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Processing

Passiflora foetida yielding and nutritional composition

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Abstract - Even though wild maracuja (*Passiflora foetida*) is cultivated in tropical areas, no thorough investigation regarding its yield or nutritional composition is easily available. This paper aims to estimate its fruit yield, using four staking systems; as well as determine both its fruit pulp and peel chemical composition. The treatments used were T1= No staking, T2= A vertical rod, T3= A horizontal rod, 60 cm from the ground, T4= Two horizontal poles, 60 and 120 cm from the ground, and T5= Using horizontal trellises, 80 cm above ground. The findings showed T5, T4, T3, T2 and T1 to yield 1.40, 1.05, 0.66, 0.40 and 0.35 tons of fruits per hectare, respectively. In general, the fruit pulp held higher nutrient content than that of fruit peel. The pulp presented 2.6%, 4.5% and 24.3% protein, lipids and carbohydrates, respectively. We conclude this genotype to bear low yielding potential, which may be lightly enhanced when cultivated using horizontal trellises.
Index terms: Physicochemical composition, horizontal trellises, Amazonian fruit.

Composição nutricional e produtividade de *Passiflora foetida*

Resumo - Apesar de que o maracujaí (Passiflora foetida) é cultivado nos trópicos, há falta de trabalhos relacionados à sua produtividade e composição nutricional. O objetivo deste trabalho foi estimar a produtividade desta espécie utilizando quatro sistemas de tutoramento, assim como determinar a composição química da polpa e da pele, separadamente. Os tratamentos utilizados foram: T1= sem tutoramento; T2= uma vara vertical; T3= uma vara horizontal a 60 cm do solo; T4= duas varas horizontais a 60 e 120 cm do solo, e T5= usando uma latada a 80 cm do solo. Resultados mostraram que T5; T4; T3;T2 e T1 produziram 1,4; 1,05; 0,66; 0,40 e 0,35 t de frutos por hectare, respectivamente. Em geral, a polpa da fruta teve teores mais elevados de nutrientes que a pele. A polpa apresentou 2.6%, 4.5% e 24.3% de proteínas, lipídeos e carboidratos, respectivamente. Portanto, este genótipo tem baixo potencial produtivo, mas pode ser melhorado levemente utilizando uma latada.
Termos para indexação: Composição físico-química, latada, fruto amazônico.

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Passiflora foetida grows wild in the Amazonian region. Agronomical and nutritional composition investigations must be undertaken so as to ascertain its commercial potential.

Genus *Passiflora* L. comprises about 524 species, being 500 from the Americas (FEUILLET; MACDOUGAL, 2007). South America holds 95% of *Passiflora* species (YOCKTENG et al., 2011). In spite of the high biodiversity shown by this genus, 95% of the Brazilian area being employed for its cultivation is just covered with yellow passion fruit (*P. edulis* f. *flavicarpa*) (MELETTI; BRÜCKNER, 2001). The annual mean fruit production from 2010 to 2014 showed to be 856,000 tons in 59,000 hectares, with mean fruit yield of 14.5 t ha^{-1} (IBGE, 2014).

The species *P. foetida* also presents a genetic diversity (BEENA; BEEVY, 2015), and in general it is considered to be a medicinal weed. Ethnobotanical studies pointed its leaves and fruits in treatment of asthma, icterus, skin disorders, inflammation, digestion disorders, stomachache, constipation, flatulence, dizziness (WAGNER et al., 1990), and anti-cancer activity (PURICELLI et al., 2003).

This wild species releases an unpleasant smell. Its small sweet orange fruits (<2 cm of diameter,) taste like commercial fruits such as 'Granadilla' (*P. ligularis*) or 'Maracujá do Mato' (*P. cincinnata*). Therefore, its yielding and cultivation methods should be determined in order for it to be marketed either *in natura* or processed.

As passion fruit is cultivated using staking systems (COSTA et al., 2008) this paper aims to determine which staking system may lead to a greater fruit yield. In addition, it was estimated both fruit peel and pulp chemical composition.

Mature fresh fruit were collected from a wild maracuja, growing alongside Benjamin Constant to Atalaia do Norte city roadway Km 12 (4º 26' S and 70º 06' W). The fruits were washed in water, next the seeds were winkled out. The seeds with aril were fermented in water for 72h at ambient temperature. Then, they were dried for 48h at room temperature (28ºC). Finally, the seeds were kept in glass hermetic flasks at 5.6 ºC and 30% of relative moisture.

The staking systems experiment was carried out at experimental horticultural station from Instituto Nacional de Pesquisas da Amazônia (INPA) located at Km 14 on the AM-10 highway in Manaus. The soil was red-yellow Oxisol. The local climate is 'Af' type, with mean annual 2450 mm rainfall (ALVARES et al., 2013).

The sowing was done on December 15th, 2013, using Styrofoam trays with 72 cells and sterile substrate (50% of soil and 50% of organic compost). This sterilization was done using 0.5% HCl. After two weeks, seedlings with two true leaves were transplanted to 300 ml plastic cups using the same sterile substrate. On January 11th, 2014, the seedling were transplanted into holes of 30x40 cm of diameter and depth respectively. The fertilization per hole was based on 2 kg of organic compost, 100 g of triple superphosphate, 80 g of KCl and 40 g of urea. The harvest was performed from third to sixth month, when the yielding cycle finished.

The experiment was carried out in randomized block design, with 5 treatments, 3 blocks and 5 plants per plot, which were spaced at 2 m x 2 m. The treatments were T1= No staking, T2= A vertical rod, T3= A horizontal rod, 60 cm from the ground, T4= Two horizontal rods, 60 and 120 cm from the ground, and T5= Using horizontal trellises, 80 cm from the ground. The harvest was done weekly from the fourth to the sixth month, when fruits had yellow pericarp . The traits assessed were number fruit number, fruits length and diameter, seed number per fruit and fruit yield.

The physicochemical composition was performed in Foods and Nutrition Laboratory of INPA. One composite sample of fruits from all treatments was collected in a polyethylene bag and carried to the laboratory. Then 20 healthy fruits were selected and washed in water through immersion in 400 ppm of hypochlorite sodium for 30 minutes. Next, they were washed and submersed in water at 43ºC for 24h. Then, fruits were cut in the middle with stainless steel knife and the seeds and pulp separated from the peel. The pulp was isolated from the seeds using electric depulper. Both pulp and skin were dried in a stove with forced air circulation at 60ºC for 72h. Then they were grinded and sieved at 1.5 mm mesh in small polyethylene bags. Centesimal analyses in proteins, carbohydrates, lipids, ashes and moisture content were performed in triplicate for these samples. These analyses followed the recommendations of the Association of Official Analytical Chemist (1995). Agronomical data were analyzed through analyses of variance (ANOVA) and Scott-Knott mean tests ($P<0.05$). Laboratory data estimated pulp and peel means and standard deviations. The software used was GENES (CRUZ, 2013).

The fruit yield was significantly affected by system staking and ranged from 0.4 to 1.4 t ha^{-1} (Table 1). The treatments T5, T4 and T3 increased the fruit yield by 300%, 200% and 89% respectively. However, using horizontal trellises (T5) yielded more than others (Table 1), it was threefold the one, which used no staking system (T1). The second most recommendable one was that with two horizontal rods at 60 and 120 cm from the ground (T4). The staking using a horizontal rod at 60 cm from ground (T3) increased fruit yield, but just about 50% that of T4 and T5. The staking that used a vertical stick was ineffective in increasing the fruit yield. On the other side, the mean Brazilian yield of *P. edulis* is 14.5 t ha^{-1} (IBGE, 2014), therefore this wild maracuja bears lower yield potential than that *P. edulis*. These findings suggest the genetic improvement would be necessary.

Treatments T5, T4, T3 and T2 increased the number of fruits per plant significantly by 195%, 130%, 48% and 92% respectively. This would indicate that any kind of staking would significantly increase the number of fruits per plant, including the simplest staking with one vertical rod (T2). Nevertheless, horizontal trellises showed to be the most efficient one. Given the yield and number of fruits per plant findings one infers staking to be necessary for farming small-passion fruit, just as it happens with commercial varieties of yellow and purple passion fruit.

A significant increase of fruit yield and number of fruits per plant by stacking (Table 1) may have been related to increased flowers exposure. Being that T5 exposes more than T4, and so on (T5>T4>T3>T2>T1), which would facilitate fecundation by insects (COSTA et al., 2008). This would account for the efficiency of conduction in horizontal trellises to increase the fruits productivity. However, depending on their budget and time to dedicate to the management of this crop, any one of these staking systems, but for the one vertical rod one, could be recommended to the family farmers in the state of Amazonas.

Means multiple comparison tests detected no significant differences ($P \leq 0.05$) for fruit traits such as length, diameter, mean mass and seed number per fruit. This would indicate these characters not to be affected by staking. However, the lowest values of these traits were found for the treatment with no staking. Indicating that the lack of staking would tend to diminish fruit size and mass.

It was found that, in general, pulp holds more nutrients than peel does, except for moisture, potassium and iron (Tables 2 and 3). On the other hand, moisture and protein content (67% and 2.6%, respectively) showed to be similar to those of yellow (72.2% and 3%) (ROMERO-RODRIGUEZ et al., 1994) and purple (72% and 3.1%) (SCHOTSMANS; FISCHER, 2011) passion fruit varieties. Small passion fruit exhibited higher lipid content (4.5%) than yellow (0.12%) (ROMERO-RODRIGUEZ et al., 1994) and purple (0.07-0.7%) (SCHOTSMANS; FISCHER, 2011) passion fruit did. Regarding carbohydrates content small passion fruit had a lower amount (24.3%) than yellow (38.1%) and purple (37.1%) passion fruit did (CHAN et al., 1972).

Considering the macro and microelements one finds sodium, potassium and magnesium contents to have been lower in small passion fruit (1.15 mg, 0.68 mg and 0.7 mg) than in yellow (8 mg, 208 mg and 28 mg) (ROMERO-RODRIGUEZ et al. 1994) and purple passion fruit (7-30 mg, 100-764 mg and 16-29 mg) (SCHOTSMANS; FISCHER, 2011; ZIBADI; WATSON, 2004). Similarly, micronutrients such as zinc, iron and copper (54.8 µg, 18.5 µg and 4 µg respectively) were lower in mini-passion fruit than in yellow (600 µg, 600 µg and 200 µg) (ROMERO-RODRIGUEZ et al., 1994) and purple passion fruit (100 µg, 1600 µg and 100 µg) (ZIBADI; WATSON, 2004). Therefore, this fruit would have a lower amount of nutrients than commercial passion fruit would.

Fruit peel has proved to be relevant as a source of nutraceuticals in the diet of humans or animals. Thus, the peels of banana (AGAMA-ACEVEDO et al., 2016), mango (JAHURUL et al., 2015), opuntia (KOUBAA et al., 2015), rambutan (WANLAPA et al. 2015), passion fruit (JANEBRO et al., 2008; KULKARNI; VIJAYANAND, 2010) among others, have been utilized. In this study, we have found that in general the pulp holds more nutrients, with higher contents of K and Fe (4.3 and 42.5 µg/100 g) (Table 3).

In addition, commercial passion fruit (*P. edulis*) peel flour presented 9.4% moisture, 3.9% protein, 0.3% lipids, 79.4% carbohydrates and 6.9% ash contents (CAZARIN et al., 2014). Yet ,wild maracuja peel displayed 86%, 0.5%, 0.6%, 11.7% and 1.1%, respectively (Table 2), of the formerly mentioned nutrients. It can be explained on account of making peel flour decreases moisture raising the percentage of nutrients. Despite this, this wild maracuja showed twice the lipids content the commercial passion fruit peel flour did. Hence, this genotype peel flour would have higher lipids content than commercial *P. edulis*.

All these findings suggest that this wild maracuja (*P. foetida*) is more productive when staked with horizontal trellises (1.4 t ha^{-1}), yet its yielding is ten times lower that *P. edulis*. Then, a breeding program must include this genotype an another ones from the same site.

In general, pulp and peel macro and micronutrient content showed to be low relative to the commercial passion fruit (*P. edulis*). However, the sweet wild maracuja lipid content has shown to be higher both in the peel and pulp. Other comparative studies will be necessary so as to ascertain its acceptability for consumers both *in natura* and processed foods.

Table 1- Morphoagronomic features means of wild maracuja (*Passiflora foetida* L.) grown in different staking systems. Manaus, 2013.

Staking type	Fruit number per plant	Yield (t ha^{-1})	Fruit length (cm)	Fruit diameter (cm)	Fruit mean mass (g)	Seed number per fruit
T1	97.6 d	0.35 d	1.86 a	1.73 a	1.3 a	26.6 a
T2	187.5 c	0.40 d	1.89 a	1.77 a	1.4 a	30.6 a
T3	144.7 c	0.66 c	1.94 a	1.77 a	1.5 a	37.3 a
T4	224.6 b	1.05 b	1.89 a	1.75 a	1.4 a	30.2 a
T5	288.2 a	1.40 a	1.92 a	1.76 a	1.5 a	32.3 a
Mean	188.52	0.77	1.90	1.76	1.42	31.40
CV (%)	38.82	57.95	1.62	0.95	5.89	12.41

Equal letters indicate that there was no significant difference by Skott and Knott test ($P < 0.05$)
Legend: T1 = No staking. T2 = A vertical rod. T3 = A horizontal rod 60 cm above the ground. T4 = Two horizontal poles 60 and 120 cm from the ground. Trellis T5 = 80 cm from the ground

Table 2- Chemical composition in 100 g of whole matter of peel and pulp of wild maracuja (*Passiflora foetida* L.) of the upper Solimões region, Amazonas, Manaus, 2014.

Component	Pulp	Peel
Moisture (g)	67.48 ± 0.29	86.09 ± 0.11
Protein (g)	2.55 ± 0.05	0.53 ± 0.00
Lipids (g)	4.47 ± 0.08	0.60 ± 0.00
Glycids (g)	24.26 ± 0.05	11.68 ± 0.09
Ash (g)	1.24 ± 0.05	1.09 ± 0.09
Calories (kcal)	147.53 ± 0.02	54.28 ± 0.05

Table 3- Mean concentration values of micro and macro elements in 100 g of whole matter of peel and pulp of wild maracuja (*Passiflora foetida* L.) of the upper Solimões region, Amazonas, Manaus, 2014.

	Na (mg)	K (mg)	Ca (mg)	Mg (mg)	Mn (µg)	Zn (µg)	Fe (µg)	Cu (µg)
Peel	1.15±0.01	4.33±0.15	4.247±0.07	0.68±0.00	3.81±0.15	35.90±0.92	42.46±1.36	1.24±0.27
Pulp	1.15±0.01	0.68±0.01	5.28±0.60	0.71±0.01	5.28±0.17	54.8±1.47	18.52±2.3	4.04±1.08

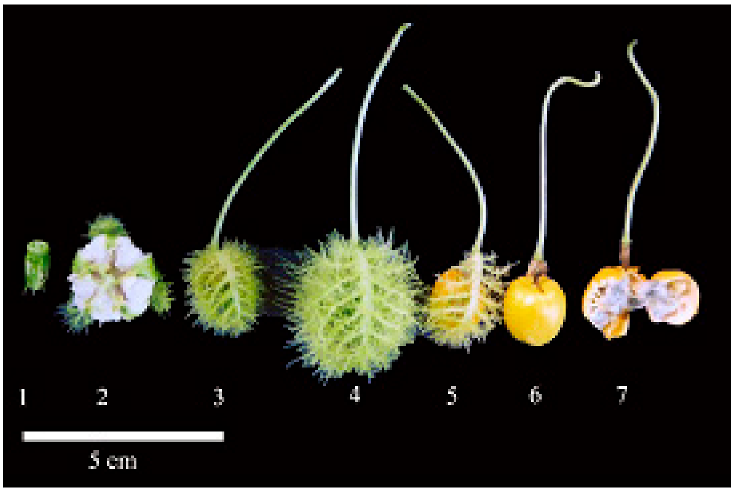

Figure 1- Ripening phases of wild maracuja fruits (*Passiflora foetida* L.). 1 and 2: flowering phase; 3 to 5: immature fruits; 6 and 7: mature fruits.

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