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Extraction and Encapsulation of Beetroot (*Beta Vulgaris.*L) Extract Using Spray Dryer

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ABSTRACT

This study aims to obtain encapsulated beetroot extract in a powder form using spray drying technology. The beetroot extract, as core material was obtained using aqueous extraction method. The encapsulated beetroot extract powder was produced by spray drying process using the combination of maltodextrin and gum arabic as wall material in the ratio of 1:2 (core material : wall material), and drying inlet air temperatures at 120°C, 140°C and 160°C as independent parameters. Thus the effect on spray drying inlet air temperatures on encapsulation efficiency, moisture content and betanin content of encapsulated beetroot extract powder was evaluated.

Key-words: Betanin, Spray dyer, Encapsulation Efficiency, Moisture Content.

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1. INTRODUCTION

Colours are one of the important quality indicators that determine the consumer acceptance of foods. In recent days market for application of synthetic colourants has decreased in favour of natural colourants. Fruits and vegetables are good sources of natural colourants. But the natural colours have disadvantage as reduced stability.

Betalains are natural water-soluble, nitrogen-containing pigments, with a colouring power competitive to those of synthetic colourants (Cassano *et al*., 2007). They are actually comprised of two groups of pigments: the red–purple betacyanidins and the yellow betaxanthins. The major commercially exploited betalain crop is red beetroot (*Beta vulgaris* L.) whose main pigments is betanidin-5-0-β- glucosidase or betanin which is the most common betacyanins (strack et al., 2003).

Beet root has been bred to produce a number of varieties, being with a strongly coloured root due to its high betalain concentration. The red-purple betacyanin comprises the major part of pigments in beetroot, and of these betanin comprises 75–95%. The beetroots are pressed and the water partially removed to give a product containing 0.5% pigments. Characteristically betanins are known to be relatively unstable, sensitive to heat, light, oxygen and pH conditions therefore encapsulation technique was used to avoid colorant degradation. It is reported that stabilization of betalains and polyphenols could be improved using encapsulation by spray drying (Desai and Park, 2005).

Encapsulation is a process by which very tiny droplets or particles of liquid or solid material are surrounded or coated with a continuous film of polymeric material (Bansode *et al*., 2010). Spray drying technique is the most commonly used economical method in the food industry and the quality attributes of the powder produced are dependent on the drying parameters and the character of the food material (Barros and Stringheta, 2006). It involves the atomization of emulsions in a drying medium at high temperature causing a very rapid water evaporation, which in turn results in the formation of a capsule and the trapping of the ingredient inside a coating material (Favaro-Trindade *et al*., 2008).

In the practice, it is rare that a single encapsulating agent should possess all the properties, making it common to use a combination of two or more components. Although several encapsulating agents are commercially available, gum arabic and maltodextrin are the most commonly used encapsulating agent in spray drying, presents compositional characteristics which are seen as ideal for the microencapsulation of lipid contents, as it both serves as an active surface agent and in drying the matrix (Tonon et al., 2010). Maltodextrin have low emulsifying capacity, low viscosity at high concentrations and reduces the powder stickiness and have been studied as potential substitutes for gum arabic in atomized emulsions, or used in conjunction with gum arabic to satisfy the required properties of the encapsulating material (Azeredo, 2005).

The objective of this work was to study the effect on spray drying inlet air temperatures on encapsulation efficiency, moisture content and betanin content of encapsulated beetroot extract powder was evaluated.

2. MATERIALS AND METHODS

2.1. Materials

The beetroot was bought from the local market in Kattankulathur, Chennai which was cultivated in Theni district. It was stored in the refrigerated condition in order to prevent the changes due to environmental conditions. The wall materials maltodextrin and gumarabic were purchased from Hi-Media and it was stored in air tight container until use.

2.2. Extraction of juice from beetroot

The beetroot were washed, sanitized with 50 mg/kg of sodium hypochlorite solution for 10 min, peeled, sliced and steam blanched for 3 min and air cooled. The cooled beetroot slices were ground by using a high speed mixer at 3000 rpm for 2 min. The ground material was manually pressed and filtered with a muslin cloth and beetroot extract was extracted at ambient condition.

2.3. Preparation of feed emulsion

Emulsions were prepared in 1:2 (core material: combination of wall materials) ratio. 100 ml of beetroot extract was taken and mixed with 200 ml of combination of maltodextrin and gum arabic to prepare 1:2 emulsion. For the preparation of combination of wall materials 50 g of maltodextrin and gum arabic was dissolved separately in 60 ml of distilled water at 60ºC which was made up to 100 ml. The prepared wall material concentration was filtered using muslin cloth and mixed together (maltodextrin and gumarabic). This immiscible mixture is emulsified using high speed mixer at 3000 rpm until the extraction dispersed completely. Then it is emulsified by adding 2 drops of Tween 80.

2.4. Spray drying

The prepared emulsion was pumped to the spray drier (Make: S.M.Scientech, Kolkata, Plate 3.4) through 0.7 mm diameter nozzle. The dryer parameters of the spray dryer were inlet air temperatures 120, 140 and 160°C, outlet air temperature 95±2 °C, compressed air flow pressure at 350kPa, feed rate 17 rpm and air flow rate 2600 rpm was used to produce encapsulated beetroot extract powder. The obtained encapsulated powder was packed in aluminium foil pouches and sealed using the hand sealer. It was stored in a dessicator containing calcium chloride at ambient condition until for future use.

2.5. Quality analysis

Spray dried powders produced with different inlet temperatures were analysed for encapsulation yield, moisture content and betanin content.

2.5.1. Encapsulation efficiency

The encapsulation efficiency (ME) was calculated according to the equation no (1) (McNamee *et al.*, 2001):

$$\%\text{Encapsulation efficiency} = \frac{\text{Total betanin} - \text{Surface betanin}}{\text{Total betanin}} \times 100 \text{ ------------------- (1)}$$

2.5.2. Moisture content

5 g of triplicate encapsulated beetroot extract powder is kept in a ventilated hot air oven (Make: Hitech Equipments, Chennai.) at 105±2ºC for 3 h. The moisture content was calculated according to the equation no (2) (AOAC, 2000)

$$\text{Moisture content }\%(\text{db}) = \frac{\text{Initial weight - Final weight}}{\text{Final Weight}} \times 100 \text{ ------------------- (2)}$$

2.5.3. Betanin Content

Betanin content of encapsulated beetroot extract powder was quantified according to Wybraniec and Mizrahi (2002). Encapsulated beetroot powder was weighed and diluted with deionised water. Diluted sample was filtered before performing spectrophotometric measurement (Make: Sigma scientific instruments, Chennai , Model: SL 217). Quantification of betanin was carried out by the following equation no (3):

$$\text{BC (mg/100g)} = \frac{A \times DF \times MW \times V \times 100}{\varepsilon \times L \times W} \text{ ------------------------- (3)}$$

where BC is betanin content, A is the absorption value at 538 nm, DF is the dilution factor, MW is the molecular weight of betanin (550 g/mol), V is the pigment solution volume (milliliters),Ɛ is the molar extinction coefficients of betanin (60,000 L/mol cm), L is the path length of the cuvette (1 cm) and W is the weight of encapsulated beetroot powder, g.

3. RESULTS AND DISCUSSION

3.1. Encapsulation efficiency

The microencapsulation efficiency is related to the physio-chemical characteristic of both the core and wall material. In the present study, the microencapsulation efficiency ranged from 96 to 99%, values much higher than those found in literature, using spray drying. The best of encapsulation efficiency was 98.9±0.01 % at 140°C. The encapsulation efficiency increase and decreased in increasing temperature. Wang *et al.*, 2012 also reported that for the encapsulation of lutein with porous starch and gelatin mixiture the encapsulation efficiency increase in the embedding temperature from 50 to 60°C. While the embedding temperature was from 60 to 70°C, the encapsulation efficiency decreased. The best encapsulation efficiency of lutein is 94.4±0.04 % at 60°C. In conclusion, since the efficiency found in the present work was higher than those obtained in the literature, combination of gum arabic and maltodextrin as wall material could be considered an excellent choice for the encapsulation of beetroot extract using spray drying technology.

3.2. Moisture Content

The moisture content of the powder varied from 3.4 to 2.2% (db). Moisture content was significantly influenced by the inlet air temperature. Moisture content of the powder decreases with increase on inlet air temperature. Lower the moisture content will give long storage of powder. According to Tonon *et al.*,2008 at higher inlet air temperatures, there is a greater temperature gradient between the atomized feed and the drying air, resulting in a greater driving force for water evaporation and thus producing powders with lower moisture content. Goula and Adamopoulos, 2005 reported that an increase in air inlet temperature leads to a decrease in moisture content. The greater the temperature difference between the drying medium and the particles, the greater will be the rate of heat transfer into the particles, which provides the driving force for moisture removal. When the drying medium is air, temperature plays a second important role. As water is driven from the particles in the form of water vapor, it must be carried away, or the moisture will create a saturated atmosphere at the particle surface. This will slow down the rate of subsequent water removal. The hotter the air, the more moisture it will hold before becoming saturated. Thus, high temperature air in the vicinity of the drying particles will take up the moisture being driven from the food to a greater extent than with cooler air.

3.3. Betanin content

Betanin content decreased with increasing inlet air temperature. Janiszewska and Wldarczyk, 2013 reported that increase in inlet air temperature decreased betalain retention. Similar results were observed by Chegini and Ghobadian, 2007 for orange juice. An inlet temperature of 140°C has been found to decrease retention of bioactive compounds such as betacyanins and indicaxanthins for cactus pear juice (Saenz et al., 2009).

4. CONCLUSION

The inlet air temperature of 140°C could be recommended as s good drying condition because of the higher encapsulation efficiency (98.9±0.01) and also because of good physical properties of encapsulated beetroot extract powder. Maltodextrin and gumarabic can protect betanin from degradation during storage. Microencapsulation by spray drying is the most economical and flexible way that the food industry can encapsulate color ingredients.

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