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Review

Application of maltodextrin in green corn extract powder production

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ABSTRACT

Corn is widely consumed in Brazil and spray drying allows for versatility in its use. This study aimed to evaluate the effects of maltodextrin concentrations and the inlet air temperature on the physical properties of green corn extract dried by spray drying. A central composite rotatable design (CCRD) was applied with the independent variables of inlet air temperature of 150–180 °C and maltodextrin concentration of 0–20% (w/w). An inlet air temperature of 163 °C and a maltodextrin concentration of 2.67% (w/w) displayed a good drying performance in relation to the yield (36.36%), moisture (1.39%), activity water (0.063), solubility (92.11 g/100 g), wettability (139.58 g/s), density (0.66 g/mL) and colour (L: 92.50, C*: 15.47 and h°: 97.46) closest to the green corn extract. The microstructure indicated surface roughness and particle size D_{50} ranged from 5.79 to 75.84 μm.

Contents

1. Introduction

Corn is a cereal that can be used as food, feed or as raw material for industry [1,2]. Before ripening, corn grain is consumed raw, roasted or cooked and its extract is used in several food formulations, including ice cream, desserts and bakery products.

However, this product is perishable and requires processing to supply the growing population that relies on its nutrients and good storage stability. Drying is one of the processes that is used to preserve corn. Spray drying has been widely used in the food industry to obtain fruit juices [3–5], starch products [6–8], oleoresins [9–12], colourants [13–15] and aromatic compounds [16–18].

This process has been widely used because of its advantages, such as a low nutrient degradation (aroma, flavour and colour) due to instant contact with high temperatures, high productivity and effective control of variables with high energetic efficiency, as well as for acquisition of products with different physical properties (shape, size and density) due to different processing conditions [3,19–23].

However, its energetic efficiency depends on the physical and chemical properties of the material to be dried, the dryer design and the operating conditions [20,24,25]. To increase efficiency in both

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performance and encapsulation of an active compound, this process needs support. Carrier agents are used to increase the glass transition temperature of the material to be dehydrated and to avoid collapse and adherence to the drying chamber. Furthermore, they protect the food from oxidative reactions resulting from thermal processing via rapid crust formation during the first drying period [21,22,26,27]. Maltodextrin stands out for its good solubility, low viscosity at high solid concentrations and low cost [25,28,29].

Due to a lack of published results on spray drying green corn extract, this work aimed to evaluate the effect of inlet air temperature and maltodextrin concentrations on the physical properties of this powder.

2. Materials and methods

The corn (*Zea mays*), which is characterised by a milky grain stage, was purchased in local shops. Maltodextrin (20 DE Mor Rex 1920) was supplied by Corn products (Mogi, SP, Brazil).

2.1. Experimental design

The experimental design according to Rodrigues and Iema [30] was used, which is based on the response surface methodology (RSM). A 2^2 complete experimental design with a central composite rotational design (CCRD), eleven treatments, 4 factorial points, 4 axial points and 3 repetitions at the central point was used. The independent variables included the inlet air temperature x_1 (°C) and the maltodextrin concentration x_2 (% w/w) and their respective levels are presented in Table 1.

The results from the design were fitted with the following polynomial (Eq. (1)).

$$Y = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \beta_{11} x_1^2 + \beta_{22} x_2^2 + \beta_{12} x_1 x_2 + \varepsilon \quad (1)$$

where β_n are the regression coefficients, Y is the response analysed, x_1 and x_2 are the coded independent variables (air inlet temperature and maltodextrin concentration) and ε is the experimental error. The following responses were analysed: yield (Y), moisture content (MC), water activity (a_w), wettability (Wet), solubility (Sol), apparent density (AD), colour parameters (L, C* and h°) and particle size (D_{50}).

The optimum process conditions for corn extract powder production were determined by analysing the results of the variables that were significantly affected by the drying conditions using Response Desirability Profiling according to the methodology described by Derringer and Suich [31].

The results from the analyses of variance (ANOVA), the fitted model and the Response Desirability Profiling were analysed with the aid of the software Statistic 8.0 (Stat Soft, Tulsa, USA).

Table 1
Experimental design of spray drying.

Assay	Coded variables		Real variables	
	x_1	x_2	x_1 (°C)	x_2 (% w/w)
1	−1	−1	154.36	2.91
2	+1	−1	175.64	2.91
3	−1	+1	154.36	17.09
4	+1	+1	175.64	17.09
5	−1.41	0	150	10
6	+1.41	0	180	10
7	0	−1.41	165	0
8	0	+1.41	165	20
9	0	0	165	10
10	0	0	165	10
11	0	0	165	10

x_1: temperature of the drying air (°C); x_2: maltodextrin concentration (% w/w).

2.2. Processing of green corn extract

The corn cobs were husked, washed and immersed in a 200 mg/L solution of sodium hypochlorite for 15 min and then pulped in an electric pulping machine (Macanuda, Joinville, Santa Catarina, Brazil). After pulping, the samples were frozen in individual portions of 400 g in polyethylene bags and stored in a cooling chamber at −18 °C. For drying, the extract was thawed and supplemented with maltodextrin according to the experimental design. The solution was homogenised with water until a temperature of 60 °C was reached for 15 min at 2500 rpm in an Ultraturrax homogeniser (TECNAL Piracicaba, Brazil).

2.3. Spray drying

Spray drying was performed in a bench dryer system with a dual fluid spray nozzle in a spray drying Labmaq Brazil 1.0 MSD spray dryer (Ribeirão Preto, São Paulo, Brazil) with a 3 mm diameter nozzle, an atomizing air of 40 L/min and an air pressure of 4.0 bar. The drying air temperatures were experimentally determined at a feed flow rate of 0.70 L/h. The dryer was fed with a peristaltic pump at an adjusted rotational speed and the air temperature was monitored to determine the variation of these factors as a function of the parameters adopted for the feeding of the dryer and the product characteristics.

2.4. Analytical methods

The yield for each experimental treatment was calculated using the Eq. (2) adapted from Vasconcelos et al. [32].

$$Y = \left(M_p / M_s\right) \times 100 \quad (2)$$

where Y is the yield on dry basis (%), M_p is the total dehydrated substance and M_s is the dry weight.

The powder's moisture content was determined in triplicate using the gravimetric method in an oven at 70 °C according to AOAC [33].

The water activity was measured with AquaLab (model 3 TE Decagon, USA) and the samples were prepared in triplicate with 5 g of powder and placed in plastic containers at room temperature of 25 °C.

The wettability test was based on the methodology proposed by Vissotto et al. [34]. It was determined by measuring the time required to complete a timer for dissolving 1 g of product in 100 mL of distilled water at 25 °C wrapped in a 250 mL beaker.

The solubility was assessed following the method proposed by Cano-Chauca et al. [25]. One gramme of powder was transferred into a beaker containing 100 mL of distilled water and homogenised. The solution was transferred to a tube and centrifuged at 2600 rpm for 5 min. A 25 mL aliquot of the supernatant was transferred to a petri dish, accurately weighed and placed in an oven at 105 °C. The amount of powder present in the supernatant was measured and identified as the soluble portion of the powder.

The apparent density was determined according to the methodology proposed by Goula and Adamopoulus [35]. Twenty grammes of green corn powder was weighed and poured into a 250 mL graduated cylinder. The samples were manually beaten repeatedly by lifting up and letting go of the cylinder under its own weight from a vertical distance of 14 ± 2 cm until a negligible difference in volume between successive measurements was observed by the mass and apparent powder volume (whipped).

The colour parameters were determined using the Konica Minolta CR400 colourimeter (Minolta Co., Osaka, Japan) with a 6 point reading for each sample. The samples were placed in petri dishes and scattered at a thickness of 10 mm. The parameters of the International Commission on Illumination (CIE), corresponding to the L values, which determine how dark or light the colour is, ranged from zero (black) to 100 (white) and a* (green to red) and b* (yellow to blue). The hue angle