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Quality and consumer acceptance of dehydrated araticum pulp

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Abstract - Araticum (*Annona crassiflora*) is a native plant of the Brazilian Cerrado. Its fruits have high nutritional value and very typical aroma and taste. Notwithstanding, the crop has rapid postharvest loss and production is concentrated over a short period. Drying is a conservation alternative that can allow offseason consumption. This study evaluated the influence of different drying times of araticum pulp on its quality and consumer acceptance. Mature araticum pulps commercialized in Janaúba (MG) were dehydrated in a forced-air circulation dryer at 60 °C for 0 (*in natura*), 4, 6, 8, and 10 hours. After drying, pulps were conditioned in plastic pots and analyzed for physical, chemical, and sensory characteristics. Prolonged drying altered pulp color. The product became less acid at drying times longer than 6 hours. Consumers liked the color and were undecided about the texture and taste, regardless of drying time. However, they preferred the appearance of araticum dehydrated for 6 hours compared to 10 hours. This fruit can be dried at 60 °C for 6 hours to reduce energy costs without affecting the final quality of the product.
Keywords: *Annona crassiflora*. Conservation. Cerrado fruit. Drying.

Qualidade e aceitação do consumidor pela polpa de araticum desidratada

Resumo - O araticum (*Annona crassiflora*) é uma planta nativa do cerrado brasileiro, cujos frutos apresentam aroma e sabor bastante expressivo, além de nutritivos. No entanto, apresentam rápida perda pós-colheita, além de uma produção concentrada. A secagem é uma alternativa de conservação e pode permitir seu consumo nos períodos de entressafra. Objetivou-se com o presente estudo avaliar a influência de diferentes tempos de secagem da polpa de araticum sobre a qualidade e aceitação do consumidor. Polpas de araticuns maduros comercializados em Janaúba (MG) foram desidratadas em secador com circulação de ar forçado sob temperatura de secagem de 60 °C por 0 *(in natura)*, 4, 6, 8 e 10 horas. Após a secagem, foram acondicionadas em potes plásticos e analisadas quanto às características físicas, químicas e sensoriais. A secagem prolongada promoveu mudança na coloração da polpa. O produto tornou-se menos ácido nos tempos superiores a 6 horas. Os consumidores gostaram da cor e se

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mostraram indecisos quanto à textura e sabor, independentemente do tempo de secagem, porém gostaram mais da aparência do araticum desidratado por 6 horas, que em 10 horas. De forma geral, a secagem desta fruta pode ser realizada a 60 ºC por 6 horas, reduzindo os gastos com energia, sem prejudicar a qualidade final do produto.
Palavras-Chave: *Annona crassiflora*. Conservação. Frutos do Cerrado. Secagem.

Introduction

Araticum (*Annona crassiflora* Mart.) is a native plant of the Brazilian Cerrado. Its fruits are exotic, attractive due to typical aroma and taste, and very nutritious. Moreover, they are considered good sources of B vitamins such as B1, B2, and PP (OLIVEIRA *et al*., 2008). Fruits can be consumed *in natura* or processed as sweets, ice creams, juices, and flours. Their commercialization, which is informal, is fundamental for the regional market with a view to plant extractivism (SOARES *et al*., 2009).

Annona crassiflora has rapid postharvest loss and seasonality of production (SOARES *et al*., 2009). In this way, industrialization with a view to increasing shelf life and fruit consumption in the offseason becomes important.

Drying is a conservation method widely used to reduce food losses, since it reduces the amount of water available in the food, creating an environment that is unfavorable for microbiological growth. This method delays chemical and enzymatic reactions, maintaining quality for a long period, thus extending the useful life of the product (OLIVEIRA *et al.*, 2015).

Vegetables can be dried naturally using environmental conditions such as solar radiation, high temperatures, air currents, and low relative humidity. Moreover, they can also be artificially dried, with the raw material being subjected to artificial heat under controlled conditions of temperature, humidity, and air current (GAVA; SILVA; FRIAS, 2008).

According to Celestino (2010), in addition to the physical changes, several chemical changes occur during drying, altering the nutritional value, color, aroma, taste, and texture of fruits. Hence, it is necessary to control the drying process to obtain a quality final product.

Thus, this study evaluated the influence of different araticum pulp drying times on its quality and consumer acceptance.

Materials and Methods

The study was conducted at the Laboratory of Plant Food Technology (LPFT) of the State University of Montes Claros (UNIMONTES), Janaúba Campus, Minas Gerais State. Mature (cracked) araticum fruits marketed in Janaúba City in March 2018 were used.

Treatments consisted of five drying times (0, 4, 6, 8, and 10 hours) in a completely randomized design (CRD), with four replicates each and two fruits per replicate.

Mature fruits were washed in running water and sanitized in a 50 ppm sodium hypochlorite solution for 15 minutes. To obtain the pulp, fruit peel was removed along with fruit wedges, subsequently separating the pulp covering the seeds. Then, part of the pulps was separated to obtain zero-time (*in natura*) values. The other parts were placed in trays and taken to dehydration in a forced-air circulation dryer (brand Pardal, model PE14) at 60 °C for 4, 6, 8, and 10 hours. These temperature and times were defined based on preliminary tests and on literature data (CORRÊA *et al*., 2011). After drying, the products were packed in plastic pots with lids and stored for physical, chemical, and sensory analysis.

Moisture content (loss by desiccation) was determined by the difference between the initial and final mass of araticum, after heating in an air-circulation oven at 105 ºC (Kiln Quimis, Q31714-42) until constant mass (INSTITUTO ADOLFO LUTZ, 2008).

Yield was given by the ratio between fruit mass after drying and *in natura* pulp, determined in an analytical balance (Tecnal, Mark 210A) through the following equation: Yield = [(final product weight x 100) / initial weight]. Results were expressed in percentage values.

Instrumental color was given in terms of L, C, and Hue angle (ºHue), determined by a colorimeter (Konica Minolta CR-400). Luminosity (L) values range from 0 (darker) to 100 (brighter); C indicates chroma or color purity, ranging from 0 to 60, where relatively lower values represent impure colors (lower pigment content); and ºHue, or hue angle, ranges from 0º to 360º. For the latter parameter, 0º corresponds to the red color; 90º - yellow color; 180º or -90º - green color; 270º or -180º - blue color, and 360º - from red to black.

The samples were crushed and homogenized for the evaluation of soluble solids, pH, and titratable acidity. Soluble solids content was evaluated by reading in a digital refractometer (Milwaukee MA871), with results expressed in ºBrix; pH was obtained by potentiometry (pH-meter TEC-3MP); titratable acidity was determined by sodium hydroxide (NaOH) titration with phenolphthalein indicator, with results expressed in g $100g^{-1}$ malic acid (INSTITUTO ADOLFO LUTZ, 2008).

Total carotenoid content was determined by spectrophotometry (Spectrophotometer IL-226-NM), being obtained according to the methodology described by Lichtenthaler (1987), with results expressed in µg mL^{-1} extract.

Only the dehydrated samples were used in the sensory analysis, that is, the zero-time was not considered. Initially, purchase intention was evaluated, in which the participants evaluated dehydrated araticum pulps and answered if they would buy the product. The evaluation, based on appearance, used a five-point scale ranging from 1 ("definitely would not buy") to 5 ("definitely would buy").

In parallel, the products were evaluated for acceptance according to Meilgaard *et al*. (1999), using a hedonic nine-point scale ranging from 1 ("dislike extremely") to 9 ("like extremely").

Eighty people took place in the study, including staff, trainees, and students from UNIMONTES – Janaúba. Participants were araticum connoisseurs and consumers, aged between 18 and 60 years. Samples were presented monadically, following a balanced design according to Dutcovisy (2013). The study was previously submitted and approved by the Ethics and Research Committee of the State University of Montes Claros, under No. 2,666.071.

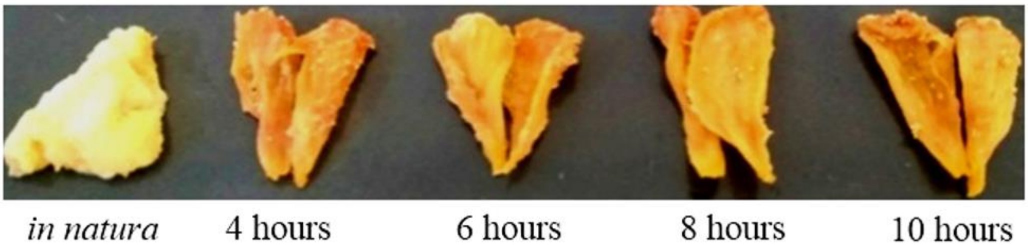
Physical and chemical data were subjected to regression analysis to evaluate the effect of different drying times ($p<0.05$) on product quality.

Since the data obtained did not present homogeneity and normality, nonparametric statistics were used for sensory analysis by applying the Friedman test at 5% significance ($p<0.05$) through the statistical program SISVAR 5.6.

Results and Discussion

Figure 1 shows the pulps after the drying process.

Figure 1- Araticum (*Annona crassiflora*) pulps used in the study.



Source: The authors (2018)

Drying times affected moisture, instrumental color (luminosity, chroma, and ºHue), titratable acidity, and soluble solids content, as shown by the analysis of variance ($p<0.05$) (Table 1).

Araticum dry yield, in turn, was not affected by drying times ($p>0.05$), with an overall mean of 28.94% (Table 1). This result indicates that the moisture reduction of 0.68% at each hour of drying was not sufficient to affect pulp yield in the different times.

Likewise, pH was not influenced by drying times ($p>0.05$), with an overall mean of 4.73 (Table 1). MORAIS *et al*. (2017) found similar results, where pasteurization at 85 ºC did not alter the pH of araticum pulp.

Total carotenoid content in dehydrated araticum did not show significant difference between drying times ($p>0.05$), remaining with an overall mean of 2.38 $\mu g.g^{-1}$ pulp (Table 1). According to Gava; Silva; Frias (2008), oxidation of pigments such as carotenoids is more common in dehydrated vegetables, different from fruits, whose color changes during drying are due to enzymatic reactions and nonenzymatic browning.

According to Rodriguez-Amaya (1998), the highest carotenoid losses occur via oxidative degradation, which depends on factors such as exposure to oxygen and light, time and temperature of heat treatment, among others. Moreover, heating promotes trans-cis isomerization, thereby reducing process stability. Reis (2002) observed a reduction in the total carotenoid content of ‘Tommy Atkins’ mangoes after drying at 60 ºC and 70 ºC. The author attributed this decrease to the degradation caused by high temperatures and the presence of oxygen.

Silva *et al*., (2015) reported reduction of total carotenoid content in heat-treated (blanching and pasteurization) araticum pulp, which was not observed in the present study after drying.

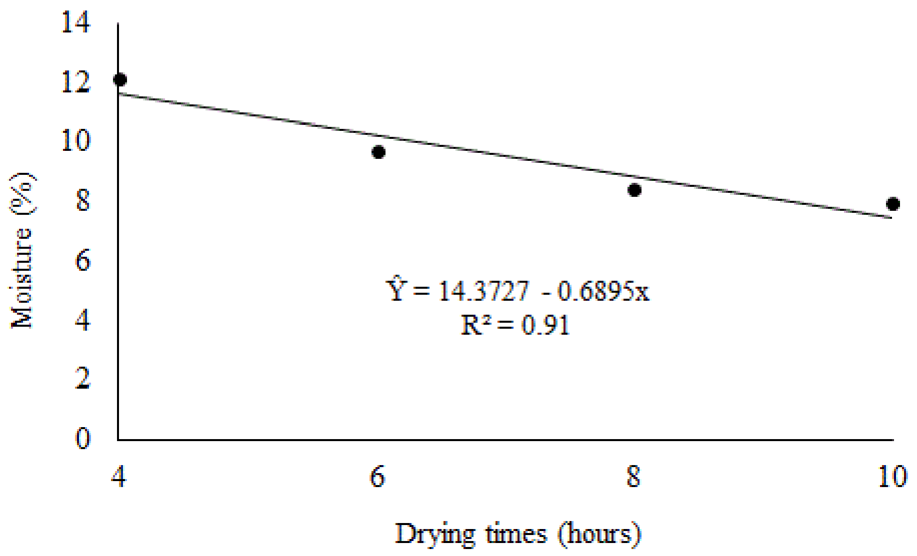
Table 1 - Analysis of variance for moisture (%), yield (%), luminosity (L), chroma (C), hue angle (˚Hue), pH, titratable acidity (TA), soluble solids (SS), and carotenoid content (CC) in araticum (*Annona crassiflora*) dehydrated at different drying times.

		Mean Square								
S. of Variation	DF	Moist.	Yield	L	C	°Hue	pH	TA	SS	CC
Drying Time	4	13.88*	1.27^{ns}	406.99*	18.53*	227.65*	0.06^{ns}	0.31*	446.60*	0.47^{ns}
Residue	15	3.34	1.10	21.43	9.53	13.52	0.08	0.04	10.31	0.74
CV (%)		19.14	3.63	9.38	10.07	5.51	6.16	26.72	9.36	36.08
Overall Mean		9.54	28.94	49.37	30.64	66.75	4.73	0.77	34.29	2.38

Source: The authors (2018)
*significant at 5%; ^{ns} nonsignificant at 5%.

Regarding moisture (Figure 2), the zero drying time was removed from the graph, highlighting only the effect between drying times. There was a significant linear effect ($p<0.05$), in which every hour of drying accounted for a moisture reduction of 0.68%. At the end of the process, the mean of both treatments was below the value of 25% moisture (mean between 7.94% and 12.1%) established by the Brazilian Legislation for dried fruits (BRASIL, 2005). This water content allows the shelf life of the product to be extended, thus avoiding the development of microorganisms favored by higher moisture (CORNEJO *et al*., 2003) as observed for *in natura* (zero drying time) araticum pulp, with 73.78% moisture.

Figure 2 - Moisture in araticum (*Annona crassiflora*) dehydrated at different drying times.



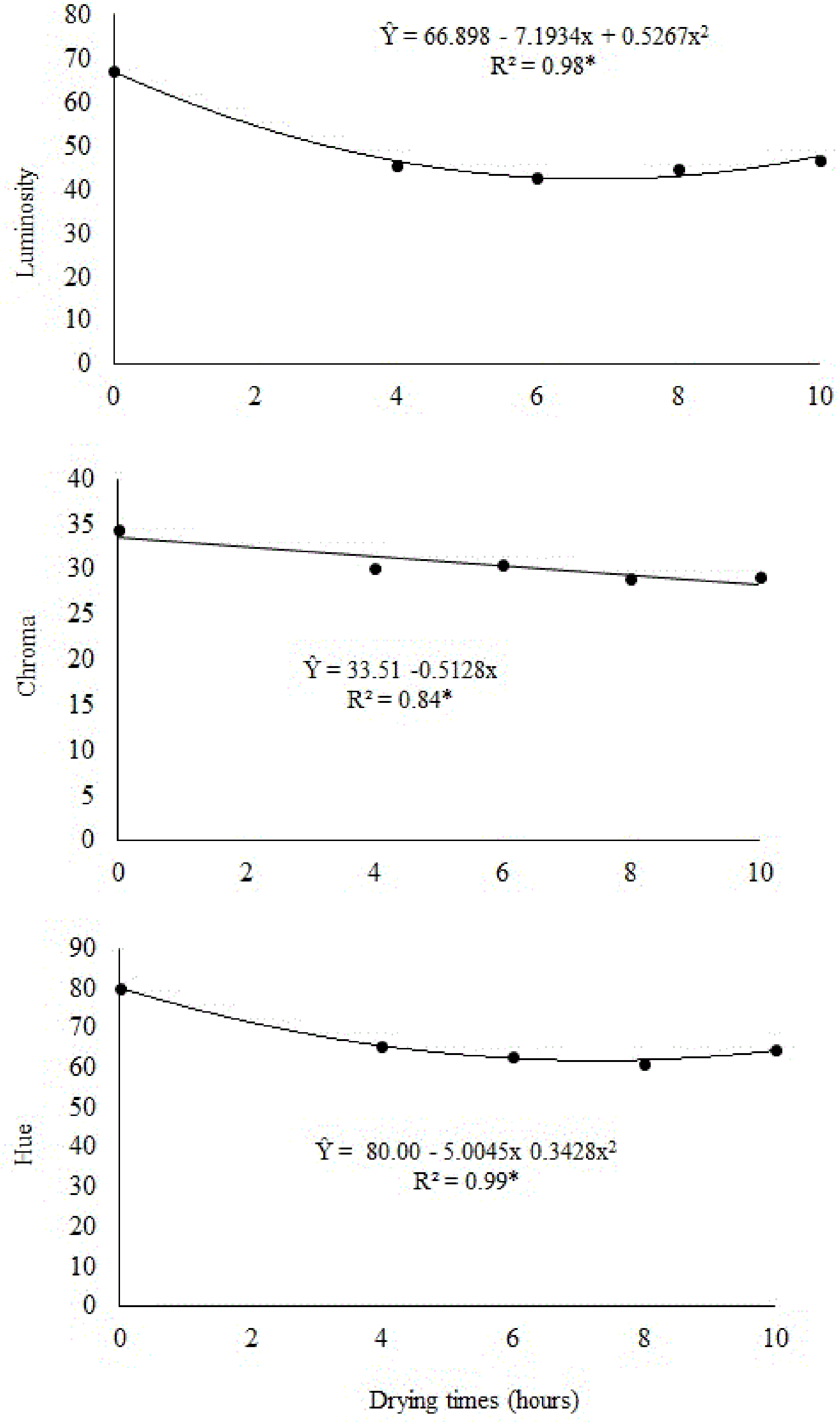
Source: The authors (2018)

Regarding instrumental color (Figure 3), the luminosity of dehydrated araticum (Figure 3A) showed a quadratic effect ($p<0.05$), in which *in natura* pulp presented a higher value, indicating brighter samples. Drying led to a decrease in luminosity for all treatments, in which samples were darker from the 4-hour time. According to Fellows (2006), drying changes the characteristics of the food surface, thus altering the reflectivity and color of the product.

The influence of drying time on chroma (Figure 3B) showed a linear effect ($p<0.05$), with a decrease of 0.5128 at every hour of drying. Chroma indicates color purity, ranging from 0 (grayish) to 60 (pure), thus the samples with higher drying times presented a less pure color, with lower chroma levels.

Hue angle (ºHue) was also affected by drying time ($p<0.05$), behaving quadratically (Figure 3C), with a decrease from 79.97 to 65.00 between 0 and 4 hours of drying. This result can be verified by the color change of the pulp from yellow to orange-yellow when subjected to drying. According to Gava; Silva; Frias (2008), color changes may be related to the drying process itself; to modifications of pigments such as chlorophyll and carotenoids (which was not observed in the present study); to Maillard reactions; and to the action of polyphenoloxidase enzymes. Duarte *et al*. (2017) did not observe significant changes in Hue angle in lyophilized *Annona crassiflora* pulp.

Figure 3 - Instrumental color: luminosity (A), chroma (B), and ºHue (C) in araticum (*Annona crassiflora*) dehydrated at different drying times.

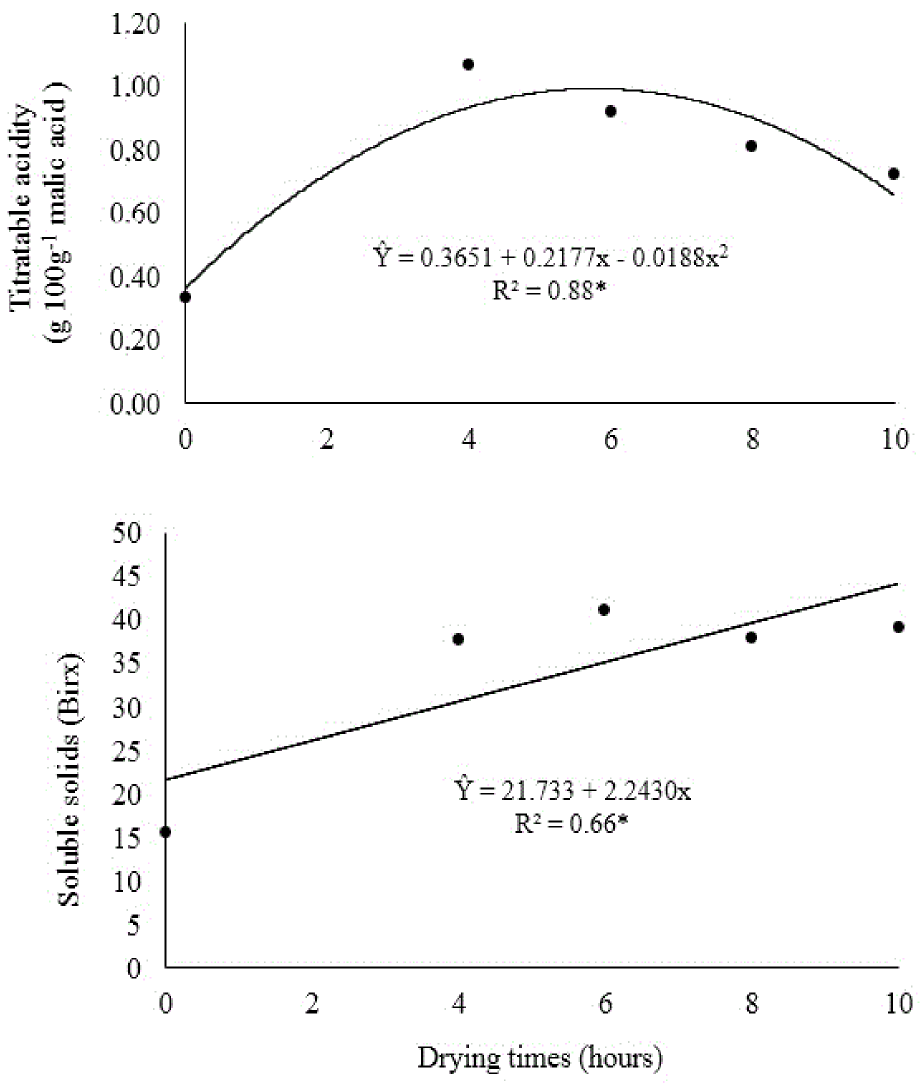


Source: The authors (2018)

Regarding titratable acidity, the quadratic model showed the best fit ($p<0.05$), with higher accumulation until 5.79 hours, decreasing from this time on (Figure 4A). In a study with sweet potato flour, Araújo *et al.* (2015) observed that as drying temperature increased, titratable acidity decreased. According to the authors, organic acids oxidize at higher temperatures. Thus, decreased titratable acidity in the present study may be linked to longer drying exposure time, even at constant temperature. For Reis and Schmiele (2019), among other characteristics, the low acidity of araticum favors the action of microorganisms, limiting *in natura* consumption of the pulp. Thus, drying can be an option for conservation of this product.

Soluble solids showed a linear effect ($p<0.05$), with an increase of 2.24 ºBrix at each hour of drying (Figure 4B). The water content is reduced during drying and there is an increase in sugar concentration when compared to *in natura* foods (CELESTINO, 2010). When analyzing the characteristics of dried 'Italia' grapes, De Souza Costa *et al*. (2015) also observed an increase in soluble solids content with increasing temperature and drying time.

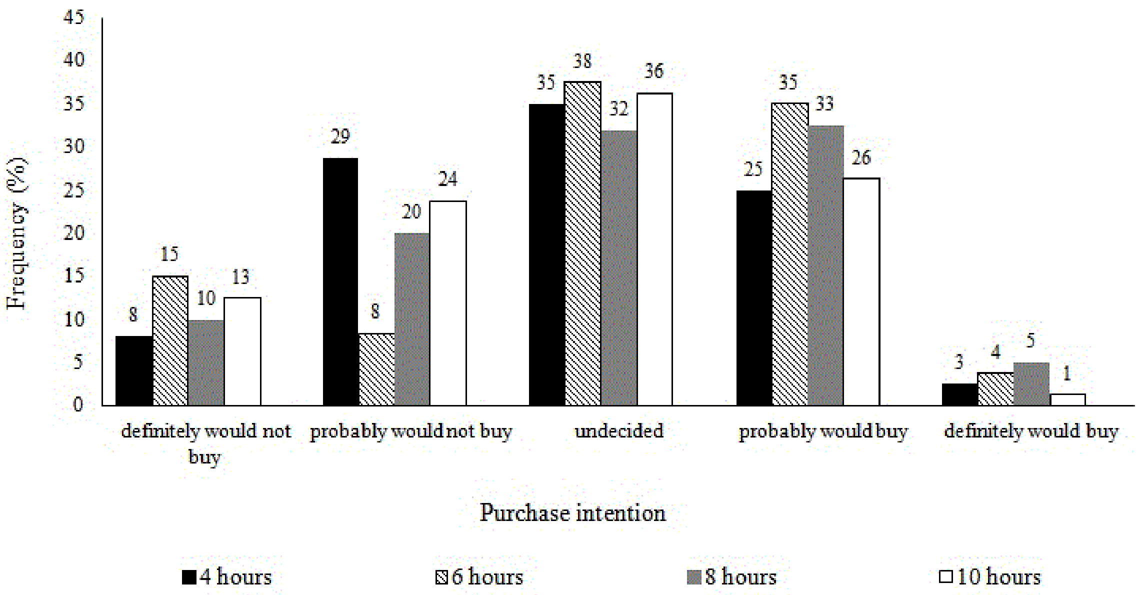
Figure 4 - Titratable acidity (A) and soluble solids content (B) in araticum (*Annona crassiflora*) dehydrated at different drying times.



Source: The authors (2018)

Regarding purchase intention (Figure 5), based on the general appearance of the product, 37% of consumers would not buy products dehydrated for 4 or 10 hours, while 39% and 38% would buy products dehydrated for 6 or 8 hours of drying, respectively. Moreover, 35%, 38%, 33%, and 36% of consumers remained undecided regarding products dehydrated for 4, 6, 8, or 10 hours, respectively.

Figure 5 - Frequency distribution (%) of the purchase intention ratings of 80 consumers: a structured 5-point scale ranging from “definitely would not buy” (1) to “definitely would buy” (5).



Source: The authors (2018)

Table 2 shows the results of the acceptance of appearance, color, texture, and taste.

Table 2 - Means of the scores attributed by the tasters (80) in the acceptance of araticum (*Annona crassiflora*) dehydrated at different drying times (hedonic scale ranging from 1 = “dislike extremely” to 9 = “like extremely").

Drying time	Sensory attribute			
	Appearance	Color	Texture	Taste
4 hours	5.66 ab	6.01 a	5.35 a	5.09 a
6 hours	6.03 a	6.26 a	5.55 a	5.35 a
8 hours	5.55 ab	6.19 a	5.15 a	5.32 a
10 hours	5.40 b	6.00 a	5.20 a	5.05 a

Source: The authors (2018)
Means followed by the same letter in the column do not differ from each other by the Friedman test at 5% significance ($p<0.05$).

For appearance, there was a difference between 6 and 10 hours ($p<0.05$), in which consumers slightly liked the product dried for 6 hours and were undecided about the appearance of araticum pulp dehydrated for 10 hours. The higher acceptance of the product which underwent 6 hours of drying relates to higher purchase intention (and lower rejection), as shown in Figure 5. This result agrees with Alves *et al.* (2010), who cited that consumers use appearance as an important criterion in food purchase decision.

Drying times did not affect the acceptance of color, texture, and taste ($p>0.05$). Consumers showed a slight appreciation of the color and were indifferent about the texture and taste of dehydrated products (Table 2). This result indicates that consumers were not bothered by the change in color and texture provided by drying, regardless of drying exposure time. This was confirmed by the comments of consumers, who described the color of dehydrated araticum as "attractive" and "pleasant", and the texture as "good", "not very hard", "hard", and "very hard".

Despite the increase in soluble solids content after drying (Figure 3B), consumers were undecided as to whether they liked the product's taste or not. When invited to comment, consumers reported the taste as "mildly sweet", "intense", and "characteristic of the fruit". Moreover, the taste resembled that of other Cerrado fruits such as pequi (*Caryocar brasiliense* camb) and sour coconut (*Butia capitata*), which may have contributed to such indecision. Arruda *et al*. (2016) developed milk caramel containing araticum pulp and observed well-accepted sensory characteristics. Likewise, Silva *et al*. (2018) studied food bars prepared with 20, 30, 40, and 50% *Annona crassiflora* pulp flour replacing oat meal. The authors mentioned that all formulations were accepted by consumers, especially with addition of 50% araticum pulp flour. These results suggest better acceptance of araticum when used as an ingredient in the fabrication of products.

For Komeroski (2016), the choice of a food by the consumer was related to sensory attributes. In this sense, taste is the main characteristic (the product will only be consumed if it is tasty), followed by pleasant aroma and appearance.

Conclusions

Prolonged drying at 60 ºC changes araticum pulp color, but does not change total carotenoid content. Consumers prefer the appearance of the product dehydrated for 6 hours compared to 10 hours. In addition, they slightly like the color and are indifferent about the texture and taste of araticum dehydrated at different drying times.

The results of the present study allow to infer that the drying of this fruit can be carried out at 60 ºC for 6 hours to reduce energy costs without impairing the final quality of the product.

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