No 2/2007
March/April
Volume 17

PHYSICOCHEMICAL AND SENSORY CHANGES DURING MICROENCAPSULATION OF ACEROLA JUICE THROUGH SPRAY-DRYING

Henriette M.C. Azeredo, Kênya C.B. Mendes,
Arthur C.R. Souza, Deborah S. Garruti,
Maria Iranilde R. Andrade

Submitted: December 18, 2006 Accepted by Peer Review: February 12, 2007

ABSTRACT

The objective of this work was to study physicochemical and sensory changes in acerola juice through spray-drying microencapsulation. Raw, filtered acerola juice was added with maltodextrin (DE 10) at a 1:2 mass ratio (maltodextrin/acerola juice). The dispersion was homogenised and spray dried. Both ascorbic acid and anthocyanins were well retained in the microencapsulation process. However, a* and L* colour values were reported to decrease, probably due to pH rise (causing anthocyanin to lose red colour) and caramelization and/or ascorbic acid browning (causing the lightness to decrease). Sensory tests indicated that, in addition to red colour losses, the process resulted in decreased acerola flavour intensity, probably due to thermal degradation of volatiles.

INTRODUCTION

Acerola (Malpighia emarginata D.C.), also known as Barbados Cherry or West Indian Cherry, is a bright red fruit originated from Central America and northern South America (21). It gained great economical importance in Brazil. Acerola consumption has increased over the last decades, thanks to its antioxidant properties. These properties are related to the fruit's high vitamin C content (20), as well as the presence of anthocyanins. Anthocyanins are, in turn, mainly responsible for acerola's red colour (7). These antioxidants, constituting one of the most important classes of functional compounds, have been associated with the reduction of oxidative stress symptoms in the human body. Antioxidant properties of ascorbic acid and their relation to health benefits were reviewed by González et al. (2005). Several authors have also reported the antioxidant activity of anthocyanins (9) and their possible role in reducing the risk of chronic-degenerative diseases, e.g. coronary heart disease and cancer (16). However, both vitamin C and anthocyanins are greatly susceptible to degradation, fuelled by oxygen, light and pH levels, among other factors (5).

Brazil has expanded its acerola production to respond to the large international demand for frozen acerola pulp (26). To produce acerola beverages, alternative methods have been applied, e.g. enzymatic hydrolysis in connection with microfiltration to produce clarified acerola juice, with excellent microbiological quality and high ascorbic-acid retention (22). The drying processes would provide some advantages, such as reduced costs for storage, transportation and retailing through weight reduction and energy savings. Spray drying is an adequate process for heat-sensitive food, such as fruit juice. However, powders produced by spray-drying fruit extracts tend to be very hygroscopic, because of the usually high sugar and acid contents of fruit. The stickiness and caking of the particles may be minimized by conducting spray-drying as a microencapsulation process (4). Microencapsulation encompasses the enclosure of microparticles (core) in a coating, mainly to protect the core from ambient factors, e.g. light, moisture, oxygen, or from other ingredients thereby minimizing chemical and physical changes, thus safeguarding the overall product quality (10). Increased stability of anthocyanins (13) and ascorbic acid (30) have been reported to result from microencapsulation. Moreover, spray-drying is an inexpensive and very frequently employed technique to microencapsulate food products (11).

Therefore, the objective of this work was to evaluate physicochemical and sensory changes during microencapsulation of acerola juice.

MATERIALS AND METHODS

Acerolas were collected from a plantation site in Caucaia (Ceara State, Brazil) and processed at Embrapa Tropical

Agroindustry (Fortaleza, CE, Brazil). The fruits were washed, selected, sanitized in a sodium hypochlorite solution (50 mg/kg, for 15 min.) and processed in a depulper (Itametal Bonina DF A8, Itabuna, BA, Brazil). The pulp was filtered in a 0.3-mm mesh sieve. The pulp yield was 51.8 %.

A sample of the raw filtered juice was packed in glass jars covered with aluminium foil and frozen until subsequent sensory tests. To the remaining juice, maltodextrin (DE 10) was added at a ratio of 1:2 (maltodextrin/acerola juice). The dispersion was atomized in a Mini Spray Dryer Büchi B-290 (Büchi Labortechnik AG, Flawil, Switzerland) with the following operational conditions: inlet temperature, 100°C; outlet temperature, 56 °C; flow rate, 0.4 L/h.

The following analyses were carried out for both the raw acerola juice (RAJ) and the microencapsulated acerola juice (MAJ): water activity (in Aqualab CX-2, Decagon), ascorbic acid content (25), total anthocyanins (19), colour (Hunter), moisture content and pH (2). Colour measurements and pH of the MAJ were taken after reconstituting it in such a way as to achieve the same acerola dry-weight of RAJ. The assessment of the retention degree of anthocyanins and ascorbic acid during microencapsulation were based on their contents on a dry acerola basis (d.a.b.), i.e., disregarding maltodextrin (in MAJ) and moisture (in RAJ and MAJ). Means of colour parameters, pH as well as anthocyanin and ascorbic acid contents (d.a.b.) of MAJ were compared to those of RAJ by t-tests (Statistica, StatSoft, Tulsa, USA).

The difference-from-control sensory test (23) was modified into a bipolar test, to enhance the evaluation of the degree and direction of the differences between a nectar from MAJ versus the raw filtered juice (RAJ), in terms of red colour and acerola flavour intensity. The test was conducted in the Sensory Analysis Laboratory of Embrapa Tropical Agroindustry, using individual booths illuminated by daylight-corrected fluorescent lamps. The coded samples were presented in randomized order. Each panellist evaluated the contents of three 20-ml cups: the RAJ nectar – prepared by diluting RAJ in water (RAJ/water, 1:1) and added with 20 % sucrose – (labelled "control") versus the two test samples, i.e. the RAJ nectar and the MAJ nectar, each labelled with a random 3-digit number code. The two cups with the test samples contained the blind control and the nectar prepared by diluting and sweetening MAJ in such a way as to equal the acerola dry-weight and total soluble solids of the control. Panellists were asked to rate the degree of difference between each coded sample and the control, in terms of red colour and acerola flavour intensity on a 7-point structured scales ranging from -3 ("greatly less intense") to +3 ("greatly more intense"), 0 being "equal to the control". The rate-means obtained from the two test samples were compared by a t-test.

TABLE 1: PHYSICOCHEMICAL DATA ON RAW ACEROLA JUICE (RAJ) AND MICROENCAPSULATED ACEROLA JUICE (MAJ)

Determination		RAJ	MAJ	p
Moisture content (%)		94.43	5.97	-
Water activity		0.988	0.437	-
pH		3.3	3.6(1)	0.04
Ascorbic acid ($mg.100g^{-1}$)	(wet basis)	582.03	851.90	-
	(d.a.b.)(2)	9700.51	8518.98	<0.01
Total anthocyanins ($mg.100g^{-1}$)	(wet basis)	11.71	19.24	-
	(d.a.b.)(2)	195.10	192.37	0.08
L*		+39.59	+29.30(1)	0.02
a*		+20.27	+11.69(1)	<0.01
b*		+15.46	+18.37(1)	0.06
C*		25.49	21.77	0.04
h(0)		37.33	57.53	0.03
ΔE*		15.16		-

(1) MAJ was reconstituted prior to pH and colour measurements, in such a way as to achieve the same acerola dry weight of RAJ.
(2) Dry acerola basis, i.e., based on acerola solids

RESULTS AND DISCUSSION

The results of physicochemical determinations on RAJ and MAJ are presented in Table 1. The water activity of MAJ (0.44) was below the lower limit for microbial growth, 0.60 (29). Hence, the product is expected to exert a good stability at room temperature. Ascorbic acid (AA) was well retained in the microencapsulation process. Although significant ($p<0.05$), AA's degradation during the process (12.18 %), was lower than that reported by Torregrosa et al. (2006) in orange-carrot juice upon pasteurization (17 %), and almost as low as that observed on pulsed electric field treatment (10 %), the latter being a non-thermal preservation process highly recommended for treating heat-sensitive products. The anthocyanin losses were non-significant ($p<0.05$), while conventional juice processing usually promotes considerable degradation of these pigments. Mikkelsen & Poll (2002), for example, reported 25 % anthocyanin degradation during black-currant-juice processing. The high retention of these heat-sensitive compounds in the present study is attributed to the low time required for spray-drying (11). Despite non-significant anthocyanin losses, colour changes were observed between RAJ and reconstituted MAJ. Since increasing pH causes anthocyanins to lose red colour (6), the pH rise may at least partly explain colour changes, which resulted in a total colour difference (DE*) of 15.16. The lightness (L*) decrease may be attributed to caramelization or ascorbic

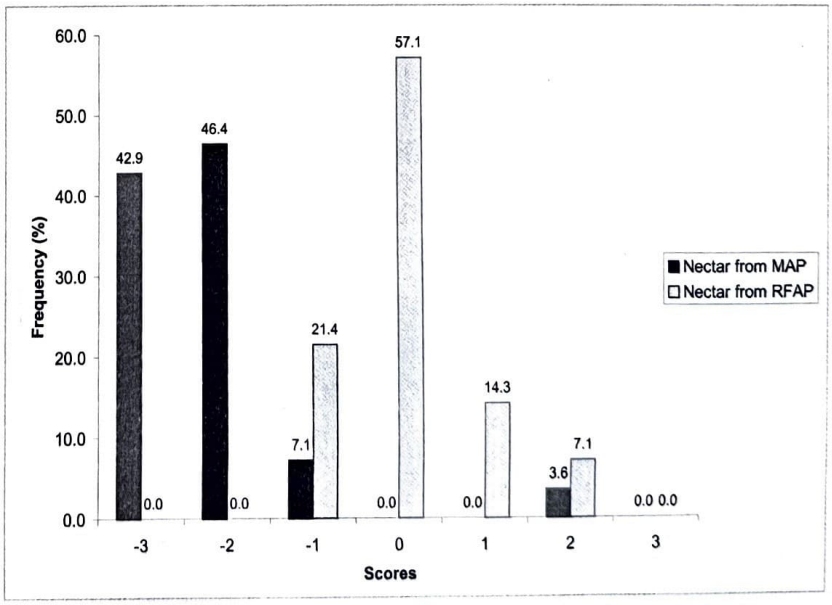

Fig. 1: Frequency histogram: results of difference-from control tests for colour intensity.
(all Figures Azeredo)

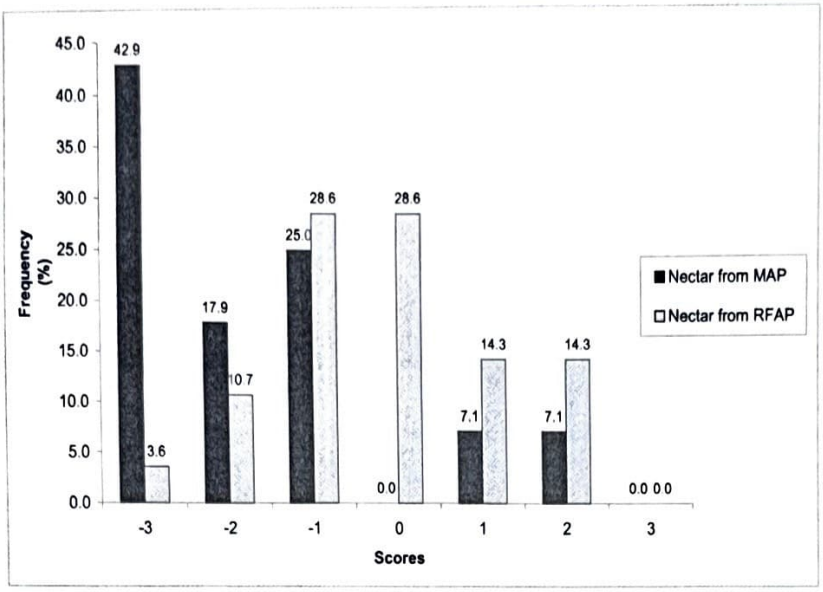

Fig. 2: Frequency histogram: results of difference-from control tests for acerola flavour intensity.

acid browning (18). The significant differences in chroma (C*) and hue angles (ho) resulted mainly from red colour loss.

Figures 1 and 2 present the frequency histograms for the results of difference-from-control tests for red colour and acerola flavour intensity, while Table 2 presents the corresponding results of t-tests. Most panellists (near 90 %) scored the MAJ nectar between -3 and -2 (Figure 1), that is to say, the red colour intensity of the MAJ nectar was considered as being moderately too greatly less intense than the control (RAJ nectar). This effect may be caused by anti-copigmentation, reported by Dangles et al. (1992) to result from inclusion complexes of colourless and yellowish forms of anthocyanins (carbinol pseudobase and chalcone, respectively) and cyclodextrins, accelerating the fading of the anthocyanin solution. According to Stintzing & Carle (2004), sources rich in starches and cyclodextrins might also show a fading reaction upon processing. Similarly, the MAJ nectar was considered by most panellists as having less intense acerola flavour than the RAJ nectar. This may be attributed to degradation of volatile compounds during processing. These differences were significant ($p<0.05$), both for colour and flavour, as indicated in Table 2.

Further studies are required in order to evaluate losses of volatile compounds and to improve the process in terms of flavour retention. Moreover, economical aspects must be considered, since the proposed process is more expensive than the conventional one used to produce frozen acerola pulp. On the other hand, the drying process provides two important economical advantages: reduced transportation costs (weight and volume reduction) and no costs for cold chain during product distribution. These advantages are especially important when the product is to be transported long distance or internationally.

CONCLUSIONS

Anthocyanins and ascorbic acid were greatly retained by the microencapsulation process, indicating that, in spite of the high temperature required for spray-drying the product, the residence time is short enough to minimize degradation of heat-sensitive compounds. However, the nectar obtained from microencapsulated acerola juice presented significantly ($p<0.05$) less intense red colour and acerola flavour than that obtained from raw acerola juice.

REFERENCES

1. Adhikari, B.; Howes, T.; Bhandari, B.R.; Troung, V. (2004). Effect of addition of maltodextrin on drying kinetics and stickiness of sugar and acid-rich foods during convective drying: experiments and modeling. Journal of Food Engineering, 62: 53-68.
2. AOAC. (1995). Official Methods of Analysis of AOAC International. 16. ed. Arlington: AOAC.

TABLE 2: STATISTICAL EVALUATION OF SENSORIAL DIFFERENCES BETWEEN NECTARS OBTAINED FROM MICROENCAPSULATED ACEROLA JUICE (MAJ NECTAR) AND RAW ACEROLA JUICE (RAJ NECTAR), ACCORDING TO T-TEST

	Mean differences-from-control			
Attributes	MAJ nectar	RAJ nectar (blind control)	t	P
Acerola colour intensity	-2.214	0.071	-9.209	$<10^{-6}$
Acerola flavour intensity	-1.500	-0.179	-3.248	0.002

3. Barreiro, J.A.; Milano, M.; Sandoval, A.J. (1997). Kinetics of colour change of double concentrated tomato paste during thermal treatment. Journal of Food Engineering, 33: 359-371.
4. Bhandari, B.R.; Datta, N.; Howes, T. (1997). Problems associated with spray drying of sugar-rich foods. Drying Technology, 15: 671-684.
5. Bridle, P.; Timberlake, C.F. (1997). Anthocyanins as natural food colours - selected aspects. Food Chemistry, 58: 103-109.
6. Cevallos-Casals, B.A.; Cisneros-Zevallos, L. (2004). Stability of anthocyanin-based aqueous extracts of Andean purple corn and red-fleshed sweet potato compared to synthetic and natural colorants. Food Chemistry, 86: 69-77.
7. Chan Jr., H.T.; Yamamoto, H.Y. (1994). Kinetics of anthocyanin decomposition in acerola juice. ASEAN Food Journal, 9: 132-135.
8. Dangles, O.; Stoeckel, C.; Wigand, M.C.; Brouillard, R. (1992). Two very distinct types of anthocyanin complexation: copigmentation and inclusion. Tetrahedron Letters, 33: 5227-5230.
9. Degenhardt, A.; Knapp, H.; Winterhalter, P. (2000). Separation and purification of anthocyanins by high-speed countercurrent chromatography and screening for antioxidant activity. Journal of Agricultural and Food Chemistry, 48: 338-343.
10. Depypere, F.; Dewettinck, K.; Ronsse, F.; Pieters, J.G. (2003). Food powder microencapsulation: principles, problems and opportunities. Applied Biotechnology, Food Science and Policy,1: 75-94.
11. Dziezak, J.D. (1988). Microencapsulation and encapsulated ingredients. Food Technology, 42: 136-151.
12. Einbond, L.S.; Reynertson, K.A.; Luo, X.D.; Basile, M.J.; Kennelly, E.J. (2004) Anthocyanin antioxidants from edible fruits. Food Chemistry, 84: 23-28.
13. Gradinaru, G.; Biliaderis, C.G.; Kallithraka, S.; Kefalas, P.; Garcia-Viguera, C. (2003). Thermal stability of Hibiscus sabdariffa L. anthocyanins in solution and in solid state: effects of copigmentation and glass transition. Food Chemistry, 83: 423-436.
14. Gómez-Plaza, E.; Miñano, A.; López-Roca, J.M. (2006). Comparison of chromatic properties, stability and antioxidant capacity of anthocyanin-based aqueous extracts from grape pomace obtained from different vinification methods. Food Chemistry, 97: 87-94.
15. González, M.J.; Miranda-Massari, J.R.; Mora, E.M.; Guzmán, A.; Riordan, N.H.; Riordan, H.D.; Casciari, J.J., Jackson, J.Á.; Román-Franco, A. (2005). Ortomolecular oncology review: ascorbic acid and cancer 25 years later. Integrative Cancer Therapies, 4: 32-44.
16. Kamei, H.; Kojima, T.; Hasegawa, M.; Koide, T.; Umeda, T.; Yukawa, T.; Terabe, K. (1995). Suppression of tumor cell growth by anthocyanins in vitro. Cancer Invest, 13: 590-594.
17. Kong, J.M.; Chia, L.S.; Goh, N.K.; Chia, T.F.; Brouillard, R. (2003). Analysis and biological activities of anthocyanins. Phytochemistry, 64: 923-933.
18. Kroh, L.W. (1994). Caramelisation in food beverages. Food Chemistry, 51: 373-379.
19. Lees, D.H.; Francis F.J. (1972). Standardization of pigment analyses in cranberries. HortScience, 7: 83-84.
20. Leung, A.Y.; Foster, S. (1996). Acerola. In: Encyclopedia of Common Natural Ingredients Used in Food, Drugs, and Cosmetics, 2nd. ed. New York: Wiley. pp. 6-7.
21. Marino Netto L. (1986). Acerola, a cereja tropical. São Paulo: Nobel.
22. Matta, V.M.; Cabral, L.M.C.; Moretti, R.H. (2000). Clarification of acerola juice by enzymatic treatment and microfiltration. Alimentaria, 309: 127-130.
23. Meilgaard, M.; Civille, G.V.; Carr, B.T. (1999). Sensory evaluation techniques. 3rd. ed. New York: CRC Press.
24. Mikkelsen, B.B.; Poll, L. (2002). Decomposition and transformation of aroma compounds and anthocyanins during black currant (Ribes nigrum L.) juice processing. Journal of Food Science, 67: 3447-3455.
25. Pearson, D.; Cox, H.E. (1976). The chemical analysis of foods. New York: Chemical Publishing.
26. Oliveira, J.R.P.; Soares Filho, W.S. (1995). Acerola: conservação, caracterização e seleção de germoplasma pelo CNPMF - EMPRAPA. In: São José, A.R.: Alves, R.E. (Ed.). Acerola no Brasil - Produção e Mercado. Vitória da Conquista: DFZ/UESB. pp. 22-27.
27. Stintzing, F.C.; Carle, R. (2004). Functional properties of anthocyanins and betalains in plants, food, and in human nutrition. Trends in Food Science and Technology, 15: 19-38.
28. Torregrosa, F.; Esteve, M.J.; Frígola, A.; Cortés, C. (2006). Ascorbic acid stability during refrigerated storage of orange-carrot juice treated by high pulsed electric field and comparison with pasteurized juice. Journal of Food Engineering, 73: 339-345.
29. Troller, J.A. (1980). Influence of water activity on microorganisms in foods. Food Technology, 44: 76-82.
30. Udin, M.S.; Hawlader, M.N.; Zhu, H.J. (2001). Microencapsulation of ascorbic acid: effect of process variables on product characteristics. Journal of Microencapsulation, 18: 199-209.
31. Wrolstad, R.E. (2004). Anthocyanin pigments - bioactivity and coloring properties. Journal of Food Science, 69: 419-421.
32. Yamashita, F.; Benassi, M.T.; Tonzar, A.C.; Moriya, S.; Fernandes, J.G. (2003). Produtos de acerola: estudo da estabilidade de vitamina C.

AUTHOR

Henriette M.C. Azeredo
Kênya C.B. Mendes
Arthur C.R. Souza
Deborah S. Garruti
Maria Iranilde R. Andrade

Embrapa Tropical Agroindustry
CEP: 60511-110 - Fortaleza - CE - BRASIL

www.cnpat.embrapa.br