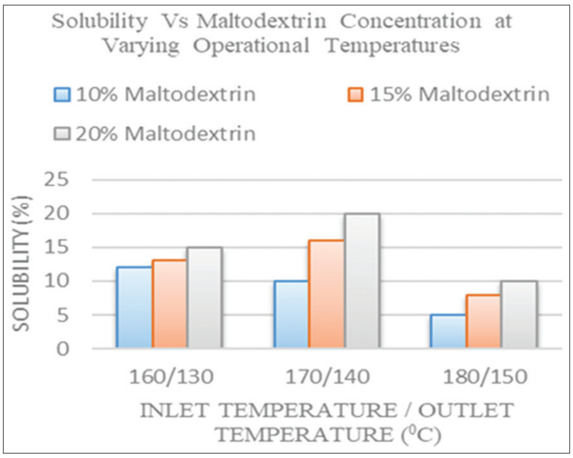

Figure 3: Effect of inlet temperature on solubility

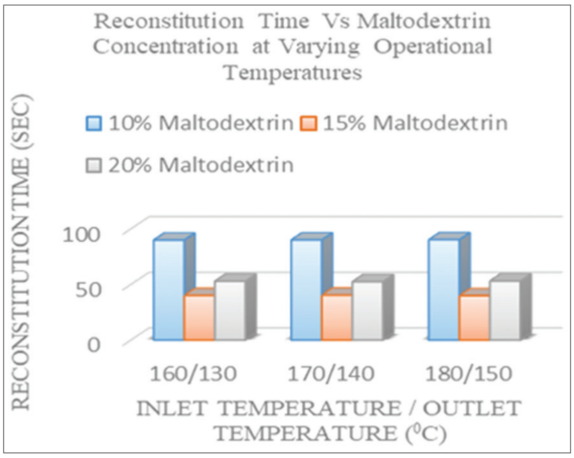

Figure 4: Effect of inlet temperature on reconstitution time

Effect of Inlet Temperature on Reconstitution Time

It is notable that irrespective of temperatures, all sugarcane powders reconstituted within the 2 min mark. This means that the powders were readily soluble in water but time for reconstitution can be improved by constant stirring [Figure 4].

Imaging

It can be derived from the above graphs that the sugarcane juice powder that was obtained with the inlet temperature 170°C and 20% maltodextrin has a lesser moisture content, good solubility, and the best re-constitution time and has better bulk density when compared with an inlet temperature of 160°C and 180°C. Hence, this sample was taken for imaging using a SEM [Figures 5,6 and Tables 1-2].

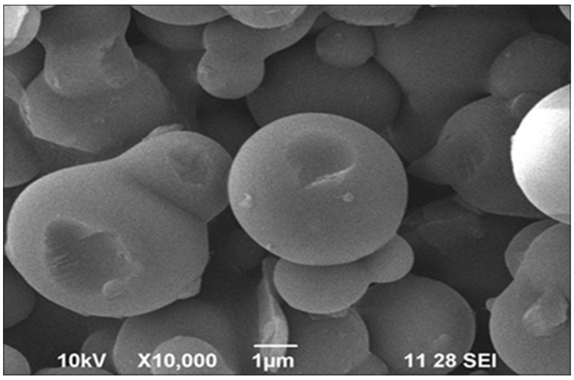

Figure 5: SEM image at 1 micrometer of 20% M.D Sugarcane juice powder at 170°C

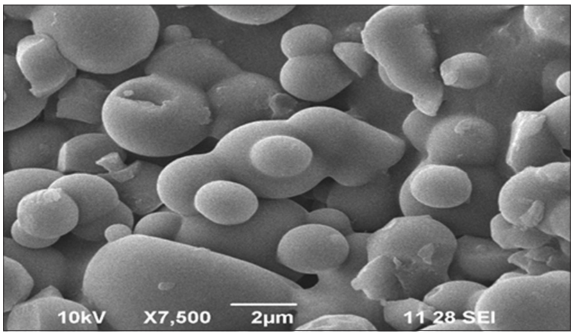

Figure 6: SEM image at 2 micrometer of 20% M.D Sugarcane juice powder at 170°C

Table 1 - Extraction of Juice

Trials	%Yield of Juice	TSS (0Brix)	pH
1	58.36	21	4.75
2	57.21	19	5
3	58.3	20	5.5
4	56.5	19	6.2
5	55.2	21	6

Table 2 - Spray dryer trials

Trials	Temperature(°C)		Aspirator speed (Nm³/hr.)	Feed rate (ml/min)	Yield (%)
	Inlet	Outlet			
T1	160	130	55	5	10.3
T2	170	140	55	5	10.5
T3	180	150	55	5	11

CONCLUSION

Sugarcane is a healthy natural drink, but it gets contaminated soon due to its high moisture and sucrose content. The present study optimized that a spray drier operating at an inlet temperature of 170°C, outlet temperature of 140°C and a feed rate of 3 ml/h produced a microencapsulated sugarcane juice powder that had lower moisture content, good solubility, best re-constitution time, and a better bulk density than other operational temperatures. Addition of carrier agents such as maltodextrin DE 20 in varying amounts did result in significant improvement of juice powder yield thereby emphasizing the need for the use of a carrier agent in microencapsulation process. Sugarcane juice powder analyzed using SEM showed that the surface of the microencapsulated powder was clear, spherical, and smooth.

Overall results of the study indicate that the spray drying of sugarcane juice into powder could produce a marketable product with high-quality indices.

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