Chemical characteristics of pequi fruits (*Caryocar brasiliense* Camb.) native of three municipalities in the State of Goiás – Brazil

Caracterização química de frutos de pequizeiro (Caryocar brasiliense Camb.) oriundos de três municípios do Estado de Goiás

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Abstract

In order to assure that the use of cerrado fruits occur in a sustainable way, studies to investigate their characteristics are extremely relevant. In this context, the present study aims to describe some chemical parameters of pequi fruits picked in three municipalities in southwestern Goiás State (Jataí, Rio Verde, and Serranópolis). In each city, two populations of pequi trees – *pequizeiros*, denominated areas, were selected. In each area, eight trees were selected for the fruit to be picked. The contents of phosphorus, potassium, calcium, magnesium, nitrogen, zinc, and ether extract were determined in the samples. The results demonstrate differences between the chemical characteristics studied for the fruits picked in different areas, which does not seem to vary in a significant way. Comparing the contents obtained in the present study with those required as human daily supply, further studies are recommended aiming at using the pequi fruit as a complementary alternative source of magnesium, manganese, and copper.
Keywords: *pequi, Caryocar brasiliense; chemical composition; nutritional value.*

Resumo

Para que a utilização de frutíferas do cerrado ocorra de maneira sustentável, estudos no intuito de se conhecer suas características fazem-se necessários. Neste escopo, o presente trabalho teve como objetivo caracterizar alguns parâmetros químicos de frutos de pequizeiro coletados em três municípios do sudoeste do Estado de Goiás (Jataí, Rio Verde e Serranópolis). Em cada município foram selecionadas duas populações de pequizeiros, denominadas áreas. Em cada área, foram eleitas oito árvores para a coleta dos frutos. Nas amostras, foram determinados os teores de fósforo, potássio, cálcio, magnésio, enxofre, cobre, ferro, manganês, nitrogênio, zinco e extrato etéreo. Os resultados indicam que as diferenças entre as características químicas estudadas nos frutos coletados nas diferentes regiões não parecem variar significativamente. Comparando os teores encontrados no presente trabalho com aqueles requeridos diariamente na alimentação humana, novos estudos são recomendados objetivando utilizar o fruto do pequizeiro como uma fonte alternativa complementar de magnésio, manganês e cobre.
Palavras-chave: *pequi; Caryocar brasiliense; composição química; valor nutricional.*

1 Introduction

The occupation and utilization of Cerrado has been done disorderly and in a wrong way, most of the time, without the necessary knowledge about the use and behavior of most native vegetable species. The anthropic activities in the region cause disturbing effects since man transformation capacity is higher than the environmental recovery capacity (ASSAD, 1996).

Thus, a great number of fructiferous species have, systematically, become extinct, therefore, their characteristics cannot be known, preserved, or utilized (ANGELONI et al., 2004).

The species *Caryocar brasiliense* (*pequizeiro*) is among the six most important species of Cerrado vegetation whose fruits are commercialized (CEASA, 1995). Firstly, it is the most important species in the Cerrado culinary culture (RIBEIRO; FONSECA; ALMEIDA, 1994). Its fruits are not consumed in natura but after cooking. It is also utilized in fries and as seasoning due to its typical flavor and smell (SILVA et al., 1994). Secondly, (PEREZ, 2004) it is often used as edible oil source since it has a nice aroma and taste. Besides, its lipid fraction has high content of oleic acid.

The *pequizeiro* flourishes from June to September and its fruits rape from September to February of the following year (ALMEIDA, 1998; NAVES, 1999). It grows in the regions of cerradão, cerrado and secondary vegetation of Distrito Federal, Goiás, Tocantins, Minas Gerais, Mato Grosso, São Paulo, Bahia, and Piauí (PREGNOLATO, W.; PREGNOLATO, N. P., 1985).

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It is widely spread over the region of Cerrados, often growing in several places (RIBEIRO et al., 1997; SANTOS; AOKI, 1992; SILVA et al., 1994).

According to Gribel (1986) and Gribel and Hay (1993), the *pequizeiro* presents a great proportion of fruits formed by crossed pollination, significantly higher than those formed by autopollination. The flowers are visited by a range of insect and bird species, which have the function of pollinating agents such as: moth, wasps, humming birds, and bees although the most efficient pollination process is done by bats. Furthermore, the *pequizeiro* is a plant which has a typically zoochoric dispersion. The main fruit consumers are: rhea (*Rhea americana*), jackdaw (*Cyanocorax crostatellus*), and agouti (*Dasyprocta* sp.), which can act as seed spreaders to small distances by sinzoochoria.

Its generic name is derived from the Greek "Karyon" which means stone and from the Latin "Caro" which means drupaceous and fleshy fruit. The vernacular "piqui" is originally from native Brazilian Indian languages, as "py" is equivalent to skin and "qui" to thorn. Therefore, "py-qui" means fruit pulp full of thorns (MIRANDA, 1986).

Pequi fruit is a drupe up to 10 cm diameter, green, with an average weight of 104.4 g, containing one to five seeds with an average weight of 14.2 g, coated by woody endocarp with thorns and yellow fleshy mesocarp (CARVALHO et al., 1996). It is constituted, approximately, of 76.72% peel, 8.50% pulp, and 13.10% seed (VERA et al., 2007). The pulp is rich in oil constituent (61.7%) and almond (12.2%) (FERREIRA et al., 1987).

Almeida (1998), who has been studying several fruits of native species of the Brazilian Cerrado (araticum, baru, buriti, cagaita, jatobá, and mangaba), states that pequi fruit stands out with 2.64% of protein, value lower than jatobá (6%) and baru (3.87%) only. Concerning the lipid contents, the pequi fruit presented the highest value (20%) in relation to other native species (which varied from 5% to less than 1%), and the concentrations found by the author are comparable to the contents found in açaí and buriti, native fruits of the Amazon and the Cerrado region as well.

Vilas Boas (2004) states that the fiber content in the pequi fruit is considered high (average of 14%) while the carbohydrate concentrations found (average of 19.60%) are considered intermediate. Besides, the author affirms that the high acidity values range from 0.9 to 2.0.

Almeida (1998) considers that the pequi fruit stands out because of its high pectin contents, an important parameter for fruits industrialization and commercialization. According to the author, the pequi pulp contains 2.33% of pectin approximately, while other species such as buriti, cagaita, and mangaba contain values under 1%. The author compared the contents found with those present in other fruits which are also used in Brazilian diets and verified that these values are almost equivalent to those present in oranges (approximately 2.36%).

The fruits contain high contents of vitamin A, B1, and B2 (OLIVEIRA et al., 2006; PEREZ, 2004). The carotenoids content (vitamin A precursor) in the pequi pulp (approximately 7.46%) is exceeded only by the buriti pulp (16.7%) since the other native fruits of Cerrado (araticum, baru, cagaita, jatobá and mangaba) contain values under 1% (ALMEIDA, 1998). Its vitamin B1 content is considered similar to that of avocado, strawberry, genipap, and papaya; the vitamin B2 content is equivalent to that of egg yolk (CARVALHO; BURGER, 1960; POZO, 1997).

Almeida (1998) also argues that a great variation in vitamin C contents can be observed among Cerrado fruits, while pequi fruit stands out for containing approximately 78.72 mg.100 g^{-1}. Moreover, according to the author, this value is higher than that found in fruits traditionally cultivated and consumed by Brazilian population such as orange (approximately 40.9 mg.100 g^{-1}) and lemon (approximately 26.4 mg.100 g^{-1}).

In Goiás Stock Center (CEASA-GO), the most commonly commercialized native fruit of cerrado is pequi. By the year 2006, the commercialized fruit volume was approximately 3.342 tons with an average price around R$ 468.00 per ton (CEASA, 2006).

Nevertheless, besides its great economic and nutritional potential (RODRIGUES, 2005; SANTANA; NAVES, 2003), the trees have not been cultivated yet, and fruit picking is done in an extractive and predatory way (VARMA, 1986). The intensive extractivism may even produce genetic material losses since high quality fruits, originally from higher genotypes, are collected and commercialized (MELO-JUNIOR et al., 2004).

To start a process of rational economic exploitation of native fructiferous species of Cerrado, it is necessary to have knowledge about their characteristics and interaction with the environment. However, there is not much available information about the chemical composition of these fruits. The existent data are scattered or do not follow a scientific criterion.

The current work aims to characterize some chemical parameters of native *pequizeiro* fruits of six regions in three municipalities in the State of Goiás.

2 Materials and methods

2.1 Selection of the area to be studied

In three municipalities in the State of Goiás (Rio Verde, Jataí and Serranópolis), six areas for the *pequizeiro* fruit samples collection were selected. Table 1 shows the geographic coordinates of each area. The areas were selected especially according to some standards (area with little anthropic action,

Table 1. Geographic co-ordinates from the six areas for collecting pequi fruits.

Area	Municipalities	Latitude	Longitude
I	Rio Verde	17° 30' 31"	51° 30' 25"
II	Rio Verde	18° 05' 20"	50° 20' 37"
III	Jataí	18° 30' 40"	51° 30' 25"
IV	Jataí	17° 50' 26"	51° 52' 00"
V	Serranópolis	18° 10' 56"	52° 50' 12"
VI	Serranópolis	18° 30' 45"	51° 55' 48"

typical Cerrado formations and with more occurrence in this kind of study).

2.2 Fruits collection

Mature *pequizeiro* fruits (*Caryocar brasiliensis*) were picked between November and December 2006, according to maturation on the following dates: November 15th, 2006 (area I); November 29th, 2006 (area II); December 10th, 2006 (area III); December 05th, 2006 (area IV); December 07th, 2006 (area V), and November 30th, 2006 (area VI). In each area, eight trees were selected and disposed in an imaginary square with 10,000 m^2. Next, 5 fruits from each tree were picked, according to the cardinal points and the center (BRAIT, 2003). Fruits of all varieties of size, weight, and color were picked at randomly. After picking, the fruits were immediately stored in paper packs and sent to the laboratory.

2.3 Preparation of pequi samples and pH measuring

Right after taking them to the laboratory, the fruits were opened and the pH of the pulp was determined according to the methodology proposed by Pregnolato, W.; Pregnolato, N. P. (1985). The pulp was then submitted to heat drying at 70 °C for 20 hours. The samples were triturated in a plastic bush container (MIYAZAWA, 1999), and the fruits from the same tree were homogenized originating a sample. The homogenized samples were stored in polyprophylene bottles until the analysis.

2.4 Material preparation

All reusable items (glass, quartz, polyethylene, teflon, etc.) were prepared for use by washing with detergent in ultra pure water and soaked in a mixture of nitric acid, hydrochloric acid, and water (1 + 2 + 9) for 4 hours, followed by rinsing with ultra pure water and heat drying (McDANIEL, 1992).

2.5 Lipid fraction determination

Approximately 1.0 g of the stock sample was conditioned in a cotton extraction cartridge and submitted to extraction with non-polar solvents followed by evaporation of the used solvent (PREGNOLATO, W.; PREGNOLATO, N. P., 1985).

2.6 Calcium and magnesium determination

Approximately 0.5 g of the *pequi* sample was mineralized by 2:1 hydrogen peroxide (H_2O_2) and perchloric acid ($HClO_4$) digestion at 220 °C for 3 hours. The mineralized sample was dissolved 1:100 in distilled water and 1:50 in 2.5% lanthanum solution. Calcium and magnesium contents were measured by atomic absorption spectrophotometry with atomization by acetylene flame in a Perkin Elmer model Analyst 100 atomic absorption spectrophotometer (MIYAZAWA, 1999).

2.7 Potassium determination

Approximately 0.5 g of the *pequi* sample was mineralized by 2:1 hydrogen peroxide (H_2O_2) and perchloric acid ($HClO_4$) digestion at 220 °C for 3 hours. The mineralized sample was dissolved 1:100 in distilled water. The potassium content was measured by flame spectrophotometry (gas GLP) in an Analyser spectrophotometer (MIYAZAWA, 1999).

2.8 Iron, copper, manganese, and zinc quantification

Approximately 0.5 g of the *pequi* sample was mineralized by 2:5:3 sulfuric acid (H_2SO_4), nitric acid (HNO_3), and perchloric acid ($HClO_4$) digestion at 220 °C for 3 hours. The mineral content was measured by atomic absorption spectrophotometry with atomization by acetylene flame in a Perkin Elmer model Analyst 100 atomic absorption spectrophotometer (VARMA, 1986).

2.9 Sulfur quantification

Approximately 0.5 g of the *pequi* sample was mineralized by 2:1 hydrogen peroxide (H_2O_2) and perchloric acid ($HClO_4$) digestion at 220 °C for 3 hours. The mineralized sample was dissolved 1:100 in distilled water after which 1 mL of 6 M chloric acid (HCl) and 0.5 g of barium chloride ($BaCl_2$) were added. After 5 minutes, the color was measured in the spectrophotometer at 420 nm (MIYAZAWA, 1999).

2.10 Phosphorus quantification

Approximately 0.5 g of the *pequi* sample was mineralized by 2:1 hydrogen peroxide (H_2O_2) and perchloric acid ($HClO_4$) digestion at 220 °C for 3 hours. The mineralized sample was dissolved 1:100 in distilled water, and 2 mL of 0.25% ammonium metavanadate (NH_4VO_3) and 2 mL of 5% ammonium molybdate ($[NH_4]_2MoO_4$) were added. After 15 minutes, the color was measured with a colorimeter at 660 nm (MIYAZAWA, 1999).

2.11 Nitrogen quantification

Approximately 0.5 g of the *pequi* sample was mineralized by 2:1 hydrogen peroxide (H_2O_2) and perchloric acid ($HClO_4$) digestion at 220 °C for 3 hours. The nitrogen content was then determined by the Microkjeldahl method (HART; FISCHER, 1971).

2.12 Statistical analysis

The results were statistically analyzed using the orthogonal contrasts method (SNEDECOR; COCHRAN, 1967). Two hypothesis and fifteen contrasts were formulated. The formulated hypothesis and contrasts can be seen in Table 2.

3 Results and discussion

In Table 3, it is possible to observe the obtained results for quantitative determinations of nitrogen (N), phosphorus (P), potassium (K), calcium (Ca), magnesium (Mg), sulfur (S), barium (B), copper (Cu), iron (Fe), manganese (Mg), zinc (Zn), pH, and lipid fraction (EE) in the pulp (mesocarp) of the sampled fruits.

The abundance of different mineral elements in this fruit stands out in the comparison of these data with the values obtained for the different fruits economically cultivated (NEPA, 2006). This fact had already been emphasized by Almeida and Silva (1994) and Ferreira et al. (1987). Due to the fact that *pequizeiro* is characteristic of low fertility soils (SANTANA; NAVES, 2003), the mineral contents in the fruits were unexpected leading to the hypothesis that this is a highly efficient plant on nutrient extraction from the soil (FERREIRA et al., 1987; RIBEIRO, 1983).

The average calcium contents were 1.61 $g.kg^{-1}$ with coefficient of variation 7.07%, having significant differences among the sampled areas, except for the contrasts 1 (area I × area II), 11 (area III × area V), 12 (area III × area VI), and 15 (area V × area VI) with the predominance of pequi fruits from regions I and II. The obtained averages are similar to those found by other authors (ANGELONI et al., 2004; GUEDES; ORIÁ, 1978; LIMA, 1980).

The contents found for phosphorus (average of 1.62 $g.kg^{-1}$ with coefficient of variation 5.34%) differ in a significant way in all sampled areas, except for the contrast 1 (area I × area II). The averages obtained are similar to those reported by Angeloni et al. (2004). However, they are higher than the contents reported by Miranda (1986) (0.3 $g.kg^{-1}$), Lima (1980) (0.495 $g.kg^{-1}$), Guedes and Oriá (1978) (0.3055 $g.kg^{-1}$), and Ferreira et al. (1987) (1.00 $g.kg^{-1}$).

Comparing the indexes of pH in pequi fruits, it was observed that there were no significant differences in the different areas. Vera et al. (2007) and Sales (1972) obtained a medium pH of 5.79 and 6.20 respectively higher than those obtained in this study.

The contents found for iron in the current study (average of 16.79 $g.kg^{-1}$ with coefficient of variation 2.00%) differ significantly in all sampled areas, except for contrasts 1 (area I × area II) and contrast 13 (area IV × area V). The averages obtained are similar to those found in the literature (ANGELONI et al., 2004; FERREIRA et al., 1987; GUEDES; ORIÁ,1978; LIMA, 1980).

Furthermore, Miranda (1986) and Angeloni et al. (2004) reported concentrations of potassium, magnesium, and sulfur similar to those found in the present study (average of 5.60, 1.74 e 0.76 $g.kg^{-1}$, respectively, with coefficients of variation 1.047, 5.024 and 4.522% respectively). These metals contents differ in significantly in all sampled areas, except for potassium in contrast 1 (area I × area II), and for magnesium in contrasts 1 (area I × area II), 4 (area I × area V) and 10 (area III × area IV).

Angeloni et al. (2004) and Ferreira et al. (1987) found contents for copper, manganese, and zinc similar to those found in the present study (average of 9.36, 14.41 and 24.84 $mg.kg^{-1}$, respectively, with coefficients of variation 2.62, 1.70, and 1.09% respectively). These metal contents differ significantly in all sampled areas, except for copper in contrasts 1 (area I × area II) and 14 (area IV × area VI).

Nitrogen concentrations (average of 11.48 $g.kg^{-1}$) and fat (average of 58.11 $g.100\ g^{-1}$) found in the present study agree with those found in the literature (BRAIT, 2003; FERREIRA et al., 1987), but differed significantly among the sampled areas, except for contrast 1 (area I × area II).

Observing Tables 4 and 5, With respect to the variance analysis, it can be seen verified that, in general, there were significant differences among the mineral contents of fruits picked in different areas. According to Melo-Junior et al. (2004), the mineral contents variation suggest a diversity among the populations studied in each region considering that this diversity may be the result of environmental factors or heterogeneity among the populations. Vera et al. (2005) and Vera et al. (2007) have already emphasized this peculiarity concerning chemical and physical characteristics of the *pequizeiro* fruit, such as mass, volume, lipid fraction, pH, and visual aspect. This tendency was observed even among the areas III to IV and V

Table 2. Formulated hypothesis and contrasts.

Hypothesis	$H0: Y0 = 0$ $H1: Y0 \neq 0$
Contrasts	$Y1 = (1)\mu1 + (-1)\mu2 + (0)\mu3 + (0)\mu4 + (0)\mu5 + (0)\mu6$
	$Y2 = (1)\mu1 + (0)\mu2 + (-1)\mu3 + (0)\mu4 + (0)\mu5 + (0)\mu6$
	$Y3 = (1)\mu1 + (0)\mu2 + (0)\mu3 + (-1)\mu4 + (0)\mu5 + (0)\mu6$
	$Y4 = (1)\mu1 + (0)\mu2 + (0)\mu3 + (0)\mu4 + (-1)\mu5 + (0)\mu6$
	$Y5 = (1)\mu1 + (0)\mu2 + (0)\mu3 + (0)\mu4 + (0)\mu5 + (-1)\mu6$
	$Y6 = (0)\mu1 + (1)\mu2 + (-1)\mu3 + (0)\mu4 + (0)\mu5 + (0)\mu6$
	$Y7 = (0)\mu1 + (1)\mu2 + (0)\mu3 + (-1)\mu4 + (0)\mu5 + (0)\mu6$
	$Y8 = (0)\mu1 + (1)\mu2 + (0)\mu3 + (0)\mu4 + (-1)\mu5 + (0)\mu6$
	$Y9 = (0)\mu1 + (1)\mu2 + (0)\mu3 + (0)\mu4 + (0)\mu5 + (-1)\mu6$
	$Y10 = (0)\mu1 + (0)\mu2 + (1)\mu3 + (-1)\mu4 + (0)\mu5 + (0)\mu6$
	$Y11= (0)\mu1 + (0)\mu2 + (1)\mu3 + (0)\mu4 + (-1)\mu5 + (0)\mu6$
	$Y12= (0)\mu1 + (0)\mu2 + (1)\mu3 + (0)\mu4 + (0)\mu5 + (-1)\mu6$
	$Y13= (0)\mu1 + (0)\mu2 + (0)\mu3 + (1)\mu4 + (-1)\mu5 + (0)\mu6$
	$Y14= (0)\mu1 + (0)\mu2 + (0)\mu3 + (1)\mu4 + (0)\mu5 + (-1)\mu6$
	$Y15 = (0)\mu1 + (0)\mu2 + (0)\mu3 + (0)\mu4 + (1)\mu5 + (-1)\mu6$

Table 3. Contents ($g.kg^{-1}$ or $mg.kg^{-1}$ in the dry matter) found for some chemical parameters in *pequizeiro* fruits picked in six different areas in the municipalities of Rio Verde, Jataí, and Serranópolis (GO).

Variables	N	P	K	Ca	Mg	S	B	Cu	Fe	Mn	Zn	pH	EE
	$g.kg^{-1}$	$g.kg^{-1}$	$g.kg^{-1}$	$g.kg^{-1}$	$g.kg^{-1}$	$g.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$	$mg.kg^{-1}$		$g.100\ g^{-1}$
Area I average	12.08	2.06	6.00	2.01	1.88	0.87	3.45	10.98	18.06	16.00	27.03	4.23	59.84
Area II average	12.03	2.02	5.94	2.01	1.97	0.93	3.49	11.04	18.02	16.00	27.01	4.14	59.92
Area III average	10.89	1.08	5.06	1.37	1.48	0.57	2.74	8.43	15.13	11.37	21.76	4.05	55.68
Area IV average	11.25	1.40	5.40	1.60	1.56	0.66	2.84	9.03	16.03	12.98	23.60	4.08	57.22
Area V average	11.65	1.68	5.68	1.37	1.85	0.70	2.93	7.90	16.15	14.51	24.00	4.08	57.28
Area VI average	11.02	1.51	5.52	1.34	1.69	0.80	3.13	8.82	17.05	15.67	25.67	4.14	58.73

Table 4. Variance analysis of some chemical parameters of *pequizeiro* fruits native of six regions in the State of Goiás.

Source of variation	GL	N	P	K	Ca	Mg	S	B
Contrast 1	1	0.9527	0.7981	3.2087	0.0001	3.6735	10.8093*	1.3592
Contrast 2	1	743.8167*	504.0050*	1012.3152*	127.1560*	83.2743*	304.9082*	614.2900*
Contrast 3	1	360.0986*	231.5410*	412.1467*	50.6395*	55.7457*	147.0921*	445.8283*
Contrast 4	1	96.3991*	75.7484*	111.8772*	127.1560*	0.4329	94.4227*	325.6731*
Contrast 5	1	587.0898*	157.8821*	266.8309*	137.2240*	19.9149*	17.3430*	125.0364*
Contrast 6	1	691.5283*	464.6998*	901.5372*	127.1560*	121.9283*	430.5365*	673.4396*
Contrast 7	1	324.0067*	205.1510*	342.6239*	50.6395*	88.0395*	237.6501*	496.4201*
Contrast 8	1	78.1850*	60.9956*	77.1922*	127.1560*	6.6285**	169.1271*	369.2066*
Contrast 9	1	540.7420*	136.2292*	211.5183*	137.2240*	40.6949*	55.5359*	153.5724*
Contrast 10	1	68.8359*	52.3247*	132.6069*	17.3073*	2.7529	28.4459*	13.4706*
Contrast 11	1	304.6665*	189.9717*	451.1249*	0.0001	71.6989*	59.9770*	45.3732*
Contrast 12	1	9.2603*	97.7120*	239.6905*	0.1980	21.7423*	176.8137*	183.8270*
Contrast 13	1	83.8682*	42.4207*	94.5600*	17.3073*	46.3536*	5.8130**	9.3987*
Contrast 14	1	27.6011*	7.l0297**	15.7326*	21.1427*	9.0221*	63.4199*	97.7736*
Contrast 15	1	207.6951*	14.9132*	33.1518*	0.1918	14.4755*	30.8319*	46.5440*
Remainder	42							
General average		11.485209	1.623750	5.600208	1.615000	1.739583	0.756667	3.097917
Standard derivation(%)		0.758	5.342	1.047	7.070	5.024	4.522	1.869
Tabulate F values F(0.05;1;35) = 4.08 F(0.01;1;35) = 7.29								

*Significant in 1%; and **significant in 5%.

Table 5. Variance analysis of chemical parameters of *pequizeiro* fruits native of six regions in the State of Goiás.

Source of variation	GL	Cu	Fe	Mn	Zn	pH	EE
Contrast 1	1	0.3021	0.0501	0.2297*	0.0085*	2.6335	0.3915
Contrast 2	1	427.8192*	306.0603*	1393.0449*	1505.9006*	9.6744*	965.2989*
Contrast 3	1	249.8937*	146.4279*	584.1174*	635.7085*	6.9541*	382.7587*
Contrast 4	1	625.4935*	129.6077*	135.6233*	498.9893*	6.6020*	363.2810*
Contrast 5	1	309.0277*	35.8884*	4.8969**	99.7893*	2.6335	68.6130*
Contrast 6	1	450.8994*	298.2793*	1429.0524*	1498.7575*	2.2129	1004.5701*
Contrast 7	1	267.5740*	141.0613*	607.5147*	631.0704*	1.0287	407.6326*
Contrast 8	1	653.2895*	124.5618*	147.0165*	494.8811*	0.8961	387.5238*
Contrast 9	1	328.6550*	33.2569*	7.2479*	97.9569*	0.0001	79.3701*
Contrast 10	1	23.7731*	29.0935*	173.0539*	184.7608*	0.2240	132.3659*
Contrast 11	1	18.7150*	37.3326*	659.3480*	271.1906*	0.2926	144.2240*
Contrast 12	1	9.6386*	132.3395*	1232.7552*	830.3892*	2.2129	519.2002*
Contrast 13	1	84.6739*	0.5129	156.8199*	8.2667*	0.0046	0.2543
Contrast 14	1	3.1370	37.3327*	482.0491*	231.7641*	1.0287	127.2593*
Contrast 15	1	55.2151*	29.0936*	88.9785*	152.4881*	0.8961	116.1359*
Remainder	42						
General average		9.3677	16.79958	14.411667	24.844791	4.11937	58.110626
Standard derivation (%)		2.6222	2.002	1.701	1.092	2.693	0.461
Tabulate F values F(0.05;1;35) = 4.08 F(0.01;1;35) = 7.29							

*Significant in 1% and **significant in 5%.

to VI (Tables 4 and 5). The fruits from areas I and II tend to be similar and have higher values than those found in other areas, fact that can be explained by the high rates of genetic flow in these regions.

The coefficients of variation obtained for all characteristics studied are relatively low (vary from 7.07 to 0.46%) indicating the low variation among the collected fruits in the same area. The trees analyzed in each area probably present low gene variability. Because of the systematic destruction of Bioma Cerrado and the non existence of the traditional ecologic galleries, there is the tendency to higher homogeneity among the vegetal species in the same area with consequent homogeneity of chemical and physical characteristics. Besides, these chemical and physical characteristics of soils are expected to be homogeneous in the same area reflecting on the chemical composition of the fruits.

Table 6. Some daily needed minerals.

	Phosphorus	Potassium	Calcium	Magnesium	Barium	Copper	Iron	Manganese	Zinc
	mg	mg	mg	mg	mg	mg	mg	mg	mg
WHO	-	-	400-500	300	-	-	10-20	2-3	10-15
Franco	1200	3750	1200	280-350	2-7	2-3	5-28	-	12-15
NRD	-	2000	800-1200	280	-	-	10-15	2-5	12-15
HIRSCH	800-1200	2000-3500	800-1200	280-350	-	1,5-3	10-30	-	12-19
Coutinho	1200	2500	800	200-300	-	3,7	12	2,5-7	2,5

Source: Adapted from WHO (1996), NRD (1989), Franco (1992), Hirch (1999) and Coutinho (1981).

The determined contents of zinc, copper, calcium, potassium, magnesium, and phosphorus are higher than those of almost all fruits traditionally cultivated and consumed by Brazilian population. The iron contents are lower than those found in plum only and the manganese contents only than those found in pineapple (NEPA, 2006).

Comparing the values shown in Tables 3, 4, and 5 are with those in Table 6, which shows the values of daily needed minerals recommended by Word Health Organization (VILAS BOAS, 2004), NRD (1989), Franco (1992), Hirch (1999) and Coutinho (1981), it is possible to verify that the *pequizeiro* fruit pulp is a potential potassium, magnesium, copper, and manganese source.

According to Gaw et al. (1999), magnesium is a macroelement that plays an important role in the metabolic processes as a specific coenzyme of certain enzymes. Manganese is a microelement very important in several enzymatic systems constituting part of enzyme urease, responsible for urea elimination such as pyruvate dehydrogenase involved in glucose utilization. Copper is a microelement essential to several important organic functions, such as iron mobilization for hemoglobin synthesis. This mineral abundance and the metabolic/nutritional importance mentioned above evidence the pequi fruit value as food diminishing the likeability of its use as a complementary alternative source of these minerals.

Comparing the results obtained with the mineral composition of the fruits cultivated that are commonly consumed by Brazilians and with the daily ingestion need of magnesium, manganese and copper, it is recommended studies for the *pequizeiro* fruit utilization as a complementary alternative source of these minerals.

4 Conclusions

Pequi fruits native of different areas have significant variability concerning mineral composition and lipid fraction, and fruits picked from the same area have low variation concerning mineral composition and lipid fraction.

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