

## Pulp yield and mineral content of commercial hybrids of yellow passion fruits

### Conteúdo mineral e rendimento de polpa de híbridos comerciais de maracujá-amarelo

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#### Summary

Physical analyses and an analysis of the mineral content were carried out by peroxide-perchloric wet-digestion, taking readings using inductively coupled plasma-atomic emission spectrometry (ICP-AES) and measurements using an analytical balance and digital paquimeter, of three commercial hybrids of *Passiflora edulis f. flavicarpa* Deg.: BRS Sol do Cerrado, BRS Ouro Vermelho and BRS Gigante Amarelo, cultivated and harvested from the experimental area of Embrapa Cerrados, Planaltina, DF, Brazil, in October/2007. Eighteen fruits were evaluated for each hybrid, and presented weights and dimensions superior to those found in the scientific literature, without significant differences between the hybrids. Sol do Cerrado showed less weight loss post storage when compared to the other hybrids, but no significant differences were found with respect to the other physical parameters studied. The mineral contents found in the hybrids were higher than the values found in the scientific literature and in the Brazilian food composition tables (TACO) elaborated by NEPA-UNICAMP. The Sol do Cerrado had a higher iron content than the other hybrids. The hybrids are excellent sources of minerals, especially in comparison with the frozen pulp sold in supermarkets.

**Key words:** *Passiflora edulis*; Physicochemical properties; Elemental composition; Health; Functional foods.

#### Resumo

Análises físicas e de conteúdo mineral foram executadas por meio de digestão peróxido/perclórica com leitura em ICP-AES, e medições, com auxílio de balança analítica digital e paquímetro digital, de três híbridos comerciais de *Passiflora edulis f. flavicarpa* Deg. – BRS Sol do Cerrado, BRS Ouro Vermelho e BRS Gigante Amarelo –, cultivados na área experimental da Embrapa Cerrados, Planaltina-DF, no período de outubro de 2007. Dezoito frutos de cada híbrido foram avaliados e apresentaram pesos e dimensões superiores àqueles encontrados na literatura científica, sem diferenças significativas entre os híbridos. Sol do Cerrado apresentou menor perda de peso após o armazenamento em relação aos demais híbridos. Não foram encontradas diferenças significativas em relação aos demais parâmetros físicos estudados. O conteúdo de minerais encontrados nos híbridos foi superior àqueles encontrados na literatura científica e na Tabela Brasileira de Composição de Alimentos (UNICAMP, 2006) elaborada pela NEPA-UNICAMP. Sol do Cerrado apresentou teores de ferro superiores aos demais híbridos, o que pode ser devido a diferenças na absorção desse elemento por parte do híbrido. Os híbridos mostraram-se excelentes fontes de minerais, especialmente em comparação com a polpa de maracujá-amarelo congelada de supermercado.

**Palavras-chave:** *Passiflora edulis*; Propriedades físicoquímicas; Composição elementar; Saúde; Alimentos funcionais.

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### 1 Introduction

Passiflora is a tropical culture and about 90% of the worldwide production is concentrated in Brazil, which has the biggest production and consumption of Passiflora in the world, *P. edulis* f. *flavicarpa* Deg being the most cultivated. The Passiflora pulp is more consumed worldwide than the fruit *in natura*, since the fruit has a short "shelf life".

Embrapa Cerrados has a collection with more than 150 accesses of passifloras, and has developed a plant breeding program for *P. edulis* with three commercial hybrids showing good agronomic characteristics. Higher, disease-resistant fruits, with improved nutritional value are a differential for the population.

Fruits are an easy, low cost source of minerals (GONDIM et al., 2005). The IDR is the amount of vitamins, minerals and proteins that should be consumed daily for a healthy population (BRASIL, 1998).

According to Chitarra and Chitarra (1990), the appearance of the fruits is one of the quality components, including the size (dimensions, weight and volume) and shape (longitudinal versus transversal diameters), in addition to the nutritional value, such as the mineral content. The pulp content is directly related to the fruit dimensions: longitudinal and transversal length, fruit, peel and seed weights (MACHADO et al., 2003).

The objective of this work was to determine the mineral and pulp contents of the commercial varieties of the following *P. edulis* hybrids: BRS Gigante Amarelo, BRS Ouro Vermelho and BRS Sol do Cerrado, all cultivated in Embrapa Cerrados, Planaltina, Brazil.

### 2 Material and methods

The fruits were harvested from the experimental area of Embrapa Cerrados, located in Planaltina, DF, Brazil. Eighteen (18) fruits were harvested, randomly selected from each commercial hybrid of *P. edulis* in October/2007. The pulps were extracted with the aid of a plastic bolter.

The fruits of the three hybrids of *P. edulis* were analyzed with respect to the following parameters: weight of the fresh fruit and after seven days of storage at 10 °C (CHITARRA and CHITARRA, 1990), weight of the peels and seeds and the pulp volume, to obtain the following data: weight of the fresh fruit, water loss, percentage of peels and seeds per fruit, pulp yield and pulp density. The peel is the epicarp and the mesocarp was incorporated into the pulp (endocarp).

For the analysis of the macro and micronutrients, the dried pulps were wet-digested using 0.2 g of dry material and a perchloric acid/hydrogen peroxide mixture (2 mL/1 mL) at 300 °C for 25 min. The readings were made using inductively coupled plasma-atomic emission spectrometry (ICP-AES), using yttrium (Y) as the internal

standard (ADLER and WILCOX, 1985). All analyses were carried out in triplicate and the results were subjected to a statistical analysis. The data from the study were evaluated by the software Excel from Microsoft and GENES, to compare the means using Tukey's test at  $p \leq 0.05$ .

### 3 Results and discussion

Table 1 shows the values found in the physical analyses of the commercial hybrids of *P. edulis*.

The fruits of the three hybrids were heavier than the values demanded by the consumers (over 120 g), with no significant differences between the genotypes. The values were similar to those described by Godoy et al. (2007), who also studied fruits from *Passiflora edulis* and found a total average weight of 211.30 g, to those found by Farias et al. (2007), with an average fruit weight of 177.28 g; to those found by Machado et al. (2003), with an average fruit weight of 154.2 g and to those found by Negreiros et al. (2007), with 166.28 g.

With respect to the water loss during storage (seven days), the losses were small and significantly different between the genotypes. The hybrid Sol do Cerrado presented the smallest water loss in comparison to Ouro Vermelho and Gigante Amarela, an important characteristic for the commercialization of *in natura* fruits, since this characteristic enhances the shelf life.

There were no significant differences between the other parameters ( $p \leq 0.05$ ).

The pulps studied showed an average density between 1.04 and 1.06, superior to the data from Machado et al. (2003), who found a value of 0.75 g.cm<sup>-3</sup>, but similar to the density found by Soares et al. (2004), of 1.045. A high concentration of total soluble solids could explain the increase in pulp density.

Table 2 shows the mineral contents found in the pulps of the three commercial hybrids of *P. edulis*.

There are few scientific data available concerning the macro and micronutrients of Passiflora, and all are for *P. edulis*. It is common knowledge that fruits are an excellent source of minerals. There was no significant difference between the genotypes with the exception of the iron content of BRS Sol do Cerrado, which was higher than that of the other hybrids.

The hybrids showed high mineral contents when compared to the values found by Soares et al. (1977) for *P. edulis* - in mg.100 g<sup>-1</sup>: 238 (K), 20.2 (Na), 4.1 (Ca), 10.1 (Mg), 0.18 (Fe), 0.24 (Zn), 0.06 (Cu) and 0.16 for Mn. The only difference was that BRS Sol do Cerrado showed a higher iron content in relation to the other hybrids. This variation could reflect genetic differences in the mineral absorption and accumulation capacities. However complementary studies are necessary to confirm this observation. Table 3 shows a comparison of the mineral

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**Table 1.** Physical analyses of the commercial hybrids of *P. edulis* – BRS Ouro Vermelho, BRS Sol do Cerrado and BRS Gigante Amarelo. FG: value of F of the genotype.

Parameter	Genotype	Max. value	Min. value	Mean	Standard deviation	FG
Fresh fruit weight (g)	BRS Ouro Vermelho	270.00	119.00	190.86 <sup>a</sup>	44.87	0.4491 <sup>ns</sup>
	BRS Gigante Amarelo	256.00	123.00	202.11 <sup>a</sup>	38.56	
	BRS Sol do Cerrado	255.00	122.00	190.94 <sup>a</sup>	46.03	
Water loss (%)	BRS Ouro Vermelho	0.13	0.05	0.09 <sup>a</sup>	0.02	0.0140 <sup>*</sup>
	BRS Gigante Amarelo	0.13	0.04	0.08 <sup>a</sup>	0.02	
	BRS Sol do Cerrado	0.10	0.04	0.06 <sup>b</sup>	0.02	
Peels weight (g)	BRS Ouro Vermelho	148.00	63.00	92.36 <sup>a</sup>	24.02	0.1903 <sup>ns</sup>
	BRS Gigante Amarelo	133.00	72.00	93.56 <sup>a</sup>	16.65	
	BRS Sol do Cerrado	121.00	54.00	96.89 <sup>a</sup>	25.11	
% peels/fruit	BRS Ouro Vermelho	67.23	35.96	51.34 <sup>a</sup>	9.41	0.7629 <sup>ns</sup>
	BRS Gigante Amarelo	68.35	37.25	49.10 <sup>a</sup>	8.47	
	BRS Sol do Cerrado	74.68	35.29	53.32 <sup>a</sup>	9.99	
Seeds weight (g)	BRS Ouro Vermelho	41.79	7.28	25.60 <sup>a</sup>	9.31	0.1761 <sup>ns</sup>
	BRS Gigante Amarelo	38.58	11.61	25.95 <sup>a</sup>	7.44	
	BRS Sol do Cerrado	48.00	10.26	24.86 <sup>a</sup>	10.81	
% seeds/fruit	BRS Ouro Vermelho	17.79	6.50	13.73 <sup>a</sup>	3.12	0.8978 <sup>ns</sup>
	BRS Gigante Amarelo	16.92	9.01	13.17 <sup>a</sup>	2.13	
	BRS Sol do Cerrado	17.77	875	12.97 <sup>a</sup>	3.03	
Weight pulp without seeds (g)	BRS Ouro Vermelho	122.62	28.93	63.90 <sup>a</sup>	25.84	1.2099 <sup>ns</sup>
	BRS Gigante Amarelo	120.64	38.12	72.30 <sup>a</sup>	24.03	
	BRS Sol do Cerrado	97.21	20.53	60.90 <sup>a</sup>	22.52	
Pulp volume / fruit (mL)	BRS Ouro Vermelho	109.00	28.00	61.36 <sup>a</sup>	25.05	0.9255 <sup>ns</sup>
	BRS Gigante Amarelo	111.00	36.00	68.07 <sup>a</sup>	22.71	
	BRS Sol do Cerrado	94.00	20.00	58.33 <sup>a</sup>	21.39	
Yield pulp/fruit (%)	BRS Ouro Vermelho	47.81	15.82	33.41 <sup>a</sup>	8.63	0.6894 <sup>ns</sup>
	BRS Gigante Amarelo	46.44	23.50	34.51 <sup>a</sup>	6.75	
	BRS Sol do Cerrado	46.41	12.66	31.45 <sup>a</sup>	8.52	
Pulp density	BRS Ouro Vermelho	1.12	1.01	1.04 <sup>a</sup>	0.03	3.3547 <sup>ns</sup>
	BRS Gigante Amarelo	1.19	1.01	1.06 <sup>ab</sup>	0.04	
	BRS Sol do Cerrado	1.09	0.99	1.04 <sup>b</sup>	0.02	

<sup>ns</sup>non-significant; <sup>\*</sup>significant at 5%. #Values followed by the same small letters for the same genotypes are not significantly different (Tukey  $p \leq 0.05$ ).

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**Table 2.** Results of the analyses for the macro and micronutrients of the commercial hybrids of *P. edulis* – BRS Sol do Cerrado, BRS Gigante Amarelo and BRS Ouro Vermelho.

Parameter	Genotype	Mean (mg.100 g <sup>-1</sup> )	Standard deviation	FG
Nitrogen	BRS Ouro Vermelho	866.00 <sup>a</sup>	39.60	1.4612 <sup>ns</sup>
	BRS Gigante Amarelo	909.00 <sup>a</sup>	82.02	
	BRS Sol do Cerrado	815.50 <sup>a</sup>	92.63	
Phosphorus	BRS Ouro Vermelho	277.00 <sup>a</sup>	8.49	1.6011 <sup>ns</sup>
	BRS Gigante Amarelo	274.50 <sup>a</sup>	21.92	
	BRS Sol do Cerrado	271.50 <sup>a</sup>	2.12	
Potassium	BRS Ouro Vermelho	1335.00 <sup>a</sup>	22.63	0.5235 <sup>ns</sup>
	BRS Gigante Amarelo	1298.50 <sup>a</sup>	126.57	
	BRS Sol do Cerrado	1349.00 <sup>a</sup>	65.05	
Calcium	BRS Ouro Vermelho	14.00 <sup>a</sup>	1.41	4.2999 <sup>ns</sup>
	BRS Gigante Amarelo	14.00 <sup>a</sup>	1.41	
	BRS Sol do Cerrado	16.00 <sup>a</sup>	1.41	
Magnesium	BRS Ouro Vermelho	90.00 <sup>a</sup>	1.41	1.4354 <sup>ns</sup>
	BRS Gigante Amarelo	94.50 <sup>a</sup>	1.41	
	BRS Sol do Cerrado	97.00 <sup>a</sup>	4.24	
Sulfur	BRS Ouro Vermelho	124.50 <sup>a</sup>	3.54	1.8169 <sup>ns</sup>
	BRS Gigante Amarelo	136.00 <sup>a</sup>	2.83	
	BRS Sol do Cerrado	124.00 <sup>a</sup>	5.66	
Boron	BRS Ouro Vermelho	0.16 <sup>a</sup>	0.11	4.5507 <sup>ns</sup>
	BRS Gigante Amarelo	0.12 <sup>a</sup>	0.10	
	BRS Sol do Cerrado	0.23 <sup>a</sup>	0.03	
Copper	BRS Ouro Vermelho	1.31 <sup>a</sup>	0.40	0.2872 <sup>ns</sup>
	BRS Gigante Amarelo	1.58 <sup>a</sup>	0.69	
	BRS Sol do Cerrado	1.37 <sup>a</sup>	0.00	
Iron	BRS Ouro Vermelho	4.54 <sup>a</sup>	0.16	7.7594 <sup>*</sup>
	BRS Gigante Amarelo	5.74 <sup>a</sup>	0.55	
	BRS Sol do Cerrado	5.88 <sup>b</sup>	0.20	
Manganese	BRS Ouro Vermelho	0.32 <sup>a</sup>	0.09	0.2878 <sup>ns</sup>
	BRS Gigante Amarelo	0.42 <sup>a</sup>	0.22	
	BRS Sol do Cerrado	0.41 <sup>a</sup>	0.23	
Zinc	BRS Ouro Vermelho	1.60 <sup>a</sup>	0.13	1.5431 <sup>ns</sup>
	BRS Gigante Amarelo	1.57 <sup>a</sup>	0.14	
	BRS Sol do Cerrado	2.65 <sup>a</sup>	0.68	
Aluminum	BRS Ouro Vermelho	3.97 <sup>a</sup>	1.25	0.5232 <sup>ns</sup>
	BRS Gigante Amarelo	4.28 <sup>a</sup>	1.06	
	BRS Sol do Cerrado	4.23 <sup>a</sup>	0.45	
Sodium	BRS Ouro Vermelho	5.52 <sup>a</sup>	0.39	0.2381 <sup>ns</sup>
	BRS Gigante Amarelo	5.74 <sup>a</sup>	0.06	
	BRS Sol do Cerrado	6.14 <sup>a</sup>	0.63	

<sup>ns</sup>non-significant; <sup>\*</sup>significant at 5%. #Values followed by the same small letters for the same minerals are not significantly different (Tuckey  $p \leq 0.05$ ).

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**Table 3.** Macro and micronutrients of the commercial hybrids of *P. edulis* – Sol do Cerrado, Gigante Amarelo and Ouro Vermelho and frozen pulps from supermarkets (UNICAMP, 2006).

Parameter	Genotype	Mean (mg.100 g <sup>-1</sup> )	Frozen passiflora pulp
Nitrogen	BRS Ouro Vermelho	866.00 <sup>a</sup>	
	BRS Gigante Amarelo	909.00 <sup>a</sup>	-
	BRS Sol do Cerrado	815.50 <sup>a</sup>	
Phosphorus	BRS Ouro Vermelho	277.00 <sup>a</sup>	
	BRS Gigante Amarelo	274.50 <sup>a</sup>	15.00
	BRS Sol do Cerrado	271.50 <sup>a</sup>	
Potassium	BRS Ouro Vermelho	1335.00 <sup>a</sup>	
	BRS Gigante Amarelo	1298.50 <sup>a</sup>	288.00
	BRS Sol do Cerrado	1349.00 <sup>a</sup>	
Calcium	BRS Ouro Vermelho	14.00 <sup>a</sup>	
	BRS Gigante Amarelo	14.00 <sup>a</sup>	5.00
	BRS Sol do Cerrado	16.00 <sup>a</sup>	
Magnesium	BRS Ouro Vermelho	90.00 <sup>a</sup>	
	BRS Gigante Amarelo	94.50 <sup>a</sup>	10.00
	BRS Sol do Cerrado	97.00 <sup>a</sup>	
Sulfur	BRS Ouro Vermelho	124.50 <sup>a</sup>	
	BRS Gigante Amarelo	136.00 <sup>a</sup>	-
	BRS Sol do Cerrado	124.00 <sup>a</sup>	
Boron	BRS Ouro Vermelho	0.16 <sup>a</sup>	
	BRS Gigante Amarelo	0.12 <sup>a</sup>	-
	BRS Sol do Cerrado	0.23 <sup>a</sup>	
Copper	BRS Ouro Vermelho	1.31 <sup>a</sup>	
	BRS Gigante Amarelo	1.58 <sup>a</sup>	0.05
	BRS Sol do Cerrado	1.37 <sup>a</sup>	
Iron	BRS Ouro Vermelho	4.54 <sup>a</sup>	
	BRS Gigante Amarelo	5.74 <sup>a</sup>	0.30
	BRS Sol do Cerrado	5.88 <sup>b</sup>	
Manganese	BRS Ouro Vermelho	0.32 <sup>a</sup>	
	BRS Gigante Amarelo	0.42 <sup>a</sup>	0.07
	BRS Sol do Cerrado	0.41 <sup>a</sup>	
Zinc	BRS Ouro Vermelho	1.60 <sup>a</sup>	
	BRS Gigante Amarelo	1.57 <sup>a</sup>	0.20
	BRS Sol do Cerrado	2.65 <sup>a</sup>	
Aluminum	BRS Ouro Vermelho	3.97 <sup>a</sup>	
	BRS Gigante Amarelo	4.28 <sup>a</sup>	-
	BRS Sol do Cerrado	4.23 <sup>a</sup>	
Sodium	BRS Ouro Vermelho	5.52 <sup>a</sup>	
	BRS Gigante Amarelo	5.74 <sup>a</sup>	8.00
	BRS Sol do Cerrado	6.14 <sup>a</sup>	

\*Values followed by the same small letters for the same minerals are not significantly different (Tuckey  $p \leq 0.05$ ).

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contents found in the hybrids with the values found in frozen pulps obtained from supermarkets (UNICAMP, 2006). The results show that the hybrids had higher mineral contents, with the exception of Na, a desirable nutritional characteristic.

### 4 Conclusions

The commercial varieties of *P. edulis* developed by Embrapa Cerrados showed several differentiated physical and nutritional characteristics.

- Fruits heavier than demanded by consumers;
- High pulp yield;
- Elevated mineral content.

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