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SHORT COMMUNICATION

PREBIOTICS AS DRYING AIDS FOR SPRAY DRYING FRUIT JUICES

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Abstract: Natural fruit juices are difficult to transform into powder because they are rich in sugars and acids with low glass transition temperatures, resulting in a sticky behaviour during spray drying. The present research work aimed to test the prebiotics maltodextrin and arabic gum as drying agents in order to be able to produce dehydrated powder from pineapple, strawberry and apple juices. 2 % of maltodextrin and an inlet air temperature of 130 °C are recommended to spray dry apple juice, reaching 60 % yield of powder with a water activity below 0.40. For strawberry juice, 2 % of this carrier is recommended and the inlet air temperature, 120 °C or 130 °C, did not seem relevant. For pineapple, neither the concentration of the carrier nor the inlet air temperature seemed to be relevant.

Keywords: *fruit juice, maltodextrin, arabic gum, prebiotics, spray drying*

INTRODUCTION

Spray drying is a well-established and widely used method for transforming liquid food products into powder form. It removes most of the water present in foods by evaporation, inhibiting the microbial and enzymatic activity. Spray-dried powders can be stored at room temperature for extended periods without compromising the powder stability [1]. Spray-dried foods can be classified into two broad groups: nonsticky and sticky. Materials such as skim milk, solutions of maltodextrins, gums and proteins belong to the non-sticky group, while natural sugar-rich and acid-rich foods, such as fruit and vegetable extracts, fruit juices and honey, belong to the sticky group. The sticky behaviour of sugar-rich and acid-rich materials is commonly attributed to the low glass transition temperature (Tg) of sugars, such as fructose, glucose and sucrose, and organic acids, such as citric, malic and tartaric acid, which are the major components of those foods [2]. To minimize the stickiness problem, process and material science-based approaches may be used. The material-science based approach presents limitations. Large amounts of drying additives are required to convert fruit juices such as blackcurrant, apricot and raspberry into powder form [3]. Silicon dioxide and maltodextrin have already been used as carriers in spray drying of lime juice; maltodextrin, arabic gum, waxy starch and cellulose were also tested during spray drying of mango juice [4]. Fruit juice powders present many benefits and economic potential over their liquid counterparts, such as reduced volume or weight, reduced packaging material, easier handling and transportation, and longer shelf life [5]. However, fruit juices are rich in sugars, such as fructose and glucose, and these have very low Tg: 5 and 31 °C, respectively [6]. Therefore, the spray drying of fruit juices is complex [5] and carriers are required to increase Tg.

This work aimed to produce dehydrated powder from fruit juice. The prebiotics maltodextrin and arabic gum were tested as drying agents to produce powder from spray-dried pineapple, strawberry and apple juices. The inlet air temperature, as well as the amount of a given prebiotic were tested in order to obtain a high powder yield (above 50 %) and a low water activity (lower than 0.5). the quantity of the prebiotic would have to be the minimum possible in order to obtain a more natural powder juice fruit as possible.

MATERIALS AND METHODS

Fruit juices

Samples were prepared with concentrated fruit purée supplied by Frulact, with an average content of total soluble solids equivalent to 12 ºBrix for pineapple, 6 ºBrix for strawberry and 12 ºBrix for apple. Before being dehydrated, the purée was diluted with distilled water until a clear juice with total soluble solid content of 0.5 ºBrix was obtained. The maltodextrin 10 DE (Sigma-Aldrich, USA) or arabic gum (Merck, Germany) was added to this juice with a final concentration of 1 % or 2 % $g \cdot mL^{-1}$. The concentration of the prebiotic was initially tested in the range of 0.25 to 4 % (results not shown) and it was optimized to 1 and 2 % $g \cdot mL^{-1}$.

The total solid content was measured with a digital refractometer (model PR-32 (alpha), Brix 0 - 32 %, Atago U.S.A., Inc.,WA, USA).

Spray drying conditions

The powder was obtained using a mini spray dryer (BUCHI, B-191, Laboratory-Techniques LTD, Flawil Switzerland). The spray dryer operates concurrently and has a spray nozzle with an orifice of 1 mm in diameter. The inlet air temperature was 120 °C or 130 °C and the inlet air pressure was 6.5 bars (previously optimized; results not shown) for all essays. The outlet air temperature was 65 °C and 70 °C, respectively. The liquid feed to the dryer was about 5 mL min^{-1} and the feed temperature was 40 °C (previously optimized; results not shown). The experiments were performed at constant processing conditions. Three replicates of each experiment were performed.

Water activity determination

The water activity of the spray-dried strawberry powders was measured using a water activity meter (Aqualab series 3, Decagon Devises, Pullman, WA). Triplicate samples were measured at 23.0 ± 1 °C.

Drying yield

The drying yield (%) was determined as the % weight fraction of the total solids in the liquid feed that could be recovered in the collecting vessel attached to the bottom of the cyclone.

Statistical analysis

One-way analysis of variance (ANOVA) (using SPSS 10.0 statistics software, SPSS Inc., Chicago, IL) was used for the determination of differences between the concentration of additive and inlet temperature for each fruit. Tukey's test was additionally then formed with the purpose of means paired comparison. The results were considered significantly different when $P < 0.05$.

RESULTS AND DISCUSSION

In general, for all the three fruit juices studied, there was an increase of the yield of the process with the concentration of maltodextrin or arabic gum (Figure 1). This can be explained by an increase of T_g of the product, making the drying easier and avoiding the stickiness of the product. In general, there was an increase of the yield when the inlet air temperature increased and when maltodextrin was the carrier in apple juice, which is in agreement with a similar study on orange juice [7]. The yield of the spray drying of apple juice with 2 % of maltodextrin dried at 130 °C was the highest, reaching above 60 %. These conditions promoted the reduction the water activity, which was lower than 0.40 (Figure 2). The drying of this juice was also easier than the others. The yield of the spray drying of strawberry juice with 2 % maltodextrin dried at 120 °C presented a yield of almost 50 %. Pineapple juice presented yields of around 40 %, also when 2 % of the carrier was used. Pineapple juice with 1 % maltodextrin dried at 120 °C presented lower yield than under other conditions.

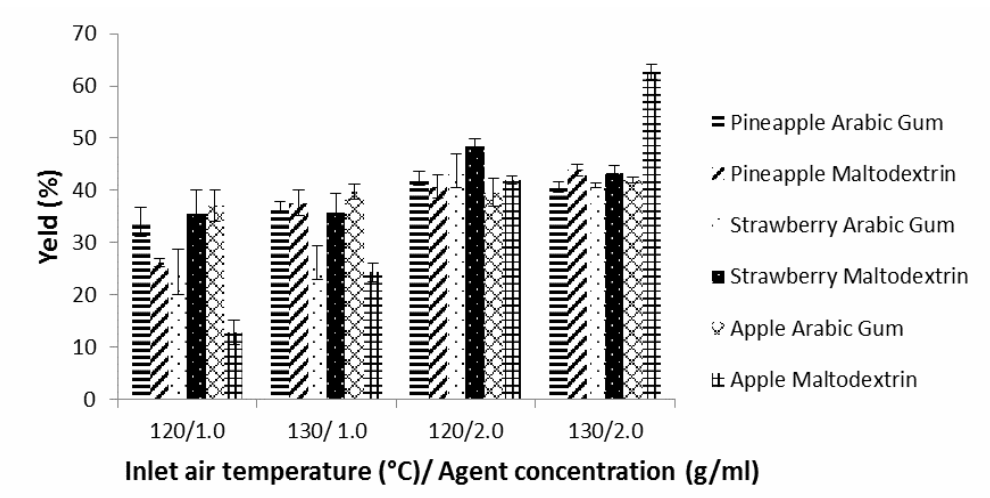

Figure 1. *Yield of spray drying of pineapple, strawberry and apple juice with maltodextrin and arabic gum*

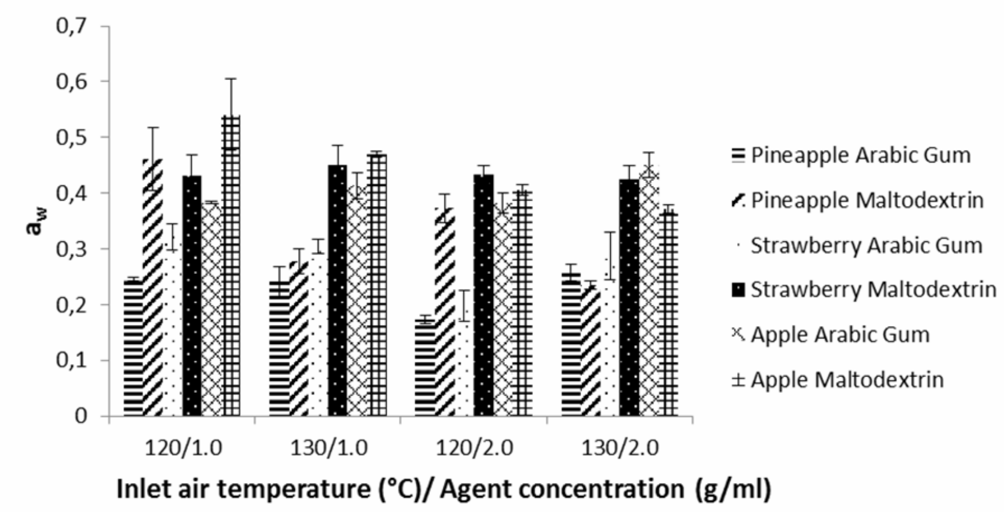

Figure 2. *Water activity of pineapple, strawberry and apple juice powder*

In general, fruit juices with arabic gum presented lower water activity of the dried powder than with maltodextrin (Figure 2). The water activity for the apple juice decreased when the concentration of maltodextrin increased. It also decreased for this juice with this carrier when the inlet air temperature increased. A similar behaviour was observed for black mulberry juice powder by Fazaeli and co-workers [8]. Increasing the inlet air temperature might have helped to decrease the water activity, by promoting evaporation of the water during the drying. Pineapple spray-dried juice with arabic gum presented the lowest a_w, of around 0.23. This was also the juice that, in general, presented lower a_w when maltodextrin was the carrier. The water activity of the strawberry powder was around 0.435 for the different concentrations of maltodextrin.

CONCLUSIONS

This study allowed to conclude that 2 % (g·mL^{-1}) of maltodextrin and inlet air temperature of 130 °C are recommended to spray dry apple, in order to reach a product yield higher than 50 %, which is the value granted for a successful spray drying at laboratory scale [9]. For strawberry juice, 2 % of this carrier is recommended and the inlet air temperature, 120 °C or 130 °C, did not seem relevant. For pineapple, neither the concentration of the carrier, 1 or 2 %, nor the inlet air temperature, 120 °C or 130 °C, seemed to be important.

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