DEVELOPMENT AND ANTIOXIDANT CAPACITY OF SAPOTA PULP JELLY (*Quararibea cordata* VISCHER)

Desenvolvimento e capacidade antioxidante de geleia da polpa de sapota (*Quararibea cordata* Vischer)

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ABSTRACT

Sapote (*Quararibea cordata* Vischer), also known as a *chupa-chupa*, is originated from the Brazilian, Peruvian and Colombian Amazon. The pulp of the ripe fruit is edible, fibrous, of intense orange color, sweet flavor and aromatic. Since the fruit is known in the Amazon only in its domesticated state, this work becomes necessary. With the aim of meeting the demand for new products in domestic and international markets, sapota pulp jelly has been developed. The jelly was assessed for moisture, ash, lipids, proteins, carbohydrates, dietary fiber, pectin, pH, total acidity, solids soluble, sugars, organic acids, carotenoids, phenolic compounds and antioxidant capacity. The final product met the standards required by Brazilian law, and 32.68% moisture and 61.06% °Brix. Also, in accordance with the laws attributed to this product, jelly sapota pulp can be considered a food rich in fiber, as presented content above 5%. The jelly, showed content of total phenolics compounds (102 mg GAE. 100 $^{-}$1) in relation to fresh fruit (21 mg GAE.100 g^{-1}). There was the identification in the antioxidant capacity (9.05% scavering of DPPH radical), giving the final product antioxidant properties. Also were analyzed the microbiological characteristics of the product which was not observed the presence of thermotolerants coliforms, yeast and molds. The sapota can be considered effective raw materials in the preparation of jam and this had an antioxidant activity and source of fiber.

Index terms: Fiber, amazonic fruits, DPPH radical.

RESUMO

A sapota (*Quararibea cordata* Vischer), também conhecida como chupa-chupa, é originária da Amazônia Brasileira, Peruana e Colombiana A polpa do fruto maduro é comestível, fibrosa, de cor alaranjada intensa, sabor doce e aromática. Por ser conhecida na Amazônia somente no seu estado domesticado, torna-se necessário este trabalho Assim, visando a atender a demanda por novos produtos no mercado nacional e internacional, foi desenvolvida a geleia da polpa de sapota. A geleia foi avaliada quanto aos teores de umidade, cinzas, lipídeos, proteínas, carboidratos, fibras alimentares, pectina, pH, acidez total, açúcares, ácidos orgânicos, carotenóides, além de compostos fenólicos e capacidade antioxidante. O produto final atendeu às normas exigidas pela legislação brasileira, sendo 32.68% de umidade e 61.06 °Brix. Também, em conformidade com a normas legais atribuídas a esse produto, a geleia da polpa de sapota pode ser considerada um alimento rico em fibras, já que apresentou teor acima de 5%. A geleia apresentou maiores teores de compostos fenólicos totais (102 mg GAE.100^{-1}), em relação à fruta *in natura* (21 mg GAE.100 g^{-1}). Houve a identificação na capacidade antioxidante na geleia de 9.05% de descoloração do radical DPPH, conferindo ao produto final propriedades antioxidantes. Foram analisadas ainda as características microbiológicas do produto onde não foi observada a presença de coliformes termotolerantes, bolores e leveduras. A sapota pode ser considerada matéria-prima efetiva no preparo de geleia e esta apresentou atividade antioxidante e fonte de fibras.

Termos para indexação: Fibra, frutos amazônicos, radical DPPH.

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INTRODUCTION

The Amazon region has the largest Brazilian biodiversity, with promising species such as sapota (*Quararibea cordata Vischer*). Sapota is a typical Amazonian plant and a native genetic resource of the region, fully domesticated by indigenous people. The fruit has intense orange color, which makes it very attractive. Sapota fruits are preferably consumed fresh, although some studies have reported its use in the preparation of juices, soft drinks, sweets, jam, or as flavoring for drinks (ALEGRÍA et al., 2005). The fruit is also used in the preparation of fruit preserves with the inside of the shell. It has very sweet taste and, when consumed for the first time, it resembles the taste of fruits like mango, papaya, coconut and avocado (BRAGA et al., 2003).

Fruits, in general, are receiving great attention because many are natural sources of antioxidants, which

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are rich in free radical scavenging activity. However, there are few data available on changes on the antioxidant capacity and phenolic compounds after the processing of fresh fruit into the final product, such as jelly (KIM; PADILLA-ZAKOUR, 2004). Generally, food processing increase oxidative stress by increasing prooxidative factors as thermal treatments (ELIAS et al., 2008).

The process of making jelly is a method of preserving ripe fruit, adding value to the final product (GAVA et al., 2008). Sapota (*Quararibea cordata Vischer*) is among these fruits, which is a fruit not widely known nationally, and developing a new product such as jelly, maintaining the main characteristics of the fruit (color, flavor and aroma) would add value to the fruit and create an alternative income for the population of the Amazon region, disseminating this exotic fruit national and internationally.

The objective of this study was to develop sapota pulp jelly and assess its *chemical* characteristics, including antioxidant properties, dietary fibers contents and microbiological.

MATERIAL AND METHODS

Source of fruits

Sapota fruits, *Quararibea cordata Vischer,* were collected in central Brazil (Goiânia, GO). The ripe fruits were selected, washed with water and cut with stainless steel material. The fruits were cut into five equal parts and pulped with the use of stainless steel spoons. Then, the seedless pulp was stored in freezer at -18° C until processing.

Jelly processing

About 400 g of sapota pulp were used for the jelly processing. The pulp was homogenized in a blender with fruit pulp / water proportion of 40:60 (w / v). The amount of added sucrose is dependent on the fruit soluble solids. Since the fruit had 11 ° Brix, a proportion of 56% sucrose was added (Centro Tecnológico de Minas Gerais – CETEC, 1985). The sucrose was divided into three equal parts: the first part was added to the crushed pulp. Then, water was added until soluble solids content between 18 and 20 °Brix was reached. Subsequently, the mixture was heated, and after the first boiling, the second part of the sucrose containing pectin previously mixed (1.5%) was added. After the second boiling, the third part of the sucrose was added. Upon reaching 60 °Brix, citric acid was added in order to prevent sucrose crystallization in the finished product and establish the gel (GAVA et al., 2008). The gel also acted as preservative and gave the necessary acidity to the taste. Heating the mixture was stopped when it reached 65 °Brix. The jelly was hot bottled in glass bottles properly sterilized and cold, leaving a space for the formation of vacuum after closing. After cooling, the flasks were sealed and stored at room temperature for subsequent chemical and microbiological analyses.

Chemical composition

The chemical composition analysis in jelly was conducted at the Laboratory of Food Chemistry and Biochemistry of the Faculty of Pharmacy - Federal University of Goiás.

Proximate composition: the ash content was determined by calcination in a muffle furnace at 550° C, model EDGCON 3P 3000 (EDG Equipments, São Carlos, SP, Brazil) to constant weight. Moisture content was determined by drying in stove at 105° C for 4 hours to constant weight (Association of Official Analytical Chemist – AOAC, 2006). Total nitrogen was determined by micro-Kjeldahl method and the nitrogen percentage was converted into crude protein by multiplying by the conversion factor of 6.25 (AOAC, 2006). Total lipids were determined by the Bligh and Dyer (1959) method. The total carbohydrates content was determined according to Dubois et al. (1956) and the total caloric value was estimated using the Atwater conversion values described by Wilson et al. (1982) and the results expressed in kcal.

Sugars: reducing sugars were determined using the 3,5-dinitrosalicylic acid method (MILLER, 1959). To determine the sucrose content, the 3,5-dinitrosalicylic acid method was used, with modifications proposed by (SILVA et al., 2003).

Soluble solids, pH and total acidy: the soluble solids were determined through benchtop refractometer SHIMADZU and expressed in °Brix. The pH was measured using a digital potentiometer Micronal B222, introducing the electrode directly into the jelly and total acidity was determined by titration with 0.1 N NaOH (AOAC, 2006).

Carotenoids: the amount of carotenoids in the jelly was determined by extraction by grinding with petroleum ether and acetone (1:3). The quantification was obtained by spectrophotometry with absorbance readings in the range of 450 nm and the result was expressed in μg g^{-1} sample (HIGBY, 1962).

Organic acids: the extraction of organic acids (fumaric and ascorbic) was performed according to Bazimarakenga et al. (1995), modified by Silva et al. (2001a) and the identification and quantification by HPLC (high

performance liquid chromatography). The results were expressed as μg g^{-1}.

Fibers: the soluble and insoluble dietary fibers contents were determined using the gravimetric enzymatic method (AOAC, 2006).

Pectins: total and soluble pectins were determined using the colorimetric method, based on product formation through condensation of hydrolyzed pectin (galacturonic acid) with carbazole (BITTER; MUIR, 1962).

Antioxidant actividad: the antioxidant potential was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl) method according to Brand-Williams et al. (1995) with modifications (BORGUINI; TORRES, 2009). The discoloration degree of the DPPH radical at 517nm, through the action of antioxidants, was spectrophotometrically measured in ethereal, alcoholic and aqueous extracts, with concentration of 0.2 mg ml^{-1}, and the results expressed in % of DPPH discoloration.

Phenolics: the determination of phenolics compounds were performed in aqueous and alcoholic extracts with extraction methodology according to Genovese et al. (2003). The total phenolics compounds were determined according to Zielisk and Kosowska (2000), using the Folin-Ciocalteu reagent and the results are expressed as mgGAE.100 g^{-1}.

All tests were performed in triplicate and the results were expressed as the mean values and standard deviation of the independent variables. All statistical analyses were performed with the STATISTICA software (data analysis software system, Version 7.1, Stat Soft, Tulsa).

Microbiological analyses

Microbiological analyses in jelly were performed according to methodologies proposed by International Commission on Microbiological Specifications for Foods – ICMSF (1983) and Silva et al. (2001b), at the Laboratory of Food Chemistry and Biochemistry of the Faculty of Pharmacy - Federal University of Goiás (Goiânia, GO, Brazil). The analyses performed were quantification of filamentous fungi and yeasts and quantification of total and thermotolerant coliforms. The sample were storage at room temperature until the time of analysis.

RESULTS AND DISCUSSION

Proximate composition

The results of the sapota jelly proximate composition are shown in table 1. The moisture content found was similar to that reported by other authors, since jelly is a processed product and requires technical standards for proper processing.

Table 1 – Proximate composition of sapota pulp jelly.

Analyses	Mean (Wet basis)	Variation coefficient
Moisture (g.100g^{-1})	32.68±1.58	4.85
Ashes (g.100g^{-1})	0.17±0.01	9.89
Proteins (g.100g^{-1})	0.78±0.03	4.62
Lipids (g.100g^{-1})	0.11±0.04	4.49
Carbohydrates (g.100g^{-1})	66.04±2.27	4.27
Caloric value (kcal.100g^{-1})	268.27±0.18	4.54

Results are mean ± standard deviation.

Yuyama et al. (2008) found 29.52% of moisture in cubiu jelly, which is very close to sapota jelly, while Miguel et al. (2008) reported 27.32% of moisture for strawberry jelly. The ash content was also similar when compared with strawberry jelly, of 0.19% (MIGUEL et al., 2008) and cubiu jelly, of 0.22% (YUYAMA et al., 2008). The protein content found in sapota jelly was slightly lower (YUYAMA et al., 2008) then cubiu jelly (0.93 g.100 g^{-1} but sapota jelly showed protein content similar to that found in the fresh pulp, of 0.56% (ALEGRÍA et al., 2007). In strawberry jelly reported by Tabela de Composição de Alimentos – TACO (2006), the protein content was also similar to that found in the fresh fruit.

The carbohydrate content found was 66.04% and is consistent with the amount of soluble solids (61.06 °Brix), shown in table 1. Lee et al. (2010) found carbohydrate values ranging from 54.20 to 62.80% in jellies prepared with powdered banana peel. The caloric value of sapota jelly is similar to many common jellies in the market such as grape jelly (247 kcal) and pineapple jelly (273 kcal), (Tabela Brasileira de Composição de Alimentos – TBCA, 2008). According to data shown, sapota pulp jelly showed good procession, since the results of its proximate composition were similar to those reported in other studies with fruit jellies. Thus, it was concluded that the fruit can be processed to obtain jelly, since the fruit meets the parameters required for a commercial jelly such as moisture content (35-38%) and soluble solids (62-55° Brix), ensuring the sustainability of people from the Amazon region.

Chemical analyses

The total sugars found, shown in table 2, were similar to those observed by Yuyama et al. (2008) in cubiu jelly, of 67.15%.

A small amount of reducing sugars was also found in the jelly, which can be explained by the reversal of part of the sucrose in acid medium during the cooking process (DAMIANI et al., 2009) .A significant content of total fibers was observed

in this study, and more than 80% of these are soluble fibers. Soluble fibers are mainly composed of pectin, mucilages and some hemicelluloses (DOLINSKY, 2009). With a significant value of soluble pectin, the sapota pulp jelly can be considered a functional food for human health because its soluble fibers have the ability to delay gastric emptying and slow down the digestion process, therefore, the fibers are associated with decreased glycemic response. Soluble fibers also decrease serum cholesterol due to the increased excretion of bile acids in the intestine (DOLINSK, 2009). According to the Brazilian law, sapota pulp jelly is a food source of fibers because it has a value greater than 3 g 100^{-1} g of fibers in its composition (AGENCIA NACIONAL DEVIGILANCIASANITARIA-ANVISA, 1998).

Table 2 – Complementary analysis of sapota pulp jelly.

Analyses	Mean (Wet basis)	Variation coefficient
Total sugars (g.$100g^{-1}$)	69.86±1.65	2.29
Reducing sugars (g.$100g^{-1}$)	4.05±0.09	2.64
Sucrose (g.$100g^{-1}$)	65.80±1.64	2.35
Soluble solids (°Brix)	61.06±1.00	1.65
pH	3.99±0.00	0.00
Total acidity (g.$100g^{-1}$)	0.12±0.00	0.00
Ascorbic acid (mg.$100g^{-1}$)	64.00±0.63	0.63
Fumaric acid (mg.$100g^{-1}$)	20.00±0.17	0.18
Carotenoids (µg.g^{-1})	0.048±0.00	0.00
Total fibers (g.$100g^{-1}$)	5.35±0.10	10.00
Soluble fibers (g.$100g^{-1}$)	4.46±0.05	10.49
Insoluble fibers (g.$100g^{-1}$)	0.89±0.05	12.83
Total Pectin (g.$100g^{-1}$)	7.67±0.70	9.18
Soluble pectin (g.$100g^{-1}$)	6.41±0.50	7.88

Results are mean ± standard deviation.

It was observed that the pH value for sapota jelly is in accordance with recommendations for an adequate gel formation, as shown in table 2. The gel formation occurs only at certain pH values, and the optimal conditions for its formation are close to 3.2. It is noteworthy that at lower values, the gel resistance decreases (GAVA et al., 2008), occurring syneresis. Yuyama et al. (2008) and Miguel et al. (2008) found pH values of 3.4 for cubiu and strawberry jelly, respectively. Thus, the pH value found in sapota jelly is consistent with recommended, causing no damage to the gel formation and presenting intermediate acidity without affecting the jelly elasticity.

A small amount of ascorbic acid was observed in the sapota pulp jelly (64 mg.100 g^{-1}). One must consider that the cooking process combined with the contact with oxygen can lead to considerable loss of this acid due to its extreme instability under these conditions. Brazilian law recommends a daily intake of ascorbic acid of 60mg/day, thus, by ingesting about 25 g of sapota pulp jelly, the consumer will be supplying 26% of the recommended daily intake of vitamin C.

A content of 0.048 µg g^{-1} of carotenoids was found in the sapota pulp jelly, as shown in table 2. Since these compounds are highly unstable to temperature and light, their contents were reduced compared to the fresh fruit, since it presented a content of 1.91 µg g^{-1}. Carotenoids are natural pigments with multiple biological functions, and many exhibit pro-vitamin A activity. The great interest in these compounds in recent years is due to their anticarcinogenic and immunomodulatory functions and antioxidant activity (MALDONADE et al., 2008). However, even with values considered low, the consumption of sapota jelly can contribute to the daily intake of vitamina A.

Kim and Padilla-Zakoura (2004) found 132.9 mg GAE.$100g^{-1}$ for cherry jelly and 144.3 mg GAE.100 g^{-1} for plum jam. It was observed that the processing of sapota pulp jelly resulted in an increase in total phenolic compounds from 21 mg GAE.100 g^{-1} to 102 mg/ GAE.100 g^{-1}, i.e., an increase of 4.8 times from the fresh fruit to the processed fruit (Table 3). Heat treatment can modify the content of phenolic compounds due to disruption of plant cell wall, with consequent release of these compounds (CHOI et al., 2006).

Table 3 – Content of phenolic compounds and antioxidant potential of sapota pulp jelly.

Analyses	Etheric Extract	Alcoholic Extract	Aqueous Extract	TOTAL
AP*	6.24±3.04	2.81±0.36	**	9.05±3.41
TP*	**	59.65±4.49	42.35±3.47	102.00±1.01

* AP: antioxidant potential expressed in % of discoloration of the DPPH radical (EE - ether extract, EOH - alcoholic extract, AE - aqueous extract), TP: total phenolic compounds expressed as mg GAE (gallic acid equivalent). 100 g^{-1} (EOH - alcoholic extract, AE - aqueous extract). Standard BHT 0.2 mg mL^{-1} = 96.92%.

Similar results were observed in the study by Kathun et al. (2006), reporting that the content of phenolic compounds in spices had the factor increased from 2 to 4 times after cooking. However, Poiana et al. (2011) found loss of the polyphenolic compounds in low sugar fruit jams. This suggests that there is difference in thermal stability among the fruit.

The DPPH radical is widely used to assess the free radical scavenging capacity. In samples of this study, this capacity was determined by the reduction of optical absorption at 517 nm due to the elimination of the stable free radical by the DPPH radical. The results of DPPH tests indicated that even after cooking, the jelly still had some antioxidant activity. After performing the method in the fresh fruit, a reduction of three times the value of the antioxidant capacity of the fresh fruit pulp was observed, showing 27.85% of total discoloration of the DPPH radical. A reduced antioxidant capacity was also observed by Kim and Padilla-Zakour (2004) comparing the antioxidant capacity of fruits before and after processing into jellies. This decrease can be attributed to the destruction of active antioxidant compounds such as vitamin C by the heating process during processing. Vitamin C is very unstable to heat and decreases significantly during the preparation of orange juice (PIGA et al., 2003).

The reduced antioxidant capacity of orange juice, based on the elimination of free radicals, was attributed to the degradation of ascorbic acid due to heating (LO SCALZO et al., 2004). Thus, it was observed that the sapota pulp jelly has reduced antioxidant capacity compared to fresh fruit due to thermal processing. However, it is interesting to observe that there is still a small percentage of discoloration of the DPPH radical, indicating that the jelly has the capacity of scavenging free radicals. These radicals react with biological substrates and may cause damage to biomolecules and thus affect human health. Today, it is known that the action of oxidizing species is responsible for mutation and even oncogenesis (BARREIROS; DAVID, 2006). Thus, the consumption of products with antioxidant properties is essential to control the action of these agents and reduce oxidative stress.

Microbiological analyses

The microbiological analyses results showed no thermotolerant coliform, molds and yeasts. Thus, sapota jelly meets the specification of the RDC Resolution No. 12, item 1 of the National Health Surveillance Agency - ANVISA (2001). These results showed that the jelly was processed under good processing procedures such as proper sanitation of fruits and equipment used.

CONCLUSIONS

The sapota is the raw material for the elaboration of effective jelly.

The use of sapota pulp for the manufacture of jelly showed that the processing of an exotic fruit with good nutritional quality is possible.

The sapota jelly showed the same characteristics as commercial jellies, according to Brazilian law, can be considered a food rich in fiber and also has antioxidant character.

The manufacture of sapota jelly is therefore an alternative of use of fruits from the Amazon region, and also alternative for the dissemination of the potential of this fruit national and internationally.

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