Food Research International 44 (2011) 2385–2390

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

Evaluation of dehydrated *marolo* (*Annona crassiflora*) flour and carpels by freeze-drying and convective hot-air drying

S.C. Corrêa [a], M.T.P.S. Clerici [a], J.S. Garcia [b], E.B. Ferreira [b], M.N. Eberlin [c], L. Azevedo [a,*]

[a] Nutrition Faculty, Alfenas Federal University, UNIFAL, 37130-000, Alfenas, MG, Brazil
[b] Institute of Exact Sciences, Alfenas Federal University, UNIFAL, 37130-000, Alfenas, MG, Brazil
[c] ThoMSon Mass Spectrometry Laboratory, Institute of Chemistry, University of Campinas, UNICAMP, 13083-970, Campinas, SP, Brazil

ARTICLE INFO

Article history:
Received 18 October 2010
Accepted 28 February 2011

Keywords:
Annona crassiflora
Dehydration
Evaluation
Physicochemical characteristics
Technological properties

ABSTRACT

Marolo (*Annona crassiflora*), an exotic fruit from the Brazilian savanna, has been used for many culinary preparations such as jelly and jam. In this study we have compared physicochemical properties, color analysis, dietary fiber and triacylglycerol analysis of *marolo* flour and carpels dehydrated by freeze-drying and convective hot-air drying. The experiments were analyzed by Tukey's test ($p<0.05$). There was a significant difference between fresh and dehydrated *marolo* as shown by the analysis of moisture, Aw, and the centesimal composition (except for the ashes).The dehydrated products showed to be sources of alimentary fiber and derivatives from oleic and palmitic acids and can be used during periods between harvests of *marolo* fruits.

1. Introduction

The Brazilian savanna is the second largest biome in South America just second to the Amazon rainforest (Proença, Oliveira, & Silva, 2000). *Marolo* (*Annona crassiflora*), also known as *Araticum*, is an exotic fruit found in the Brazilian savanna. This fruit weighs from 0.5 to 4.5 kg, and contains from 90 to 190 carpels with one seed each (Ribeiro & Pascal, 2005). Fig. 1 shows the *marolo* (*A. crassiflora*) tree (A), tree and fruit (B), fruit (C), flower (D) and cut fruit (E).

Marolo presents sensory appeal such as color, scent and flavor besides many nutritional qualities including high levels of B complex vitamins, such as thiamine (0.04 mg/100 g) and riboflavin (0.07 mg/100 g), as well as ascorbic acid (21 mg/100 g) and carotenoids (5.9 ug/g) (Agostini, Cecchi, & Godoy, 1996). In spite of these characteristics, only the native people consume *marolo* fresh in the ripe stage or frozen to prepare mainly juices, ice-creams, jellies, and jams. This limitation is reinforced by the lack of data on the quality of dehydrated products from *marolo*, as food ingredients.

Many dehydration processes are used, but freeze-drying and convective hot-air drying are the most appropriate for maintaining the biological quality of products. Freeze-drying is used and restricted primarily to industries because it requires qualified personnel and higher investment costs. In contrast, convective hot-air drying demands small investments for crop producers and small industries. This type of drying results in products that may last up to 1 year (Ratti, 2001).

The objective of this study was to evaluate the physicochemical changes for obtaining fresh and dehydrated *marolo* by freeze-drying and convective hot-air drying processes.

2. Materials and methods

2.1. Materials

Mature *marolo* fruits were harvested in 2009 in the savanna ecoregion at a farm in Machado in Minas Gerais, Brazil. The carpels of mature fruits were processed by separating the pulp from the rind and the seeds. This procedure was performed in the Laboratory of Food and Technology at Alfenas Federal University, and in the Nutritional and *In Vivo* Toxicological Analysis Laboratory, MG-Brazil.

2.2. Dehydration processes

Fresh *marolo* was submitted to a blanching process (70 °C for 5 min in hot water bath) and dehydrated by freeze-drying (F) and convective hot-air drying methods (A). Carpel and pulp dehydration with freeze-drying resulted in freeze-dried carpels of *marolo* (FCM) and freeze-dried flour from *marolo* (FFM), respectively. Carpel and pulp dehydration by convective hot-air drying resulted in convective hot-

Abbreviations: Aw, activity water; TAG, triacylglycerol; WAI, water absorption index; WSI, water solubility index; FCM, freeze-dried carpels of marolo; FFM, freeze-dried flour from marolo; ACM, convective hot-air dried carpels of marolo; AFM, convective hot-air dried flour from *marolo*.

* Corresponding author at: Faculdade de Nutrição, Universidade Federal de Alfenas — Unifal-MG, 700 Gabriel Monteiro da Silva, 700, 37130-000, Alfenas, Minas Gerais, Brasil. Tel.: +55 35 8872 8825; fax: +55 35 3299 1067.
E-mail address: luciana.azevedo@unifal-mg.edu.br (L. Azevedo).

0963-9969/$ – see front matter © 2011 Elsevier Ltd. All rights reserved.
doi:10.1016/j.foodres.2011.02.052

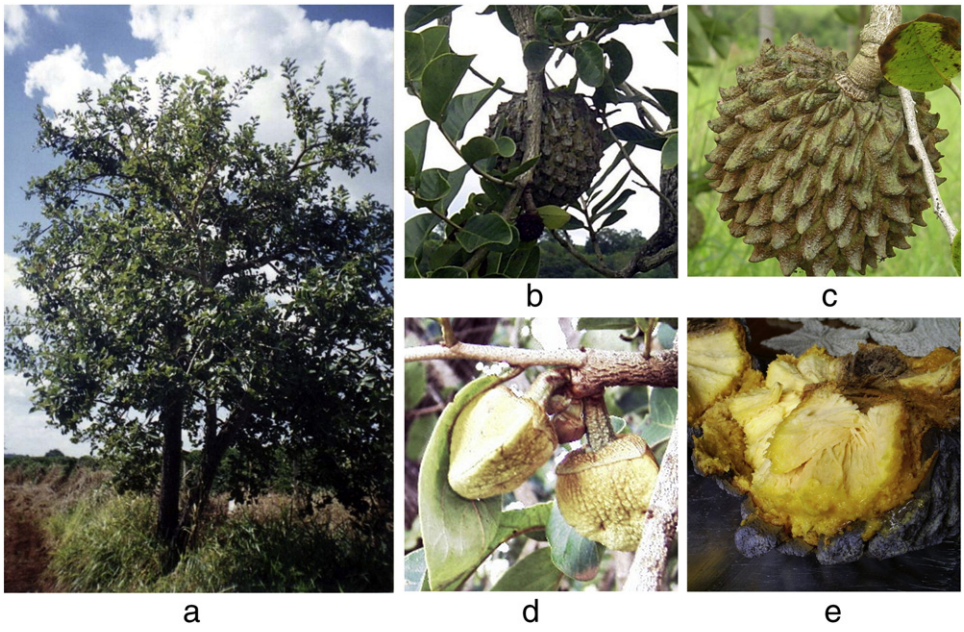

Fig. 1. A *marolo* (*Annona crassiflora*) tree (a), tree and fruit (b), fruit (c), flower (d) and cut fruit (e).

air dried carpels of *marolo* (ACM) and convective hot-air dried flour from *marolo* (AFM). After dehydration, *marolo* was ground in a blender and sifted for the uniformization of the flour granules.

For the freeze-drying (F) method, a LIOTOP-L101 drier (Brazil, São Carlos, Liobras) was used. The temperature and pressure in the closed drying chamber were −51 °C and 250 Pa, respectively. Convective hot-air drying (A) was conducted with a 400 ND drier with air circulation (Brazil, Vargem Grande Paulista, Nova Ética). The air temperature was held at 50 °C for 20 h, followed by 70 °C for 11 h until the moisture dropped below 10 g/100 g.

2.3. Physicochemical characterization of the fresh pulp and dehydrated products

The moisture content was determined with AOAC method No. 934.06 (1997). The water activity (Aw) was measured at 25 °C using an electric hygrometer Aqualab Lite (Decagon®).The ash content of the pulp was estimated by incineration in a muffle furnace at 550 °C (AOAC No. 923.03, 1997). The protein content was determined with the Kjeldahl method with a conversion factor of 6.25 (AOAC No. 960.52, 1997). The lipid content was analyzed gravimetrically following the procedures in Bligh and Dyer (1959). Available carbohydrate was estimated by the difference between the whole mass and the sum of protein, fat, ash and moisture. The pH was measured using an EXTECH Instruments microcomputer pH-vision GEHACA®, model PG1800. The level of titratable acidity is expressed as malic acid (AOAC, 1997). Dietary fiber was measured using AOAC Method 985.29 (AOAC, 1997), which was performed with a Total Dietary Fiber Assay Kit purchased from Sigma-Aldrich, USA. The specific volume (mL/g) and the specific density (g/mL) were determined by the displacement of hexane in a 100 mL graduated cylinder. The water absorption index (WAI) and water solubility index (WSI) were determined with procedures used by Anderson, Conway, Pfeifer, and Griffin (1969). Color was determined by means of a colorimeter Color Reader CR-10 (Konica Minolta®), by reflectance, determining the components L^* to represent luminosity (0 = black; 100 = white), a (+a = redness; −a = greenness), and b (+b = yellowness; −b = blueness), according to the CIE-L*a*b* system. The chrome (C*) and hue angle (h*) values were calculated as described by Minolta (1994). The chrome value was calculated as shown in Eq. (1), and the saturation angle as shown in Eq. (2).

$$\text{Chrome}(C^*) = \left[(a^*)^2 + (b^*)^2\right]^{1/2} \quad (1)$$

$$\text{Hue angle}\ (h^*) = \tan^{-1}(b^*/a^*) \quad (2)$$

2.4. Analysis of triacylglycerol (TAG) by mass spectrometry — MALDI Q-TOF MS

Analysis of triacylglycerol was performed once the dehydration process may lead to lipidic alterations through oxidative damage, modification of the fatty acid profile as well as the characteristics of the lipidic fraction compared to the non-processed product (Nawar, 1993).

Marolo pulp oil was extracted using only *n*-hexane. For that purpose, 100 mg of the pulp was weighed in a tube, and 1 ml of *n*-hexane was added. The mixture was then homogenized by vortexing for 2 min. Afterwards, the tubes were centrifuged for 1 min, and the samples were analyzed by MALDI Q-TOF MS. For this task, 2 μL of the *n*-hexane phase was placed on the MALDI plate for the identification of triacylglycerols and kept at room temperature until the solvent was completely evaporated. MALDI matrix (1 μL) was added to the sample, and the sample was dried at room temperature. The matrix was prepared from 1% (m v^{-1}) 2,5-dihydroxybenzoic acid dissolved in 1000 μL methanol.

MALDI Q-TOF mass spectra were acquired in a MALDI Q-TOF Premier mass spectrometer (Waters — Micromass, Manchester, UK). The mass spectra were obtained in the positive ion mode (LDI+) with a fixed nitrogen ion source using the following parameters: mass range from 700.0 to 1000.0 Da, mass threshold of 200.0 Da, a scan time of 2 s, a resolution of 10,000 in "V" mode, a trigger threshold of 700 mV, a signal sensitivity of 80 mV and a microchannel-plate photomultiplier set to 2100 V. Each spectrum was collected over a 1-s scan, and the spectra were accumulated for 1 min. The instrument was controlled by the MassLynx 4.1v software (Waters — Micromass, Manchester, UK). All data obtained from MALDI Q-TOF MS were analyzed using the same software.

2.5. Statistical analysis

All reported values represent the average value for the analysis of at least three separate replicates. ANOVA was performed, followed by a Tukey's test ($p<0.05$).

3. Results and discussion

3.1. Physicochemical characterization

Table 1 shows the results of physicochemical characteristics of fresh and dehydrated *marolo*.

In relation to moisture, fresh *marolo* had 77.21 g/100 g m ± 0.42 moisture, and the dehydrated *marolo* products, FCM, FFM, ACM and AFM, had 3.9 g/100 g ± 0.17, 3.6 g/100 g ± 0.20, 7.1 g/100 g ± 0.10 and 4.2 g/100 g ± 0.87 moisture, respectively.

There were no significant differences in moisture from the flours made with both drying processes; however, ACM had a higher moisture degree than the rest of the dehydrated products. Almost all deterioration processes that occur in food are influenced by the mobility and concentration of water (Le Page, Mirade, & Daudin, 2010), so it is necessary to control the moisture and the Aw of food to their increase shelf life. In this study, the dehydrated products had moisture levels lower than 10 g/100 g and Aw values lower than 0.60 (Table 1), which according to Troller (1980), prevents microorganisms, xerophilic molds and osmophilic yeasts from growing because they typically grow between 0.60 and 0.65 Aw.

As for the amount of minerals found in the *marolo* products, the ashes content (Table 1) revealed no significant differences in the amount of minerals found in the samples. However, dehydrated *marolo* products presented significant lower protein levels when compared to fresh *marolo*, but there was no significant difference among the dehydrated products. This loss might be due to the ammonia volatilization occurred during the blanching of the samples, which is performed at height temperatures (Ambasankar & Balakrishnan, 2010; Byrnes, 2000). It is worth highlighting the higher amount of lipids presented by FFM and FCM. The great porosity presented by the freeze-dried products contributed for the penetration of the solvent with intensity between the canaliculi formed after the dehydration, contributing for a better extraction of lipids content. In this case there was no interference from water, which could be competing with the solvent, bonding itself to the nutrients through hydrogen bonds. Such differences determined the carbohydrate content, which is obtained by the remainder between the whole mass and the sum of protein, fat, ash and moisture.

The acidity results obtained for fresh and dehydrated *marolo* products showed significant variation between the fresh fruit and the FCM form (Table 1). However, the pH increased slightly from baseline for all of the dehydrated samples. Similar results for pH were found by Miranda, Maureira, Rodriguez, and Vega-Gálvez (2009) in a study on dehydrated *Aloe vera*. The decrease in acidity in FCM and the increase in pH in all the dehydrated samples may be due to the loss of volatile acid compounds during the thermic process before dehydration (Silva, Finger, & Corrêa, 2008).

In relation to the fiber analysis, there was a decrease in insoluble dietary fiber in both types of dehydrated fruit carpels (Table 2) compared to the fresh carpels and FFM. Among the dehydrated products, the FFM had a higher insoluble fiber content. For the soluble dietary fiber, there was no significant difference between the samples.

The values of total dietary fiber (TDF), even those that were not analyzed statistically, decreased in all of the dehydrated samples compared to the fresh *marolo* carpels. As such, the grinding and the drying processes influence the fiber content of *marolo* products. In a previous study, Gutkoski and Pedó (2000) observed a decrease in the amount of oat fibers when they submitted oats to high temperatures.

These results are not consistent with those from Nilnakara, Chiewchan, and Devahastin (2009), who reported that drying at temperatures of 70, 80 or 90 °C had no significant effect on the composition of dietary fiber powder in the outer leaves of cabbage.

However, it is important to consider that freeze-dried and convective hot-air dried *marolo* had a high fiber content (15.88 to 25.78 g/100 g) compared to other dehydrated fruits, e.g., 22.1 g/100 g in green apple, 19.3 g/100 g in melon skin and 26.3 g/100 g in peach (Chang, Lee, Lin, & Chen, 1998).

The high fiber content associated to the flavor and exotic aroma makes the dehydrated *marolo* products potentially usable in many food preparations, aiming to increase the fiber content of fast preparing and/or instantaneous flours, or powder compounds for juices.

Fresh *marolo* presented a higher specific volume and a lower specific density compared to the ACM, AFM and FFM samples (Table 3). The FCM had, however, a higher specific volume and a lower specific density than the rest of the products, either fresh or dehydrated. This discrepancy may be due to little or no shrinkage in the freeze-dried products (Krokida & Philippopoulos, 2006), which could have caused them to have a large volume and lower specific density. This does not occur with the FFM because there was reduction in the size of granules during the process of grinding.

The results for WAI revealed a decrease in the water absorption from dehydrated products compared to fresh *marolo* (Table 3). Because the analysis was performed over a 30 min period, this lapse of time was probably insufficient to hydrate the fiber in the dehydrated products, and as a result, the hydrated soluble fiber from *marolo* fresh had a better absorption index. The WSI index showed a decrease in the solubility of the convective hot-air dried samples compared to the fresh samples. For the AFM, this index also had a lower value than the freeze-dried products. This low value may result from the interaction between nutrients, which may have occurred once these samples were submitted to high temperatures.

As for the color analysis performed on the samples as observed in Fig. 2 and Table 3, there was some browning in the convective hot-air dried samples, whereas the freeze-dried samples had a lighter coloring compared to the fresh fruit.

Table 1
Physical and chemical properties of fresh *marolo*, freeze-dried carpels of *marolo* (FCM), freeze-dried flour from *marolo* (FFM), convective hot-air dried carpels of *marolo* (ACM) and convective hot-air dried flour from *marolo* (AFM)[a].

Parameters	Fresh	FCM	FFM	ACM	AFM
Aw[b]	0.980 ± 0.01^{a}	0.185 ± 0.00^{b}	0.163 ± 0.01^{c}	0.167 ± 0.01^{c}	0.176 ± 0.00^{bc}
Ash[c], g/100 g	3.38 ± 0.22^{a}	3.55 ± 0.01^{a}	3.43 ± 0.11^{a}	3.55 ± 0.05^{a}	3.44 ± 0.02^{a}
Protein[c](N×6,25), g/100 g	12.51 ± 0.60^{a}	8.12 ± 0.16^{b}	8.18 ± 0.29^{b}	8.46 ± 0.56^{b}	7.68 ± 0.13^{b}
Total lipids [c], g/100 g	8.44 ± 0.64^{b}	10.43 ± 0.25^{a}	10.23 ± 0.07^{a}	9.13 ± 0.33^{b}	8.84 ± 0.18^{b}
Carbohydrates[c], g/100 g	75.68 ± 2.61^{b}	77.89 ± 0.18^{ba}	78.15 ± 0.24^{ba}	78.86 ± 0.16^{ba}	80.04 ± 0.66^{a}
Acidity (g/100 g malic acid)	1.23 ± 0.02^{a}	0.74 ± 0.02^{b}	1.07 ± 0.28^{ba}	0.95 ± 0.02^{ba}	1.07 ± 0.27^{ba}
pH	4.97 ± 0.04^{c}	5.34 ± 0.03^{ba}	5.34 ± 0.01^{ba}	5.31 ± 0.04^{b}	5.42 ± 0.06^{a}

[a] Values are the mean ± standard errors of five independent determinations. Means followed by different letters in the horizontal were significantly from each other in the Tukey's test ($p<0.05$).
[b] Water activity.
[c] Values are in dry basis.

Table 2
Soluble fiber, insoluble fiber and total dietary fiber of fresh *marolo* carpels, fresh *marolo* pulp, *marolo* freeze-dried carpels of *marolo* (FCM), freeze-dried flour from *marolo* (FFM), convective hot-air dried carpels of *marolo* (ACM) and convective hot-air dried flour from *marolo* (AFM)[a,b].

Marolo	Insoluble dietary fiber (g 100 g^{-1})	Soluble dietary fiber (g 100 g^{-1})	Total dietary fiber (g 100 g^{-1})
Fresh carpels	16.36 ± 0.55^{ab}	9.42 ± 0.21^{a}	25.78
Fresh pulp	10.55 ± 1.98^{bc}	12.23 ± 6.98^{a}	22.78
FCM	8.76 ± 0.41^{c}	11.47 ± 0.57^{a}	20.23
FFM	18.12 ± 1.42^{a}	7.22 ± 0.62^{a}	25.34
ACM	8.41 ± 1.06^{c}	7.47 ± 1.57^{a}	15.88
AFM	10.15 ± 3.52^{bc}	8.44 ± 2.36^{a}	18.59

[a] Values are the mean ± standard errors of five independent determinations. Means followed by different letters in the vertical were significantly different from each other in the Tukey test ($p<0.05$).
[b] Values are in dry basis.

All the dehydrated products presented a variation in yellowish coloring. The Maillard reaction often occurs when foods are heated. Parameters affecting the Maillard reaction are primarily sugars and proteins, temperature and the duration of the heat treatment (Chua, Mujumdar, Hawlader, Chou, & Ho, 2001). Caramelization may also have occurred once the fruit presented a high level of sugars (12.38 g/100 g ± 0.66) (Damiani, 2009). Convective hot-air drying did influence browning development. It was observed that the coordinates L*, chroma and hue angle indicated that the convective hot-air dried *marolo* presented a darker color (orange) when compared to freeze-dried and fresh *marolo* (light yellow). Freeze-drying also influenced coloring because the samples had a lighter color than the fresh *marolo* (yellow).

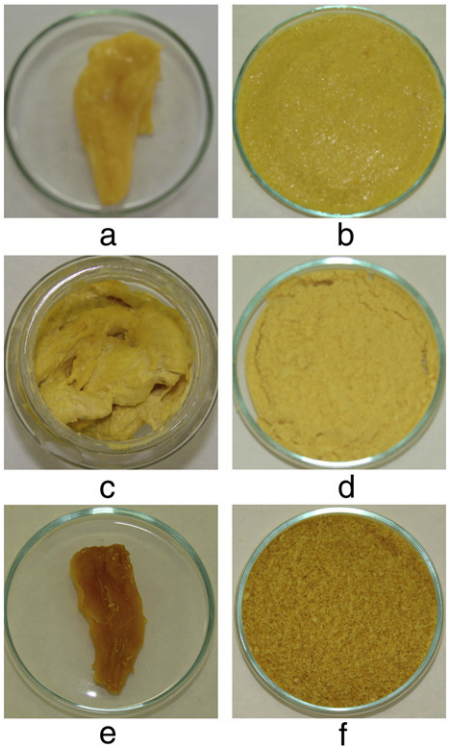

Fig. 2. Carpel (a) and pulp (b) from fresh *marolo* and dehydrated *marolo* products. FCM, freeze-dried carpels of *marolo* (c); FFM, freeze-dried flour from *marolo* (d); ACM, convective hot-air dried carpels of *marolo* (e); AFM, convective hot-air dried flour from *marolo* (f).

3.2. Triacylglycerol analysis (TAG)

The TAG analysis by MALDI Q-TOF MS was performed with the aim of identifying triacylglycerides present in *marolo* (qualitative analysis) and also to evaluate if TAG profile was changed due to the treatment employed in the fruit. So, this experiment was complementary to the Bligh and Dyer analysis.

The MALDI Q-TOF MS (Fig. 3) shows that the *marolo* oil displays a unique perfil of TAG that function as a characteristic fingerprint for rapid and clear identification. Fig. 3A shows a mass spectrum of fresh *marolo* pulp (used as control), whereas Fig. 3B and C shows mass spectra from freeze-dried and convective hot-air dried *marolo* pulp, respectively.

TAGs were detected mainly as sodium adducts $[TAG + Na]^+$ (Picariello, Paduano, Sacchi, & Addeo, 2009; Saraiva, Catharino, Cabral, & Eberlin, 2009), and Table 4 lists the identification of the main TAG ions. *Marolo* oil showed TAGs derived from oleic (76%) and palmitic (9.5%) acids (Vieira, Costa, da Silva, Ferreira, & Sano, 2006). The major TAG ions for *marolo* oil were of *m/z* 903.7, 905.7, 907.7 and 909.7. The ion of *m/z* 903.7 was assigned to the Na^+ adduct of a $C_{54:5}$ TAG that could correspond to isobaric LLO, OOLn, or SLLn (S = stearic, O = oleic, L = linoleic, and Ln = linolenic acid). The ions of *m/z* 905.8, 907.7 and 909.8 correspond to multiple unsaturated OOL and/or LLS, OOO and/or SOLo, and finally OOS and/or SSL, respectively. Another main region in the spectrum was that from *m/z* 850 to 885. The ions of *m/z* 877.7, 879.7, and 881.7 are assigned to PLL, PLO, and POO (L = linoleic, P = palmitic and O = oleic acid), respectively. In comparison, the ions of *m/z* 851.7 and 853.7 can be assigned to PPLn and PPL and/or POP, respectively (Kaufman & Wiesman, 2007).

In Fig. 3B ions with m/z 897 and 923 showed an intensity increase when compared with pulp fresh. On the other hand, ions with m/z 797

Table 3
Characterization of fresh *marolo*, freeze-dried carpels of *marolo* (FCM), freeze-dried flour from *marolo* (FFM), convective hot-air dried carpels of *marolo* (ACM) and convective hot-air dried flour from *marolo* (AFM)[a].

Parameters	Fresh[b]	FCM	FFM	ACM	AFM
Specific volume	0.89 ± 0.01^{b}	1.14 ± 0.06^{a}	0.72 ± 0.02^{c}	0.72 ± 0.05^{c}	0.73 ± 0.05^{c}
Specific density	1.12 ± 0.01^{b}	0.88 ± 0.04^{c}	1.39 ± 0.04^{a}	1.39 ± 0.10^{a}	1.38 ± 0.09^{a}
WAI[c]	11.51 ± 2.16^{a}	6.56 ± 0.47^{b}	6.41 ± 0.67^{b}	6.75 ± 0.34^{b}	6.54 ± 0.20^{b}
WSI[d]	53.03 ± 4.69^{a}	51.27 ± 0.75^{bac}	51.87 ± 3.21^{ba}	44.81 ± 1.86^{bc}	43.87 ± 0.93^{c}
Chromatic parameters					
L	78.63 ± 0.23^{c}	85.90 ± 0.35^{b}	88.13 ± 0.28^{a}	67.63 ± 0.21^{e}	71.20 ± 0.17^{d}
Chroma	41.58 ± 0.23^{a}	31.63 ± 0.10^{c}	30.32 ± 0.32^{d}	37.43 ± 0.14^{b}	37.91 ± 0.16^{b}
Hue angle (°H)	81.93 ± 0.01^{c}	84.80 ± 0.00^{b}	85.77 ± 0.00^{a}	69.84 ± 0.00^{e}	73.60 ± 0.00^{d}

[a] Values are the mean ± standard errors of five independent determinations. Means followed by different letters in the horizontal were significantly from each other in the Tukey test ($p<0.05$).
[b] Fresh moisture = 77.21 g/100 g.
[c] WAI: water absorption index.
[d] WSI: water solubility index.

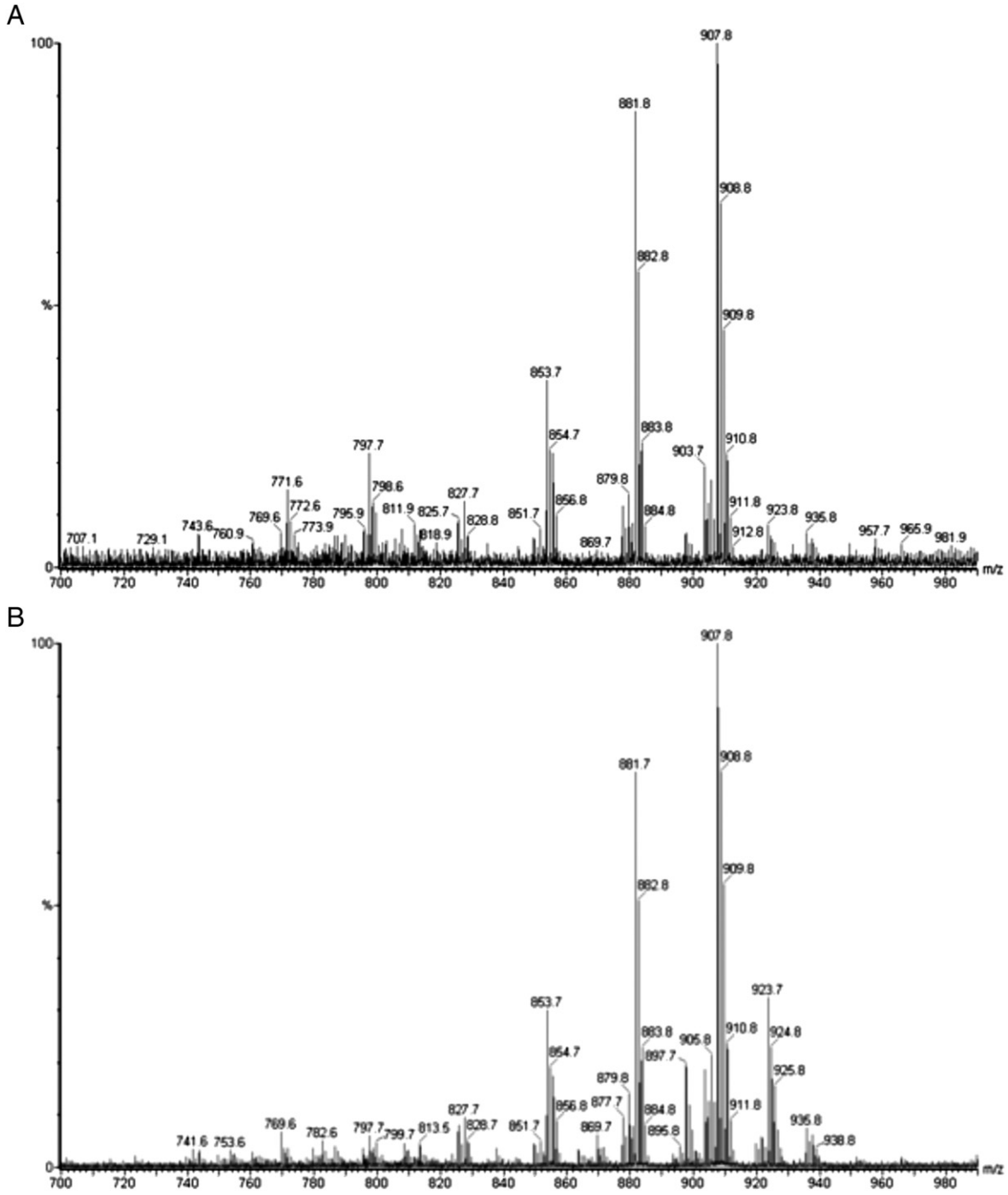

Fig. 3. MALDI Q-TOF MS fingerprints of *marolo* pulp oil samples from (A) fresh, (B) freeze-dried, and (C) convective hot-air dried *marolo* products.

and 881 showed minor intensities when compared the same sample according the MALDI results.

The most important result from Fig. 3 is that the control sample (fresh) shows a TAG profile quite similar to that of the dehydrated samples, which suggests that the drying has no significant effect on TAG composition for *marolo*.

4. Conclusions

The fresh and dehydrated *marolo fruit* evaluated in this study presented proper physicochemical characteristics for using as food ingredient in preparations such as juice, sweets and ice creams, promoting their availability for a larger share of people. Besides being known for the richness in antioxidant compounds, *marolo* provides dietary fiber, which makes this fruit beneficial for health, independently from its form, dehydrated or fresh.

Acknowledgments

The authors thank the Brazilian funding agencies FAPEMIG (CAG — APQ-02130-08), FAPESP, CNPq and FINEP for their financial support and for the scientific initiation scholarship granted to Síntia Carla Corrêa.

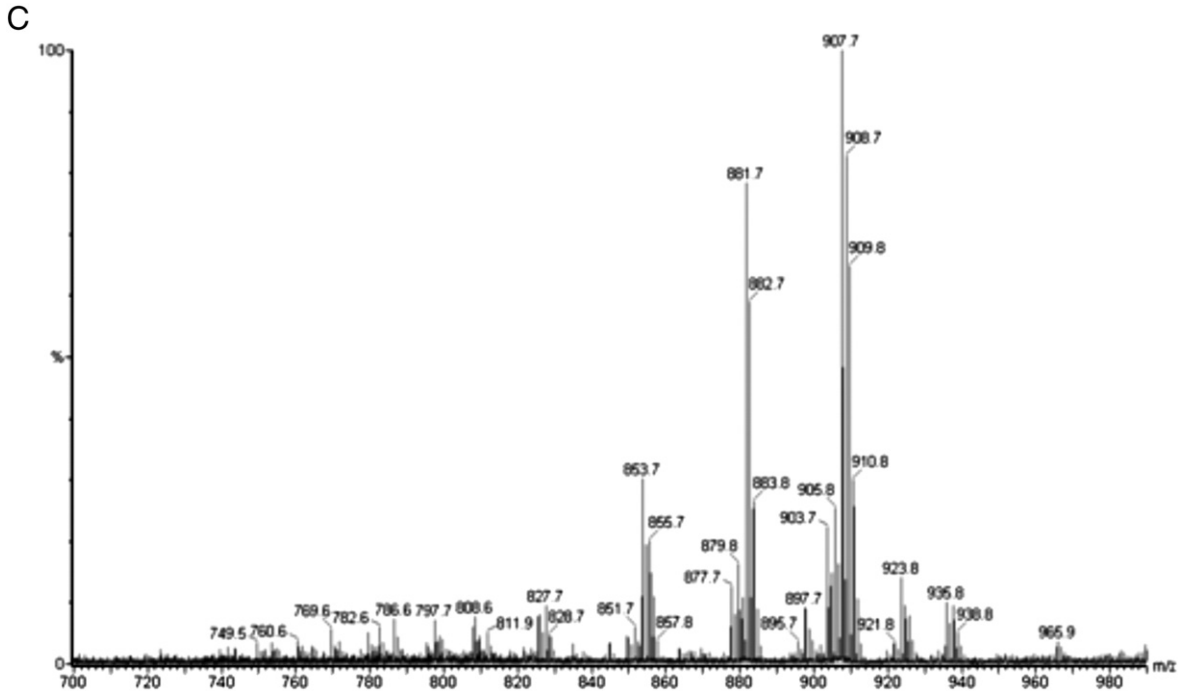

Fig. 3 (*continued*).

Table 4
Assignment of the $[M+Na]^+$ ions of TAG observed in the MALDI Q-TOF MS fingerprints of *marolo*.

$[M+Na]_+$ *m/z*	Elementary composition	TAG[a]	CN/DB[b]
771.6	$C_{47}H_{88}O_6$	MMPo	44:1
773.9	$C_{47}H_{90}O_6$	MMP	44:0
797.7	$C_{49}H_{90}O_6$	MML	46:2
799.7	$C_{49}H_{92}O_6$	MMO	46:1
801.7	$C_{49}H_{94}O_6$	MMS	46:0
825.7	$C_{51}H_{94}O_6$	PPoPo	48:2
827.7	$C_{51}H_{96}O_6$	PPPo	48:1
851.7	$C_{53}H_{96}O_6$	PPLn	50:3
853.7	$C_{53}H_{98}O_6$	PPL, POP	50:2
855.7	$C_{53}H_{100}O_6$	PPO	50:1
857.8	$C_{53}H_{102}O_6$	PPS	50:0
877.7	$C_{55}H_{98}O_6$	PLL	52:4
879.7	$C_{55}H_{100}O_6$	PLO	52:3
881.7	$C_{55}H_{102}O_6$	POO	52:2
883.8	$C_{55}H_{104}O_6$	POS	52:1
903.7	$C_{57}H_{10}0O_6$	LLO, OOLn	54:5
905.8	$C_{57}H_{102}O_6$	OOL, LLS	54:4
907.7	$C_{57}H_{104}O_6$	OOO, SOL0	54:3
909.8	$C_{57}H_{106}O_6$	OOS, SSL	54:2
911.8	$C_{57}H_{108}O_6$	SSO	54:1

[a] Fatty acid abbreviations are as follows: Ca, capric acid; La, lauric acid; M, myristic acid; Po, palmitoleic acid; P, palmitic acid; O, oleic acid; S, stearic acid; L, linoleic acid; Ln, linolenic acid; and A, arachid acid.
[b] Carbon number/number of double bounds of the three fatty acid moieties.

References

Agostini, T. S., Cecchi, H. M., & Godoy, H. T. (1996). Carotenóides no marolo *in natura* e em produtos de preparo caseiro. *Ciência e Tecnologia de Alimentos*, *16*, 67−71.

Ambasankar, K., & Balakrishnan, V. (2010). Effect of varying levels of heat and formaldehyde treatment of sardine fishmeal on nitrogen solubility, in vitro ammonia release and protein fractions. *Indian Journal of Animal Science*, *80*, 1003−1007.

Anderson, R. A., Conway, H. F., Pfeifer, V. F., & Griffin, E. L. (1969). Gelatinization of corn grits by roll and extrusion cooking. *Cereal Science Today*, *14*, 4−12.

AOAC (1997). *Official methods of analysis of the AOAC International* (16th). Gaithersburg: AOAC International.

Bligh, E. G., & Dyer, W. J. (1959). A rapid method of total lipid extraction and purification. *Canadian Journal of Biochemistry*, *37*, 911−917.

Byrnes, B. H. (2000). Liquid fertilizers and nitrogen solutions. *Fertilizer manual* (pp. 20−44). Alabama: Kluwer Academic.

Chang, S. C., Lee, M. S., Lin, C. J., & Chen, M. L. (1998). Dietary fiber content and composition of fruits in Taiwan. *Asia Pacific Journal of Clinical Nutrition*, *7*, 206−210.

Chua, K. J., Mujumdar, A. S., Hawlader, M. N. A., Chou, S. K., & Ho, J. C. (2001). Batch drying of banana pieces — Effect of stepwise change in drying air temperature on drying kinetics and product colour. *Food Research International*, *34*, 721−731.

Damiani, C. (2009). Caracterização e agregação de valor aos frutos do cerrado: Araçá (*Psidium guineensis* Sw) e Marolo (*Annona crassiflora* Mart.). 171 pp. *Ph.D. dissertation*. Food Science Departament. Federal University of Lavras.

Gutkoski, L. C., & Pedó, I. (2000). *Aveia — Composição química, valor nutricional e processamento* (1st ed.). São Paulo: Varela.

Kaufman, M., & Wiesman, Z. (2007). Pomegranate oil analysis with emphasis on MALDI-TOF/MS triacylglycerol fingerprinting. *Journal of Agricultural and Food Chemistry*, *55*, 10405−10413.

Krokida, M. K., & Philippopoulos, C. (2006). Volatility of apples during air and freeze drying. *Journal of Food Engineering*, *73*, 135−141.

Le Page, J. F., Mirade, P. S., & Daudin, J. D. (2010). Development of a device and method for the time-course estimation of low water fluxes and mean surface water activity of food products during ripening and storage. *Food Research International*, *43*, 1180−1186.

Minolta (1994). *Precise color communication: Color control from feeling to instrumentation.*: MINOLTA Co., Ltd 49 pp.

Miranda, M., Maureira, H., Rodriguez, K., & Vega-Gálvez, A. (2009). Influence of temperature on the drying kinetics, physicochemical properties, and antioxidant capacity of aloe vera (aloe barbadensis miller) gel. *Journal of Food Engineering*, *91*, 297−304.

Nawar, W. W. (1993). Lipidos. In O. R. Fennema (Ed.), *Food chemistry* (3rd ed.). New York: M. Dekker.

Nilnakara, S., Chiewchan, N., & Devahastin, S. (2009). Production of antioxidant dietary fibre powder from cabbage outer leaves. *Food and Bioproducts Processing*, *87*, 301−307.

Picariello, G., Paduano, A., Sacchi, R., & Addeo, F. (2009). MALDI-TOF mass spectrometry profiling of polar and nonpolar fractions in heated vegetable oils. *Journal of Agricultural and Food Chemistry*, *57*, 5391−5400.

Proença, C., Oliveira, R. S., & Silva, A. P. (2000). *Flores e frutos do cerrado* (1st ed.). São Paulo: Universidade de Brasília.

Ratti, C. (2001). Hot air and freeze-drying of high-value foods: A review. *Journal of Food Engineering*, *49*, 311−319.

Ribeiro, M. N. O., & Pascal, M. (2005). *Tecnologia da produção do marolo* (1st ed.). Lavras: UFLA/FAEPE.

Saraiva, A., Catharino, R. R., Cabral, E. C., & Eberlin, M. N. (2009). Amazonian vegetable oils and fats: Fast typification and quality control via triacylglycerol (TAG) profiles from dry Matrix-Assisted Laser Desorption/Ionization Time-of-Flight (MALDI-TOF) mass spectrometry fingerprinting. *Journal of Agricultural and Food Chemistry*, *57*, 4030−4034.

Silva, J. S., Finger, F. L., & Corrêa, P. C. (2008). *Secagem e armazenagem de produtos agrícolas — CD ROM* (2nd ed.). Viçosa: UFV.

Troller, J. A. (1980). Influence of water activity on microorganisms in foods. *Food Technology*, *34*, 76−82.

Vieira, R. F., Costa, T. S. A., da Silva, D. B., Ferreira, F. R., & Sano, S. M. (2006). *Frutas nativas da região centro-oste do Brasil* (1st ed.). Brasília: Embrapa Recursos Genéticos e Biotecnologia.