Original

Chemical and physicochemical characteristics changes during passion fruit juice processing

Alterações das características químicas e físico-químicas durante as etapas de processamento do suco de maracujá

Aline Gurgel FERNANDES[1], Gerusa Matias dos SANTOS[1], Daniele Sales da SILVA[1], Paulo Henrique Machado de SOUSA[1]*, Geraldo Arraes MAIA[1], Raimundo Wilane de FIGUEIREDO[1]

Abstract

Passion fruit is widely consumed due to its pleasant flavour and aroma acidity, and it is considered very important a source of minerals and vitamins. It is used in many products such as ice-cream, mousses and, especially, juices. However, the processing of passion fruit juice may modify the composition and biodisponibility of the bioactive compounds. Investigations of the effects of processing on nutritional components in tropical juices are scarce. Frequently, only losses of vitamin C are evaluated. The objective of this paper is to investigate how some operations of passion fruit juice processing (formulation/homogeneization/thermal treatment) affect this product's chemical and physicochemical characteristics. The results showed that the chemical and physicochemical characteristics are little affected by the processing although a reduction in vitamin C contents and anthocyanin, large quantities of carotenoids was verified even after the pasteurization stage.
Keywords: *passion fruit juice; hot fill process; thermal treatment; vitamin C; carotenoids; industrial processing.*

Resumo

O maracujá tem sido bastante consumido devido ao seu aroma e acidez acentuados, tendo grande importância também por seus frutos ricos em sais minerais e vitaminas, sobretudo, A e C. É utilizado em uma série de produtos como sorvetes, mousses e principalmente como suco. Porém, o processamento afeta o conteúdo, a atividade e a biodisponibilidade dos componentes bioativos. Investigações dos efeitos do processamento nos constituintes nutricionais nos sucos são escassos. Frequentemente, somente as perdas de vitamina C são avaliadas. Este trabalho objetivou investigar como as etapas do processamento (formulação/homogeneização e tratamento térmico) de suco de maracujá afetam as propriedades químicas e físico-químicas deste produto. Os resultados deste estudo indicam que as características químicas e físico-químicas são pouco afetadas pelo processamento, apesar de ter sido verificada diminuição dos teores de vitamina C, antocianinas e carotenoides, estando este último, mesmo após a etapa de pasteurização, em elevadas quantidades.
Palavras-chave: *suco tropical de maracujá; processo hot fill; tratamento térmico; vitamina C; carotenoides; processamento industrial.*

1 Introduction

In addition to their delicious taste and refreshing flavor and aroma, fruits add important vitamins, minerals, and other bioactive compounds to the human diet. The combination of vitamins, minerals, phenolic antioxidants, and fiber seem to be responsible for these effects. Parallel with this recognition, the consumption of tropical or "exotic" fruits has increased all over the world (VASCO; RUALES; KAMAL-ELDIN, 2008; RUXTON; GARDNER; WALKER, 2006).

Passion fruit is widely cultivated and processed all over the world, and Brazil is the world's largest producer and consumer of this fruit, with production of 492,000 tons in 2004 (IBGE, 2006).

The principal variety explored commercially in Brazil is yellow passion fruit (*Passiflora edulis* Sims f. *flavicarpa* Degener) (LABOISSIÈRE et al., 2007), which is destined for in natura consumption and processing industries, and the juice is its major product Passion fruit juice is the third most produced juice in the Brazilian market (AGUIAR; SANTOS, 2001). This fruit has been widely consumed because of its high aroma and acidity, especially as juice, and has also been used in a wide variety of products such as ice-creams, mousses, alcoholic beverages and others (SANDI et al., 2003).

In Brazil, passion fruit growing has a huge importance due to the quality of its fruits, which are rich in minerals and vitamins and considered an excellent source of carotenoids (MAIA et al., 2009; AZEVEDO-MELEIRO; RODRIGUES-AMAYA, 2004). The fruit also presents high content of lycopene which, despite being a carotenoid without the activity of pro-vitamin A, presents greater capacity to neutralize the singlet oxygen, responsible for oxidative damages in cells, than beta-carotene (BLUM, 1996).

The passion fruit juice is defined by Brazilian legislation, trough Normative Instruction nº 01/00 (BRASIL, 2000, p. 57), as

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[1] *Departamento de Tecnologia de Alimentos, Universidade Federal do Ceará - UFC, Av. Mister Hull, 2977, Bloco 858, CEP 60356-000, Fortaleza, CE, Brasil, e-mail: phenriquemachado@gmail.com*
**Corresponding author*

"[...] a non-fermented and not diluted beverage obtained from the edible part of passion fruit (*Passiflora,* spp.) trough adequate technologic process". It must present the fruit's characteristic odour and flavor. The color varies from yellow to orange. The Brazilian legislation establishes the following limits: soluble solids (°Brix at 20 °C), minimum of 11.0 °Brix; total acidity in citric acid, minimum of 2.5 g.100 g^{-1}, and total sugar, natural of passion fruit, maximum of 18.0 g.100 g^{-1}.

During the production of passion fruit juice, the pulp is subjected to pasteurization, thermal treatment, to ensure stability during storage (PINO, 1997), and thus it is relevant to evaluate possible modification of its effect since passion fruit is extremely sensitive to heat treatment.

According to Jales (2005), in the past few years, a strong and broadly tendency toward the consumption of juices in natura has been observed. Therefore, the improvement of pasteurization techniques made the pasteurized juice recognized and appreciated by the consumer. The processing allows the juice an extended shelf-life, but the pasteurization stage is considered an operation that causes significant changes in the juice. Therefore, the present study aimed to investigate how the stages of passion fruit juice processing (formulation/ homogenization/ thermal treatment) affect this product's chemical and physicochemical characteristics.

2 Materials and methods

2.1 Raw material

Fresh and ripe passion fruits (*Passiflora edulis* var. *flavicarpa*), acquired from producers from Metropolitan Region of Fortaleza (Brazil) were transported to a local processing unit.

2.2 Processing

The passion fruit juice was produced as presented presented in Figure 1 that depicts a flowchart (MAIA; SOUSA, 2007). The fruits were weighed and washed by immersion in chlorinated water (25 mg.L^{-1}) and selected in relation to sanity, physical integrity, uniformity of color and ripeness. The selected fruits were then submitted to cutting to separate the pulp from the peel. The juice passed through a finisher to remove excess pulp and seeds. Afterwards, the juice was formulated (passion fruit pulp, preservatives: sodium benzoate and sodium metabisulfite, and acidulant: citric acid) following by homogenization in a homogenizer with valves under pressure (100 atm). The next step was the deaeration process using a vacuum deaerator (600 mmHg) at temperature of 50 °C. Following the sequence, a thermal treatment at 90 °C for 60 seconds in a tubular heat exchanger was applied. The juice was then hot filled (85 °C) in glass bottles 500 mL and immediate closing using plastic caps. After sealing, the bottles were cooled on a continuous refrigeration conveyor and stored.

Samples of the products were collected after the formulation/homogenization and pasteurization stages as indicated in Figure 1. The determinations were made in duplicate for each replicate of the experiment as follows.

The pH was measured using a pHmeter (pHmeter, Hanna Instruments, model HI 9321, USA), periodically calibrated with buffered solutions (pH 4.0 and 7.0). (AOAC, 1995). Titratable acidity (percentage of citric acid) was determined with the dilution of 1 g of homogenized sample in 50 mL of distilled water and posterior titration with a solution of NaOH 0.1M and phenolphthalein indicator (IAL, 2004); soluble solids using a digital refractometer Atago (Atago refratometer model N-50E, USA), at standard temperature (20 °C), and the results were expressed in °Brix.; ascorbic acid level (mg.100 g^{-1} of pulp) was determined according to Cox and Pearson method (1976), which is based on the reduction of 2,6-dichlorophenol-indophenol (DCPIP) by ascorbic acid; the reducing sugars were determined by the method of Eynon & Lane according to AOAC (1995), and the results were expressed in g.100 mL^{-1} of glucose. To determine the non-reducing sugars, an acid inversion was carried out in the sample extracts according to AOAC (1995), and total sugars were calculated by the sum of

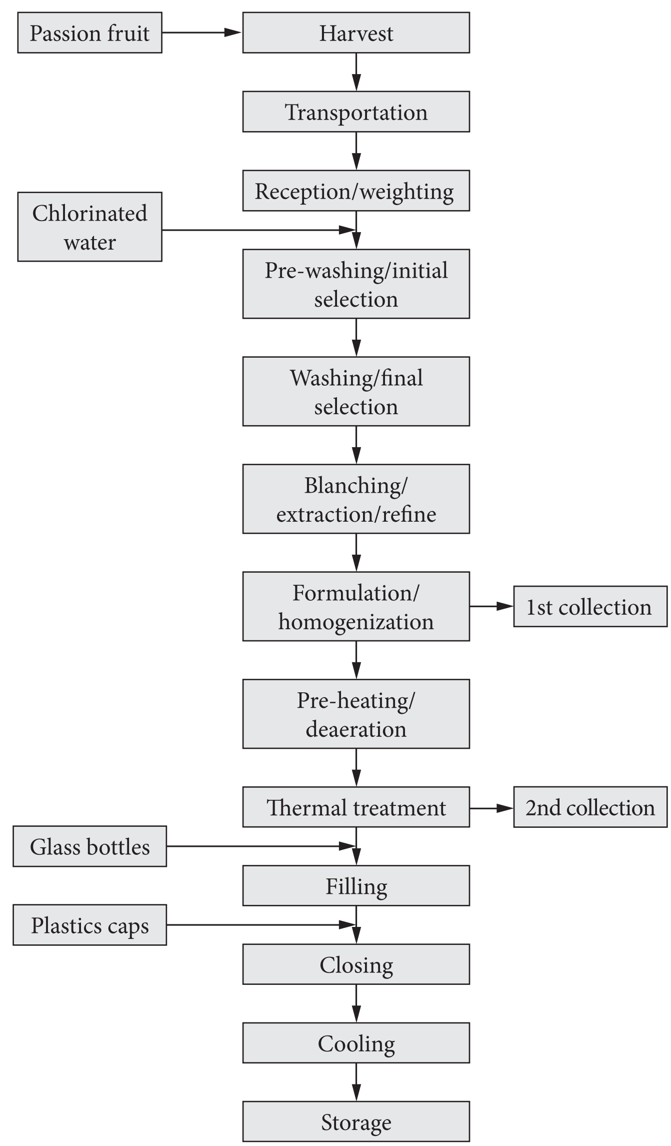

Figure 1. Fow sheet for the production of passion fruit juice bottled by hot fill process.

reducing and non-reducing sugars with the proper corrections for expression of the results in terms of g.100 mL^{-1} of glucose. For color determination, 10 mL of the sample were mixed with 10 mL of distilled water and 30 mL of ethanol. The mixture was then mixed on a magnetic stirring plate (Fanem Model 258, SP-Brazil) at 200 rpm at room temperature for 3 minutes and then filtered in a Whatman no 1 paper. A blank with distilled water instead of the sample was also prepared. Color intensity was quantified by measuring the filtrate absorbance at 420 nm against the blank in a Micronal spectrophotometer (Micronal B582 UV-VIS, São Paulo, Brazil) (RATTANATHANALERK; CHIEWCHAN; SRICHUMPOUNG, 2005); anthocyanins level (mg.100 mL^{-1}) was measured according to Francis (1982), the by immersing the samples in ethanol extract solution 95% HCL (1,5N) – 85%:15v/v for 12 hours at 4 °C. The samples were then filtered, properly diluted in a volumetric flask and absorbance was measured at 535 nm using a spectrophotometer Micronal (Micronal B582 UV-VIS, São Paulo, Brazil); total carotenoids were determined according to Higby (1962) by the extracting these pigments with isopropilic alcohol and hexane, and the samples readings were made at 450 nm in spectrophotometer Micronal (Micronal B582 UV-VIS, São Paulo, Brazil); the results were expressed in mg.100 mL^{-1}.

2.3 Statistical analyses

The variance analysis (α = 5%) was performed to test the difference in the results using a completely randomized design (CRD) with three repetitions of the experiments. In order to compare the averages, the Tukey test (α = 5%) was applied using the statistical software SAS (Statistical Analyses System), version 9.1 (SAS, 2006).

3 Results and discussion

In Table 1, it can be observed the results of chemical and physicochemical parameters of pH, soluble solids (°Brix), acidity, total sugars, and reducing sugars in the samples obtained during the processing of passion fruit juice.

According to the results, it is verified that the total titratable acidity and reducing sugars presented significant statistical difference at the level of 5% of probability by the Tukey test.

The results found in the determination of soluble solids and total and reducing sugars show a predominance of the latter in all stages, as found by Nagato et al. (2003) when analyzing ten samples of commercial passion fruit juice.

These data are also in accordance to those found by Pinheiro et al. (2006), who evaluated five samples of commercial whole passion fruit juice obtaining the following findings: pH (2.72-3.17), total soluble (12.5-13.3 °Brix), and acidity in g of citric acid over 100g of juice (2.96-4.02).

Table 2 presents the values of color, vitamin C levels, anthocyanins, and carotenoids of the samples obtained during the stages of passion fruit juice processing.

It was observed a decrease in all the attributes evaluated after pasteurization. However, only the color attribute showed significant statistical difference at the level of 5% of probability by the Tukey test.

The color parameters showed a decrease during the processing phases. This increase in absorbance could be explained by nonenzymatic browning reactions such as the assumption that high temperature accelerated the carotenoid isomerization, which led to the loss of yellowness (CHEN; PENG; CHEN, 1995).

The reduction in the vitamin C level may have occurred because of chemical oxidation and/or thermal degradation as a consequence of the thermal treatment stages (POLYDERA; STOFOROS; TAOUKIS, 2005; BURDULU; KOCA; KARADENIZ, 2006; JOHNSTON; HALE, 2005). An additional cause of the ascorbic acid depletion may be explained since it is consumed as a reagent in the Maillard reaction (DJILLAS; MILIC, 1994).

Despite the losses during processing, after pasteurization the product showed a level of vitamin C of 6.66 mg.100 mL^{-1} (Table 2), which corresponds to 0.74 mg.100 mL^{-1} juice after going through a dilution of 1 part of juice to 8 parts of water as suggested in commercial brand labels Therefore, the consumption of a 200 mL portion of processed juice would supply only 3.29% of recommended daily intake (RDI) of vitamin C for adults, which is 45 mg (BRASIL, 2005).

Table 1. Changes in chemical and physicochemical characteristics of ph, total soluble solids, titratable acidity, total sugars, and reducing sugars during the stages of passion fruit juice production.

Stages	pH	Soluble solids (°Brix)	Titratable acidity (g of citric acid.100 mL^{-1})	Total sugars (%)	Reducing sugars (% de glucose)
Formulation/homogenization	2.87^{a}	11.17^{a}	2.83^{a}	9.50^{a}	7.57^{a}
Pausterization	2.85^{a}	12.23^{a}	3.06^{b}	9.63^{a}	8.33^{b}

Samples followed by different letters in the same column indicate significant difference by Tukey test at 5% probability level.

Table 2. Changes in color, vitamin c, anthocyanins, and carotenoids during the stages of whole passion fruit juice production.

Stages	Color (absorbance at 410 nm)	Vitamin C (mg.100 mL^{-1})	Anthocyanin (mg.100 mL^{-1})	Carotenoids (mg.100 mL^{-1})
Formulation/homogenization	0.160^{a}	7.85^{a}	0.29^{a}	1.43^{a}
Pausterization	0.130^{b}	6.66^{a}	0.26^{a}	1.26^{a}

Samples followed by different letters in the same column indicate significant difference by Tukey test at 5% probability level.

The vitamin C level (Table 2) is in accordance with that found by Pinheiro et al. (2006), which varied from 5.1 to 19.2 mg.100 mL^{-1}.

The variation in the anthocyanin level is owed to immense instability of this component, which also caused a reduction in the color intensity due to the loss of these pigments (Table 2). Natural pigments are affected during the stages of food processing by light action, temperature, oxygen, metallic ions, and enzymes (STINTZING et al., 2002; WROLSTAD, 2000).

In spite of the non-difference in the average tests for the carotenoids levels, there was a little decrease between the two stages of processing. However, the carotenoid values were were still found in high concentrations, which are therefore considered as excellent sources of carotenoids.

Sian and Ishak (1991) obtained a higher retention of carotenoids in commercially pineapple juice after blanching and drying processes.

These data are also in accordance with those found by Maia et al. (2007), who reported small changes in vitamin C, carotenoids, and anthocyanin contents during the processing of acerola juice.

4 Conclusions

The physicochemical characteristics of pH, soluble solids, and sugars remained practically constant after pasteurization.

The results of this study indicate that the levels of vitamin C, anthocyanins, and carotenoids were little affected by the pasteurization stage of the passion fruit juice processing.

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