Comparative study on the quality of products obtained by spray drying at laboratory and pilot scale

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Abstract

Based upon the optimization of the microencapsulation of acerola juice in a spray dryer at the laboratory scale, the aim of this study was to consolidate the process by further testing it at pilot level. Most papers report the microencapsulation of fruit juices carried out in laboratory spray dryers in order to produce powdered juices. However, performing experiments on a pilot scale is quite important, as it is closer to the industrial reality, serving to support this segment. Tests with different concentrations of encapsulating agents were initially performed in a mini spray dryer to select the best operating conditions and formulation to be used in pilot scale equipment. In the formulation it was used centrifuged acerola juice and the encapsulating agent maltodextrin DE 5. The powdered product was analyzed for the content of vitamin C, anthocyanins and antioxidant capacity. Comparing the results obtained in lab and pilot-scale tests carried out with the same formulation, it was found that the products obtained in pilot scale better preserved the contents of vitamin C and total anthocyanins, with retention values higher than 80%. The antioxidant capacity showed the same behavior. Although the particles produced at laboratory scale had lower retention after spray drying, they showed better stability during storage. The samples produced at pilot scale showed higher vitamin C degradation and consequently lower antioxidant capacity after 60 days of storage.

Key words: bioactive compounds, vitamin C, antioxidant capacity, anthocyanins, acerola

1. Introduction

An increasing health concern combined with the intense way of life of most people has caused changes in their food habits, directing them to a healthy diet and, at the same time, of quick and easy preparation. Allied to this behavior, the demand for processed foods that contain natural ingredients has been showing a steady increase.

A natural ingredient that arouses interest in technology and nutrition is ascorbic acid. The role of this nutrient as an antioxidant has been especially relevant in recent years because the cardiovascular diseases are often related to the oxidative stress caused by free radicals. Ascorbic acid is considered one of the most potent and less toxic natural antioxidants (MEZADRI et al., 2006). The preparation of foods with natural high content of this acid may allow a reduction in the use of additives.

Acerola (*Malpighia emarginata* DC) is one of the major natural sources of ascorbic acid. According to Araújo and Minami (1994), the consumption per day of three acerolas reaches the recommended daily intake for an adult. However, due to the high perishability of the fruit, the development of alternative technologies for its better preservation is very important. Among the various emerging technologies in the food industry, the microencapsulation has a wide range of applications and is requiring further research because the market of microencapsulated products is expanding rapidly.

Spray drying is one of the most used methods for microencapsulation since there is large scale equipment already available, it is a relatively low cost process, there is the possibility of employing a wide variety of encapsulating agents and the stability of the final product is usually good. The final product can be used as dehydrated juice or as an ingredient for the development of other products (Shu et al., 2006).

Water removal by drying ensures the microbiological quality of the product and has advantages in reducing associated costs with packaging, storage and transportation (Shahidi, Han, 1993).

Most studies on spray drying for the production of powdered juices reported in the literature were carried out in bench scale dryers. However, performing experiments on a pilot scale is quite important in order to get data that are closer to the industrial reality, serving to support this segment.

In this context, this study aimed at consolidating the technology for encapsulation of acerola juice in pilot scale and verifying the retention and stability of its main components.

2. Material and Methods

Acerola fruits purchased in the local market were used as raw material. Maltodextrin DE 5 (Corn Products, São Paulo,Brasil) was used as the carrier agent.

The fruits were pulped and centrifuged in a basket centrifuge and then, maltodextrin was added. The proportion of maltodextrin to juice's total solids was 2:1. The mixture was agitated until complete dissolution and then subjected to spray drying.

For the laboratory tests, acerola juice was dried in a mini spray dryer Buchj B-190 (Flawil, Switzerland), while the pilot level tests were performed in a Niro Atomizer spray dryer (Soeborg, Denmark) with capacity of 15L/h. Both tests were performed using inlet and outlet air temperatures of 180ºC and 90ºC, respectively.

Powders were stored in laminated bags and placed in dessicators at 30ºC. Samples were analyzed immediately after preparation and at intervals of 15 days, during 60 days, with respect to vitamin C, anthocyanins and antioxidant capacity.

Vitamin C was quantified by a colorimetric method using 2,6-diclorophenol-indophenol (A.O.A.C., 1984) and replacing metaphosphoric acid by oxalic acid as solvent (Benassi&Antunes, 1998).

Total anthocyanins were analyzed according to the pH differential method, as described by Giusti & Wrolstad (2001).

Antioxidant capacity was measured by determination of the ABTS cationic radical scavenging capacity, as described by Re et al. (1999). Extraction was performed according to Rufino et al. (2007) and the results were expressed as μmol Trolox equivalent, using a calibration curve of this antioxidant.

Moisture content was determined by oven drying at 105ºC until constant weight (A.O.A.C., 1984).

Results were statistically analyzed by Analysis of Variance (ANOVA), using the software Statistica 7.0 (StatSoft, Tulsa, USA). Mean comparison analysis was performed using Tukey's procedure at $p \leq 0.05$.

3. Results and Discussion

Table 1 shows the retention of vitamin C and anthocyanin of acerola juice immediately after spray drying, as well as its antioxidant capacity preservation.

Table 1: Retention of the main compounds present in spray-dried acerola juice produced at laboratory and pilot scale.

Process Scale	Retention (%)		
	Vitamin C	Total Anthocyanins	AntioxidantCapacity
Laboratory	75.11[b]	76.82[b]	75.98[b]
Pilot plant	90.74[a]	84.10[a]	89.79[a]

Different letters indicate significant difference between sample means in the same column ($p < 0.05$).

Results obtained for the powders produced in laboratory and pilot scale, with the same formulation, show that the drying process at pilot scale better preserved the contents of vitamin C and total anthocyanins, with retention values higher than 80%. The antioxidant capacity showed the same behavior, which was expected since vitamin C and anthocyanins are some of the main compounds responsible for the antioxidant power of this fruit.

Figures 1 to 3 show the storage stability of spray-dried acerola juice with respect to the contents of vitamin C and anthocyanins and antioxidant capacity.

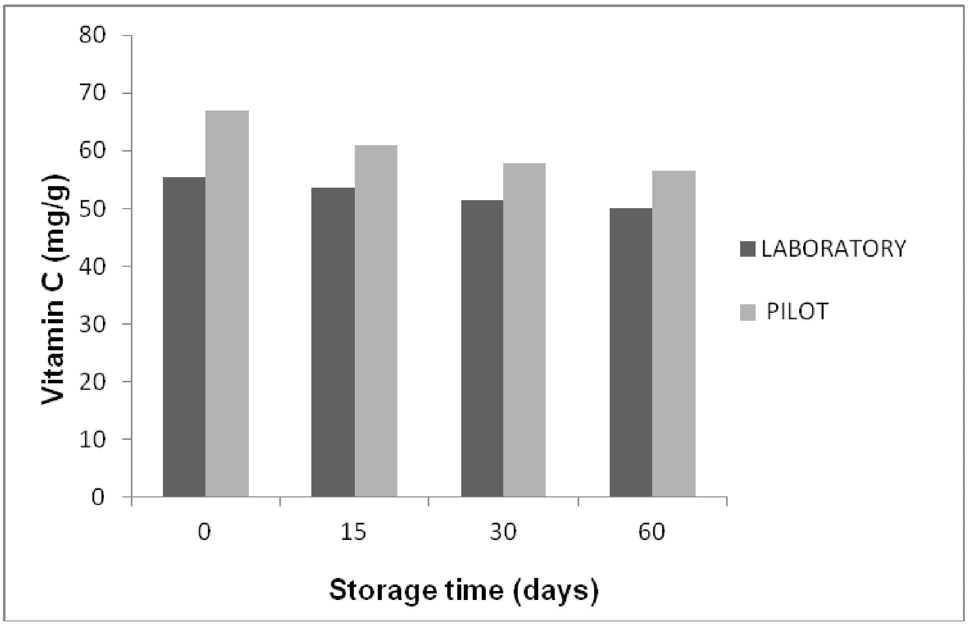

Figure 1: Vitamin C stability of spray-dried acerola juice produced at laboratory and pilot plant scale (results expressed in dry basis).

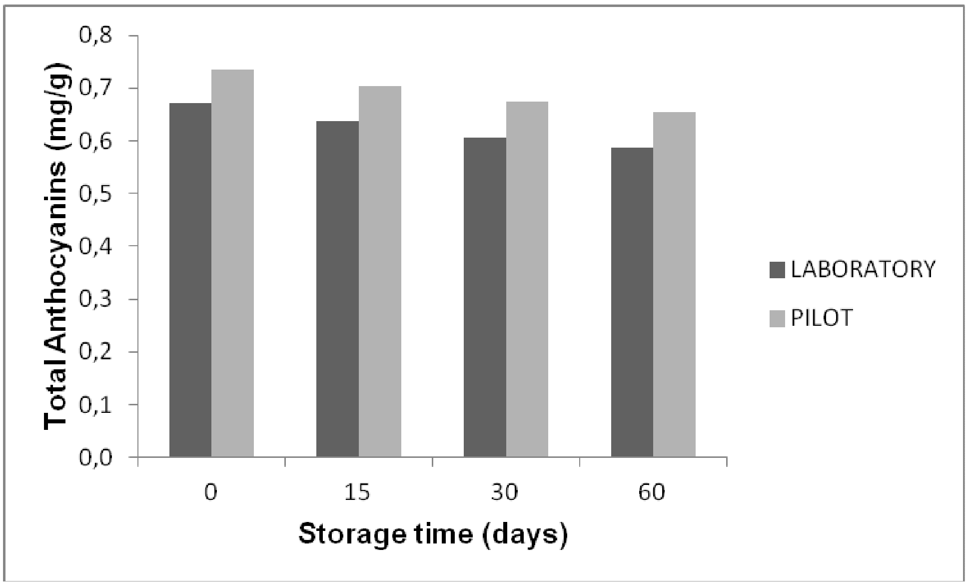

Figure 2: Anthocyanin stability of spray-dried acerola juice produced at laboratory and pilot plant scale (results expressed in dry basis).

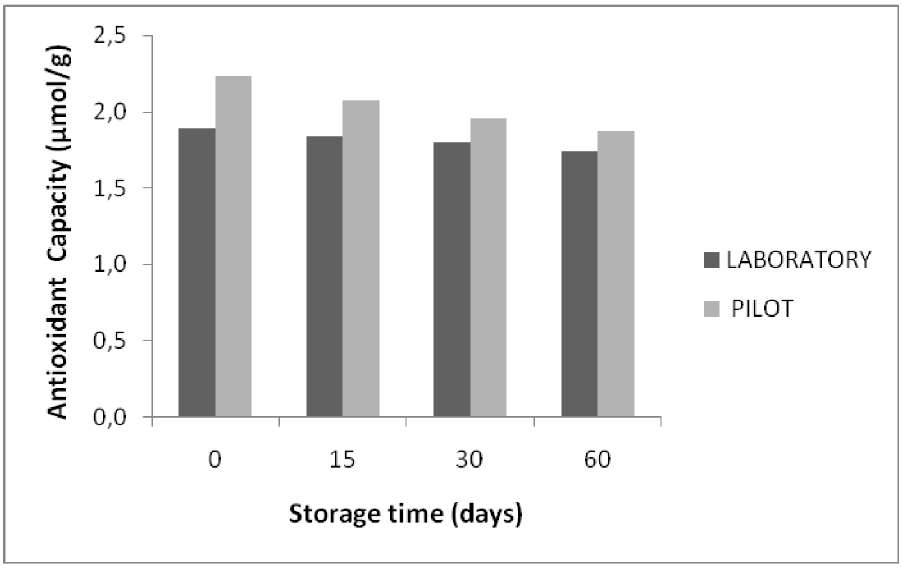

Figure 3: Antioxidant capacity of spray-dried acerola juice produced at laboratory and pilot plant scale (results expressed in dry basis).

According to Figures 1 to 3, although the particles produced at laboratory scale had lower retention after spray drying, they showed better stability during storage, mainly with respect to vitamin C content and antioxidant capacity. The samples produced at pilot scale showed higher vitamin C degradation and consequently lower antioxidant capacity after 60 days of storage.

Table 2 shows the degradation of vitamin C and anthocyanin of samples after 60 days of storage, as well as the reduction of their antioxidant capacity.

Table 2: Degradation of the main compounds present in spray-dried acerola juice produced at laboratory and pilot plant scale.

	Degradation (%)		
Process Scale	Vitamin C	Total Anthocyanins	Antioxidant Capacity
Laboratory	9.66[b]	12.70[b]	7.81[b]
Pilot plant	15.38[a]	11.15[a]	15.94[a]

Different letters indicate significant difference between sample means in the same column ($p < 0.05$).

The vitamin C degradation observed during the stability tests, both at laboratory and pilot plant scale, was higher than the observed by Figueiredo (1998), which evaluated the stability of acerola powder stored in laminated bags during one year, in a formulation composed by 15% gum Arabic and 5% maltodextrin. This indicates that gum Arabic might be suggested as a good alternative to preserve the vitamin C content in fruit juice powders.

Regarding total anthocyanins, no significant differences were observed between the two processing scales. The degradation values were lower than the observed by Ersus & Yurdagel (2007), which encapsulated black carrot anthocyanins using maltodextrin as carrier agent and observed a degradation of 33% after 64 days of storage at 25ºC.

4. Conclusion

Powdered acerola juice was successfully produced by spray drying at laboratory and pilot plant scales. The pilot plant scale provided a better retention of its main compounds immediately after drying. However, better stability was observed in the particles produced at laboratory scale. Further characterization, such as particles morphology and size still, needs to be done in order to better explain these results.

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