Anais da Academia Brasileira de Ciências (2016) 88(3): 1243-1252
(Annals of the Brazilian Academy of Sciences)
Printed version ISSN 0001-3765 / Online version ISSN 1678-2690
http://dx.doi.org/10.1590/0001-3765201620150537
www.scielo.br/aabc

Mineral composition, nutritional properties, total phenolics and flavonoids compounds of the atemoya fruit *(Annona squamosa L. x Annona cherimola Mill.)* and evaluation using multivariate analysis techniques

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Manuscript received on July 17, 2015; accepted for publication on May 27, 2016

ABSTRACT

The atemoya is a hybrid fruit obtained by crossing of cherimoya (*Annona cherimola Mill.*) with sweet sop (*Annona squamosa L.)*. The information about chemical composition of atemoya is scarce. The mineral composition was evaluated employing Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES) and the centesimal composition and the physico-chemical parameters were assessed employing procedures described in the AOAC methods. The total phenolic compounds (TPC) and total flavonoids (TF) were determined using spectroanalytical methods. Considering the Reference Daily Intake (RDI), the concentrations of K, Cu and Vitamin C found in atemoya were the highest, representing about 32, 23 and 37% of the RDI, respectively. The total carbohydrates were 32 g $100g^{-1}$ and the soluble solids was equivalent to (32.50 ± 0.03) °Brix. The result for TPC was 540.47 ± 2.32 mg_{GAE} 100 g^{-1} and the TF was 11.56 ± 1.36 mg_{QE} 100 g^{-1}. The exploratory evaluation of 42 atemoya samples was performed through Principal Component Analysis (PCA), which discriminated green and ripe fruits according to their mineral composition. The elements that contributed most for the variability between green and ripe fruits were: Ba, Ca, Cu, K, Mg and P.

Key words: atemoya, food composition, ICP OES, flavonoids, phenolics.

INTRODUCTION

Fruit and vegetables have low energy content and are an important source of sugars, minerals, aminoacid, fiber and vitamin (Bressy et al. 2013, dos Santos et al. 2013a, Souza et al. 2007). These foods can replace foods rich in saturated fats, sugar and salt, improving modes of intake of important micronutrients and dietary fibers for the human. In addition, fruits and herbal products are valuable sources of health-promoting substances active in

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neutralization of reactive oxygen species (Leja et al. 2013, Ronowicz et al. 2014). Polyphenols compounds are important secondary metabolites widely found in fruits and are of considerable interest due to their antioxidant capacity and antimicrobial, antiviral and anti-inflammatory properties (Ignat et al. 2011, da Cruz et al. 2013).

In recent years we have seen an increase in the number of studies on fruits and vegetables in terms of their constituents (Mahmood et al. 2012, Araújo et al. 2014, Anunciação et al. 2011, dos Santos et al. 2013b). These studies are led by the interest in knowing the physico-chemical composition of these foods to reveal their nutritional potential and so to collaborate in formulation of diets. Mahmood et al. (2012) determined the mineral composition of strawberry, mulberry and cherry fruits in different ripening stages and observed that overall the mineral concentrations, with except for K, decreased as fruit ripening progressed. Also concluded that the studied fruits, mainly mulberry can be explored as a rich sources of Zn and Fe (Mahmood et al. 2012). Araújo et al. (2014), compared physico-chemical composition of lettuce, peppers and tomatoes that were grown in organic and conventional systems and observed that all organic vegetables presented higher total dietary fiber (Araújo et al. 2014). To assist in the processing of chemical data in food analysis, exploratory analytical techniques, principal component analysis (PCA) and hierarchical cluster analysis (HCA), are often applied. The multivariate statistical methods examine the samples and variables together, allowing correlating many variables at once and extracting information that the conventional analysis could not demonstrate. Both (PCA and HCA) are either classified as exploratory or unsupervised, since no information regarding the identity of the samples is considered. Anunciação et al. (2011), determined and evaluated, through multivariate analysis, the mineral composition of red and white cabbage and found higher mean concentrations of K, P and Ca in these samples. Furthermore, PCA did not show difference between the mineral compositions of red and white species of cabbage (Anunciação et al. 2011). Dos Santos et al. (2013b), determined the mineral content (Ca, Cu, K, Mg, Na, P and Zn) of raw and cooked okra of conventional and organic cultivars and observed that raw samples had the highest concentrations, indicating a loss of nutrients during cooking. Also concluded that there were no difference between the mineral composition of organic and conventional samples (dos Santos et al. 2013b).

The atemoya is a fruit that belongs to the Annonaceae family and it is a hybrid developed in the beginning of the century by crossing cherimoya (*Annona cherimola Mill.*) with custard apple or sweet sop (*Annona squamosa L.*). This hybrid retains the good qualities of cherimoya and custard apple and has a small quantity of seeds, better conservation after harvest, absence of cracking and resistance to weeds and to biological control. Therefore it has received special attention from producers and also for its delicious and aromatic white pulp. The fruit can also be consumed as pulp, liqueur, ice cream, juice, sweet and fruit in syrup (Medeiros et al. 2009, Campbell and Phillips 1994). Orsi et al. (2012), verified that pulps of fresh atemoya have high nutritional values, as e.g. significant levels of carbohydrates (Orsi et al. 2012). Clerici and Carvalho-Silva (2011) summarized the major nutritional and bioactive compounds found in some fruits of Brazil. The atemoya fruit has substantial quantities of digestible carbohydrates and their consumption may assist in rapid recovery from dehydration because of the water significant content in combination of sugars and minerals (Clerici and Carvalho-Silva, 2011). Da Cruz et al. (2013), characterized the physico-chemical of the fractions skin, pulp and seed of atemoya fruit. In both seeds and skin were found largest contents of crude protein and dietary fiber, while in the pulp were found higher levels of ascorbic acid and total sugars (da Cruz et al. 2013).

The information available in the literature about chemical composition of atemoya are scarce and the culture of this fruit can be an interesting alternative sustainable livelihoods for dry northeast region of Brazil, especially in Bahia, where the survey was conducted. Thus, the aim of the present work was to determine the physico-chemical composition of atemoya fruit obtained from different cities, cultivars, cultivation and stages of maturation employing Official Methods of Analysis (OMA) and Inductively Coupled Plasma Optical Emission Spectrometry (ICP OES). In this investigation, data about moisture, lipids, protein, ashes, carbohydrates, total fibers, minerals, reducing carbohydrate, vitamin C, titratable acidity, soluble solids, pH, total calorie, total polyphenols and total flavonoids were evaluated and the mineral content results were explored using the multivariate analysis technique, PCA.

MATERIALS AND METHODS

Reagents and Solutions

All reagents used were of analytical grade (Merck, Germany). All solutions were prepared using ultrapure water obtained from a Milli-Q water purification system (Millipore, USA). Stock solutions of 1000 mg L^{-1} (Merck, Germany) of each element were used to prepare the multi-element standard solutions. Hydrogen peroxide (30% v/v) and concentrated nitric acid, both from Merck (Germany) were used for sample digestion. For determining the centesimal composition and physico-chemical parameters were used the following reagents: petroleum ether, ethyl alcohol, glacial acetic acid, nitric acid, sulfuric acid from Merck (Germany), hydrochloric acid, trichloroacetic acid, sodium hydroxide, anhydrous sodium carbonate were purchased from Merck (Germany), potassium ferrocyanide, zinc acetate and acetate of lead from QUIMIOBRAS (Brazil), copper sulfate, potassium sulfate, anhydrous sodium sulfate and Fehling's solutions A and B from F MAIA (Brazil), titanium dioxide, potassium iodide and potassium iodate from JT Baker (Brazil) and phenolphthalein in solution and methyl red were obtained from QUIMIOBRAS (Brazil). For determination of total phenolics compounds (TPC) and total flavonoids (TF) were used: Folin-Denis reagent and methanol from Merck (Germany), aluminium chloride and sodium carbonate from Vetec Chemistry (Brazil), and galic acid and quercetin from Sigma-Aldrich (USA). All material used were previously cleaned by acidification in HNO_3 (10% v/v) for 24 h followed by rinsing with ultra-pure water prepared using a Millipore system (Millipore Corp., USA).

Fruit Samples

In the present work, twelve fruit samples ideal for consumption were analyzed as to their physico-chemical composition, TPC and TF of which four (Gefner Cultivar) were purchased in several sales points of Salvador city in Bahia - Brazil and eight were harvested in organic plantation in Juazeiro, Bahia-Brazil (African Pride and Gefner cultivar). Beyond twelve samples, 42 other samples at different stages of ripening, green or ripe, were analyzed for their mineral contents.

In all analyses, the samples were previously washed with ultrapure water and the edible parts (pulp) of the fruits were separated. The pulp was homogenized with domestic processor and then used for to determine the centesimal composition and physico-chemical parameters. Already, to determine the mineral composition, TPC and TF, the processed pulp was placed in an air circulation oven (QUIMIS, São Paulo, Brazil), at 60 °C until to dryness and then was ground in an impact mill (Kingsley, São Paulo, Brazil) for 30 seconds, sieved through a Nylon® sieve (300 μm size) and stored in plastic bottles, which was placed in desiccators. All analyses were performed in triplicates for fruits collected in each sampling point and the results were expressed as mean and standard deviation.

Sample Digestion for Mineral Content Determination

Approximately 1.0 g of dry atemoya pulp was pre-digested with 1.0 mL of concentrated nitric acid, at room temperature, overnight. Then, 1.0 mL of concentrated nitric acid was added and the mixture was heated using a heating block (TECNAL, São Paulo, Brazil). The heating program consisted in gradual increase of the temperature until it reached 140 °C. Every 30 minutes, 0.5 mL of hydrogen peroxide 30% (v/v) were added up to a total of 2 mL. "Cold finger" was used throughout the digestion process, which allowed a fewer consumption of acid, which in this case is regenerated by reflux, decreasing consequently the risk of contamination by these (Ferreira et al. 2013). After complete digestion, the solutions were cooled to room temperature, transferred to volumetric flasks (10 mL), which was measured with ultrapure water. All tests were performed in triplicate and the analytes in the final solution were determined by ICP OES.

Mineral Composition

An ICP OES with axial-viewing configuration (VISTA PRO, Varian, Mulgrave, Australia) was used to determine the macro and microelements. The operation parameters were: RF generator: 40 MHz; Power: 1.3 Kw; Plasma Flow: 15 L min^{-1}; Auxiliary flow: 1.5 L min^{-1}; Nebulizer flow: 0.7 L min^{-1}. Emission intensities were obtained for the most sensitive lines, free of spectral interference: Al (396.152 nm), Ba (455.403 nm), Ca (396.847 nm), Co (238.892 nm), Cr (267.716 nm), Cu (213.598 nm), Fe (238.204 nm), K (766.491 nm), Mg (280.270 nm), Mn (257.610 nm), Na (589.592 nm), Ni (231.604 nm), P (213.618 nm), Zn (202.548 nm). The accuracy of the method was confirmed by analysis of a certified reference material of tomato leaves (SRM 1573a) and addition/recovery test.

Centesimal Composition and Physico-Chemical Parameters

The contents of the moisture, lipids, proteins, ashes, total fiber, carbohydrates, vitamin C, titratable acid, total soluble solids, pH and total calories were determined according to the analytical procedures of the Association of Official Analytical Chemist (AOAC) (AOAC 1995). Ash sample (5.0 g) was kept in a muffle furnace and incinerated at 550 °C to constant weight. The ash was then cooled in a desiccator and weighted (AOAC 920.02). Crude fat was determined by extraction of 2 g of sample put into a thimble, covered with fat-free cotton and then put into the Soxhlet apparatus. The difference in the weight gave the fat soluble material present in the sample (AOAC 920.39). The protein concentration was determined by Kjedahl method using a conversion factor of 6.25 factor (AOAC 991.20). Vitamin C (ascorbic acid) was obtained by titration method involving potassium iodide.

In order to determine these parameters, the following instruments were used: Abble refractometer (Milton Roy Co., USA); pH meter with a digital potentiometer (Orions, USA); Soxhlet apparatus (QUIMIS, São Paulo, Brazil); Kjeltec instrument, model MA-036 (MARCONI, São Paulo, Brasil). All fruits analyzed for these parameters were in their early stages of maturation, i.e., when they were suitable for consum.

Total Phenolic Compounds (TPC) and Total Flavonoids (TF)

The total phenolic compounds (TPC) were determined by colorimetric analysis using spectrophotometry, as described by Singleton and Rossi (1965), with modifications (Araújo et al. 2013). Samples of dried and powered fruit pulp (0.15 g) were submitted to extraction with 30 mL of methanol with shaking for 5 min followed by centrifugation for 5 min at 3500 rpm. Each extract was filtered and the aliquots of the resultant solution (1.0 mL each) was added 9.0 mL of ultrapure water and 2.5 mL of Folin Denis reagent. After 5 min, 2.5 mL of a 7.5% (m/v) sodium carbonate solution were added. The mixture was diluted to 25 mL with water and homogenized. After 40 min (60 °C), the

absorbance data were registered at 760 nm. The TPC was measured using a gallic acid standard and expressed as mg of gallic acid standard per 100 g of fruit. (mg_{GAE} 100 g^{-1}).

Contents of total flavonoids were determined according to the method of Woisky and Salatino (1998), with minor modifications (Fan et al. 2015). To 1.5 ml of extract, was added 3.0 ml of 2% $AlCl_3$–methanol solution. The mixture was diluted to 10 mL with methanol and homogenized. After 30 min at room temperature, the absorbance was measured at 420 nm. Total flavonoid contents were calculated as quercetin equivalents and expressed as milligrams of quercetin per 100 g (mg_{QE} 100 g^{-1}).

Multivariate Analysis

The multivariate statistical method was employed aiming to explore the relationship between the mineral compositions of fruit and to verify if there are differences between the stages of maturation, cultivation and species. So, an exploratory evaluation involving 42 atemoya fruit samples was performed using PCA, comprising 10 variables: Concentration of micro (Ba, Cu, Fe, Mn, Zn and Ca) and macro elements (K, M, Na e P) of Gefner and African Pride atemoya samples.

RESULTS AND DISCUSSION

Centesimal Composition and Physico-Chemical Parameters

The obtained results for centesimal composition and physico-chemical parameters are shown in Table I.

These results are in agreement with the results shown in TACO table (TACO 2011), which is a table that was developed to generate data on the composition of the main foods consumed in Brazil. According to Food and Drug Administration (FDA), the atemoya may be considered an excellent source of Vitamin C (37.30%), since the foods are classified as "excellent or good" sources of nutrients when one serving of these provides at least 20% and 10-20%, respectively, of the Reference Daily Intake (RDI) (Pereira et al. 2013, ANVISA 2014).

TABLE I
Centesimal composition and physicalchemical parameters of atemoya (n =10).

Centesimal composition	**Values**
Moisture	(65.18 ± 0.13) g $100g^{-1}$
Lipids	(0.55 ± 0.28) g $100g^{-1}$
Proteins[a]	(1.24 ± 0.12) g $100g^{-1}$
Ashes	(1.04 ± 0.02) g $100g^{-1}$
Carbohydrates	(31.99 ± 0.32) g $100g^{-1}$
Total fiber	(1.55 ± 0.28) g $100g^{-1}$
Physico-chemical parameters	**Values**
Total caloric value (TCV)	137.87 KCal g^{-1}
Reducing carbohydrates (glucose)	10.67 ± 0.09 g $100g^{-1}$
Vitamin C	22.39 ± 1.68 mg $100g^{-1}$
Titratable acidity (TA)	5.50 ± 0.02 mg $100g^{-1}$
Soluble solids (SST)	32.50 ± 0.03 °Brix
pH	4.60

[a] conversion factor of 6.25.

Total Phenolics Compounds (TPC) and Total Flavonoids (TF)

The average of the results (n=12) for total phenolic compounds (TPC) was 346.03 ± 2.32 mg $_{GAE}$ 100 g^{-1} in atemoya. These results are much higher than those found to TPC by Clerici and Carvalho-Silva (2011) for atemoya, but corresponding with the cited in the literature for other fruits. The contents of TPC were in range from 258 to 846 mg $_{GAE}$ 100 g^{-1} in water extracts for durian, avocado, mango, kiwifruit, mangosteen and snake fruit (Gorinstein et al. 2011).

The average of the results (n=12) for total flavonoids (TF) in atemoya was 11.56 ± 1.36 mg_{QE} 100 g^{-1}. There were no reports in the literature on the flavonoid content in atemoya fruit. The TF in the literature for the fruits: durian, avocado, mango, kiwifruit, mangosteen and snake fruit were 16.3 to 152.3 to mg_{QE} 100 g^{-1} (Gorinstein et al. 2011).

Mineral Composition

Several analytical parameters were evaluated for the method applied in determination of mineral content in atemoya fruit. The accuracy was confirmed by the analysis of certified reference material of tomato leaves (1573a) provided by National Institute of Standards and Technology (NIST) (Gaithersburg, MD, USA). The results achieved by applying the method under study are in agreement with the results of certified reference, as can be seen in Table II.

Addition/recovery tests were also performed in atemoya samples (Gefner cultivar and African Pride cultivar) involving the micro elements not exploited in certified reference material of tomato leaves (1573a). The results shown in Table III demonstrate excellent recoveries, which ranged between 92% and 103%. The addition was made from multi solution added prior to digestion in two concentration levels: 0.5 and 1.0 mg L^{-1} .

TABLE II
Results obtained for the analyzing of certified reference material (tomato leaves NIST 1573a).

Macro elements	Certified value (%)	Obtained value (%)
Ca	5.05 ± 0.09	5.01 ± 0.02
K	2.70 ± 0.03	2.76 ± 0.05
Mg	1.20	1.12 ± 0.12
Na	136 ± 4	135 ± 5
P	0.216 ± 0.004	0.220 ± 0.004
Micro elements	**Certified value (mg Kg^{-1})**	**Obtained value (mg Kg^{-1})**
Al	598 ± 12	585 ± 14
Cu	4.70 ± 0.14	4.82 ± 0.04
Fe	368 ± 7	373 ± 12
Mn	246 ± 8	246 ± 1
Zn	30.9 ± 0.7	30.6 ± 0.7

TABLE III
Addition/recovery tests performed on atemoya samples (Gefner cultivar and African Pride cultivar).

Micro and trace elements	Recovery (%)			
	Gefner Sample		African Pride Sample	
	0.5 mg L^{-1} added	1.0 mg L^{-1} added	0.5 mg L^{-1} added	1.0 mg L^{-1} added
Ba	100 ± 1	103 ± 3	101 ± 2	101 ± 1
Co	93 ± 2	98 ± 2	92 ± 2	94 ± 1
Cr	98 ± 1	102 ± 2	98 ± 1	99 ± 1
Ni	93 ± 1	99 ± 2	92 ± 1	93 ± 1

The precision of the method expressed as a relative standard deviation (RSD, n=7) was less than 5% for major and minor elements at a concentration of 5 and 50 μg L^{-1}, revealing good precisions. The limits of quantification (LOQ) obtained and expressed in μg g^{-1} for the evaluated elements were: Al (0.97); Ba (0.03); Ca (4.19); Co (0.56); Cr (0.61); Cu (0.09); Fe (0.15); K (3.73); Mg (1.36); Mn (0.13); Na (2.70); Ni (0.05); P (3.43) and Zn (0.45).

The results of the determination of minor and major elements in edible parts of atemoya in ideal stage for consumption are presented in Table IV. The elements Al, Co, Cr and Ni were evaluated, but the concentration results were below of limit of quantification (LOQ) of the method.

The predominant element in all samples was K and their concentration exceeds that of many fruits, like banana and apple, which are known as main sources of this element (Damodaran et al. 2008). The concentrations of P, K and Na in atemoya determined in this study (expressed in mg 100 g^{-1}) were higher than reported data in the TACO table for these elements. According to Food and Drug Administration, the atemoya can be considered a good source of Mg and an excellent source of Cu and K, since it provides 14, 23 and 32% of the Reference Daily Intake (RDI) (Pereira et al. 2013, ANVISA 2014), respectively.

In a study about tropical fruits in Northeastern Brazil, overall was observed that sweet sop (*Annona squamosa L.* one of the fruits that originates the atemoya) has lower concentrations of the macro and micro-nutrients (Na, K, Mg, P, Fe, Mn, Cu and Zn) than the atemoya, with except for Ca (Almeida et al. 2009). In another study involving determination of major elements in sweet sop (*Annona squamosa L.*), also observed lower concentrations (expressed in mg $100g^{-1}$) for P (22.7), K (390.61) and Mg (23.14), with except for Ca (253.70) (Brody 1999).

TABLE IV

Concentration of micro and macro elements of Gefner and African Pride Atemoya samples (*Annona squamosa L.* x *Annona cherimolla Mill.*).

Sample	Ba	Cu	Fe	Mn	Zn	Ca	K	Mg	Na	P
GS1	0.11±0.01	0.15±0.01	0.75±0.04	0.35±0.01	0.93±0.09	11.87±0.12	1362.25±10.04	64.45±3.54	13.34±0.96	47.54±1.23
GS2	0.12±0.003	0.19±0.01	1.15±0.07	0.41±0.01	1.21±0.1	11.88±0.45	931.56±26.27	28.9±0.82	14.35±0.68	37.97±1.01
AJ1	0.14±0.01	0.17±0.01	0.50±0.01	0.36±0.01	0.57±0.01	4.92±0.1	713.82±8.67	30.11±1.04	13.37±0.11	37.22± 1.97
AJ2	0.15±0.01	0.11±0.01	0.50±0.02	0.26±0.01	0.76±0.05	8.46±0.78	800.22±21.55	30.93±2.03	13.97±1.35	48.82±2.93
GJ1	0.10±0.01	0.22±0.01	0.45±0.03	0.23±0.01	0.67±0.08	5.26±1.31	902.88±6.50	29.6±2.34	16.18±0.24	50.64± 1.37
GJ2	0.23±0.02	0.20±0.02	0.48±0.02	0.39±0.03	0.78±0.003	13.16±1.81	877.43±26.96	60.82±14.99	12.41±1.0	61.2± 14.96
AJ3	0.13±0.01	0.21±0.01	0.51±0.11	0.41±0.02	0.67±0.14	48.84±4.06	303.08±33.88	28.64±4.03	20.28±1.49	103.76± 11.14
GJ3	0.081±0.002	0.23±0.01	0.57±0.01	0.23±0.02	0.64±0.02	50.02±0.35	318.00±14.07	29.95±1.77	8.53±2.47	156.63± 20.57
GS3	0.034±0.001	0.20±0.005	0.50±0.04	0.21±0.006	0.68±0.03	53.44±0.39	338.18±13.28	32.53±1.3	7.97±2.97	97.64±5.44
AJ4	0.07±0.01	0.26±0.01	0.58±0.04	0.26±0.01	0.92±0.05	59.11±4.52	334.04±2.63	31.94±0.48	15.93±2.96	208.38±10.98
GJ4	0.086±0.003	0.28±0.01	0.58±0.12	0.28±0.01	0.76±0.10	50.93±4.84	372.04±4.44	35.49±0.89	18.57±4.34	235.61±22.31
GS4	0.028±0.003	0.25±0.01	0.61±0.02	0.26±0.04	0.67±0.04	75.47±2.13	330.17±6.15	31.63±0.48	12.75±0.39	81.00±18.18

G: Gefner cultivar; **A**: African Pride cultivar; **S**: Salvador city; **J**: Juazeiro city.
Results are expressed as the mean ± SD for three measurements in 10 independents samples.

Data Evaluation Employing Principal Component Analysis

Macro and micro elements in edible parts of atemoya were determined in 42 samples, among which there were different species (Gefner and African Pride), collection points (Salvador and Juazeiro), cultivation (organic and conventional) and ripening stages (green and ripe).

Principal Component Analysis (PCA) analysis were applied, after auto-scaled, using the Statistica Software 7.0. The first of three components describe 77.77% of the total variance of the data and provide discriminatory information related to the samples. The first principal component (PC1) describes 42.34% of the total variance. The elements Ba, Ca, Cu, K, Mg and P are the dominant variables on this PC, thereby causing greater variability among the samples. The second principal component (PC2) represents 26.42% of the total variance, and the elements Fe, Mn and Zn are the dominant variables on this PC. On the PC3, in turn, the dominant variable is Na and represents 9.01% of the total variance. The Figure 1 shows two groups that are differentiated by the concentration of elements in green and ripe fruits and the Figure 2 shows the loading chart for the elements in PC1 and PC2. According to these graphs the sample differ mainly in terms of concentration of Ba, Ca, Cu, K, Mg and P and is possible to observe a larger trend of the green atemoyas possess higher concentrations of Ca, Cu, Mg and P, while ripe fruit tends to possess higher levels of Ba and K. These results can be explained by importance of these elements in the biosynthesis of chlorophyll (especially Cu and Mg) and changes in the binding form of some elements, such as Ca, in the tissue before ripening. The decrease in calcium content is one of the main factors responsible for the softening of plant tissues in most mature fruits and vegetables (Damodaran et al. 2008).

The PCAs did not show difference between the mineral compositions of atemoya fruit of different

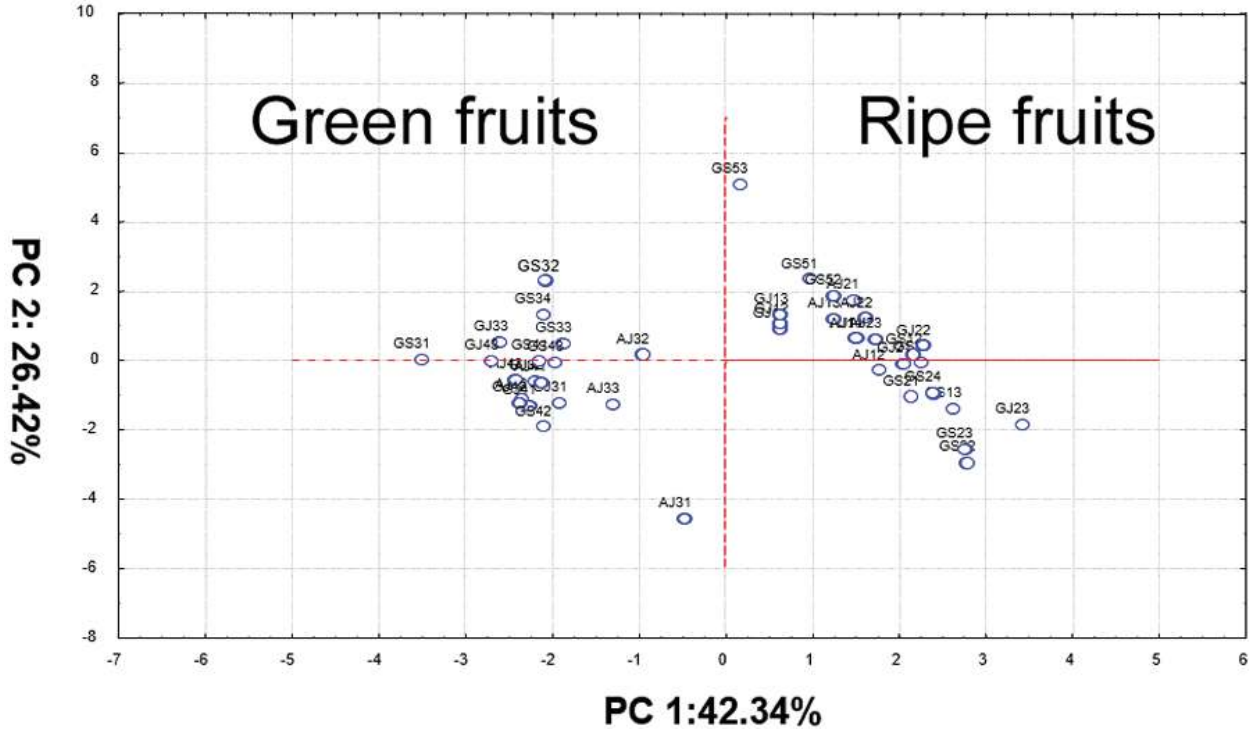

Figure 1 - Plot of PC1 x PC2 scores as a function of maturation stage for atemoya.

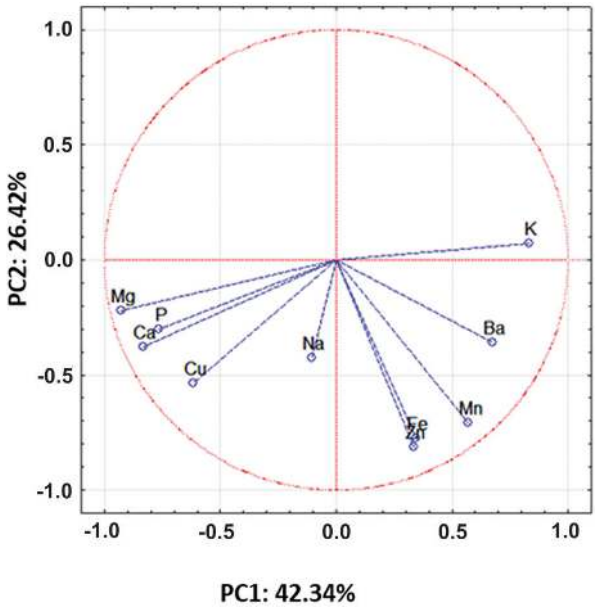

Figure 2 - Loading chart for the elements (PC1 x PC2).

species (Gefner and African Pride) and obtained from different cities (Salvador and Juazeiro) and cultivations (organic and conventional).

CONCLUSIONS

This paper evaluated the physico-chemical and nutritional properties of the atemoya fruit. The determination of minerals in atemoya by ICP OES gave a satisfactory quantification of Ba, Ca, Cu, Fe, K, Mg, Mn, Na, P and Zn. The high content of: K, Cu, Mg, Vitamin C and carbohydrates founded in the atemoya fruit reveals that it is a good dietary supplement. The total phenolic and total flavonoids content in atemoya fruit shows its antioxidant potential. The PCA discriminated the atemoya samples by the maturity stage according to their major and minor elements composition and demonstrated that Ba, Ca, Cu, K, Mg and P were the elements that contributed most to the variability between green and ripe fruits.

ACKNOWLEDGMENTS

The authors are grateful to the Fundação de Amparo à Pesquisa do Estado da Bahia (FAPESB), Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq), Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) and the Programa de Apoio a Núcleos de Excelência (PRONEX) for providing grants, fellowships and financial support.

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