

Full Length Research Paper

Chemical characteristics of fruits of two species of *Physalis* under nitrogen fertilization

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Although small fruits, with some exceptions, are not yet as popular in Brazil, some farmers have invested in this market and the genus *Physalis* can be an important alternative source of income due to its high added value and possibility of cultivation in small areas. To date, there are no specific fertilizer recommendations for even the most cultivated species (*Physalis peruviana*) and therefore the goal of this study was to evaluate the effects of nitrogen fertilization on quality of fruits of *Physalis peruviana* and *Physalis pubescens*. Plants were grown in 5 L pots containing soil and maintained in a controlled environment, in greenhouse. Treatments consisted of five N levels (kg ha⁻¹): 0, 200, 250, 300 and 350, with seven replicates per treatment. Variables evaluated were total soluble sugars and reducing sugars, phenolics, pH, titratable acidity and fruit diameter. Nitrogen increased soluble sugars (350 kg ha⁻¹) and reducing sugars (300 kg ha⁻¹), mainly in *P. pubescens*. There was a slight increase of juice pH, but concentrations of total phenols and citric acid decreased with increasing levels of N. Fruit diameter of the two species of *Physalis* was increased by N fertilization, and the best N level was 300 kg ha⁻¹.

Key words: *Physalis peruviana*, *Physalis pubescens*, reducing sugars, titratable acidity, total phenolics.

INTRODUCTION

Physalis is a plant of the family Solanaceae and according to El Sheikha et al. (2010) there are about 453 species, 100 of which are well known, and Mexico is considered the center of diversity of the genus (Whitson, 2012). Several species have shown important biological activities that turn them potential sources of pharmacological products (Tomassini et al., 2000; Wu et al., 2005; Arun and Asha, 2007).

The fruit of *Physalis* is sweet and slightly acid, with high

levels of vitamins A, C, phosphorus and iron, as well as flavonoids and phytosterols (Rufato et al., 2008). The production and quality of the fruit depends on the balance of various natural and anthropomorphic environmental factors; among them, the soil fertility is the easiest to control and its proper management can result not only in increments of crop yield, but higher quality of the fruit (Valencia et al., 2003), through biochemical and physiological processes occurring in plants (Ferreira et

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Table 1. Soil analysis.

Organic matter	P mg dm ⁻³	K cmol _c dm ⁻³	Ca cmol _c dm ⁻³	Mg cmol _c dm ⁻³	pH CaCl ₂	V (%)	pH SMP	SB cmol _c dm ⁻³	H + Al cmol _c dm ⁻³
60.31	3.46	0.40	4.86	2.10	4.6	44.20	5.30	7.36	9.29

al., 2006). Among them the photosynthetic activity and the rate of photosynthate translocation directly interferes with fruit quality, which can be understood as a set of different individual internal (color, odor, pH, soluble solids, etc.) and external characteristics (size, shape, color, etc.).

Nitrogen (N) has great effect on growth and absorption rates of other elements by the plant, and is one of the most important nutrients for plant nutrition. Nitrogen fertilization affects vegetative and reproductive characteristics of plants, enhances and increases the protein and nucleic acid synthesis, and promotes vegetative growth and the formation of floral and fruit buds. In Brazil, many crops are fertilized empirically, thus the experience of farmers prevails: But this may imply economic losses by a lack or excess of nutrients, which may result in changes in the characteristics of the fruit with decreased organoleptic quality.

Therefore, the objective of this study was to evaluate the effects of different levels of nitrogen on the chemical and physical characteristics of *Physalis peruviana* L. and *Physalis pubescens* L.

MATERIALS AND METHODS

Seedlings of *P. peruviana* L. and *P. pubescens* L. were obtained by growing them in a greenhouse, from seeds of plants at Universidade Tecnológica Federal do Paraná, Brazil. The experiment was conducted from February to October, for two years (2011 and 2012), under 28 ± 2°C in the greenhouse. Seeds were placed on Styrofoam trays containing substrate (fertile humus), and three seeds were sown per cell, with thinning after 20 days, leaving one seedling per cell. When these were approximately 15 cm high (70 days old) they were transplanted to pots (5 L) containing soil as substrate, which was analyzed to perform fertilization (Table 1) with pH corrected to 5.8.

The experimental design was completely randomized with a factorial (2 × 5) arrangement of treatments: Species (*P. peruviana* L. and *P. pubescens* L.); and five N (as urea) levels (kg ha⁻¹): 0, 200, 250, 300, 350; with 7 replications per treatment. The results were used for an ANOVA and treatment means were analyzed by orthogonal contrasts (p ≤ 0.05), using ASSISTAT software. Other two macronutrients (P and K) were maintained on fixed doses: 600 kg ha⁻¹ P₂O₅ and 500 kg ha⁻¹ KCl.

Due to the uneven ripening of the fruit, samples were taken weekly and analyses performed at Laboratory of Biochemistry and Plant Physiology of the UTFPR. Fruit were harvested when the calyx was yellow-greenish.

Fruit were weighed (Marte AY220 digital scale) and then macerated by hand and filtrated. Variables evaluated were: pH (Tecnonon mPA-210 digital pH meter), titratable acidity (ascorbic acid); concentrations of total soluble sugars (TSS), using the methodology proposed by Dubois et al. (1956) and reducing sugars (RS), through the dinitrosalicylic acid (Miller, 1959) both by

spectrophotometry (UV-1800 Shimadzu spectrophotometer UV-1800) with glucose as standard. Total phenolic compounds were determined by spectrophotometry using the methodology described by Makkar et al. (1993) with tyrosine as standard.

RESULTS AND DISCUSSION

The different levels of nitrogen resulted in variations in the levels of metabolic compounds evaluated in both species of *Physalis*. With respect to the concentrations of soluble sugars, the fruits of both species showed increase with higher levels of nitrogen up to 300 kg ha⁻¹ (Figure 1). In all levels of nitrogen tested, *P. pubescens* showed initial value of TSS greater than that of *P. peruviana*, responding better to the increments of the nutrient applied. Ferreira et al. (2006) suggest that increasing amounts of sugars until a given level of nitrogen are due to the biosynthesis of these compounds during photosynthesis, which are subsequently translocated to the fruit in the process of development and growth thereof. Bénard et al. (2009) reported higher concentrations of total sugars but at low nitrogen levels.

The reductions in TSS concentrations at levels above 300 kg ha⁻¹ nitrogen may be the result of greater vegetative growth, which was observed in the experiment, in height and dry weight of shoots, besides the greater number of fruits, particularly in *P. pubescens* (data not shown).

Nitrogen stimulates the activation of meristematic tissues of the plant, leading to increased consumption of storage sugars (Nabinger, 1996; Alexandrino et al., 2004), thus in *Physalis* nitrogen fertilization above 300 kg ha⁻¹ stimulates greater vegetative growth resulting in consumption of storage sugars to sustain this energy expenditure, hence reducing the levels to be translocated to the fruit.

This intense growth and subsequent translocation of sucrose for fruit and its inversion during maturation resulted in increases in the concentration of reducing sugars dependent on nitrogen levels in *P. pubescens*, with little variation in the levels of these compounds in *P. peruviana* (Figure 2). These responses confirm the ability of the first to respond differently to increasing levels of fertilization, possibly for being a more rustic species, not subjected to constant selection processes, even the most simple.

In tomato, Ferreira et al. (2006) found no change in total soluble solids, mainly represented by glucose and fructose, with increased level of N, which is also observed in *P. peruviana*, differently from *P. pubescens*

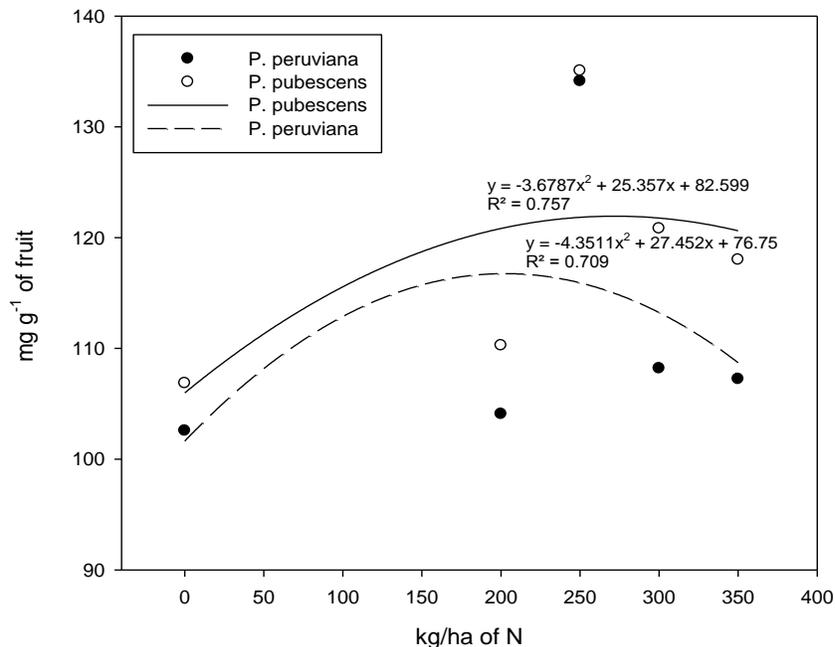


Figure 1. Concentrations of total soluble sugars (TSS) in fruits of *P. peruviana* and *P. pubescens* under different nitrogen levels.

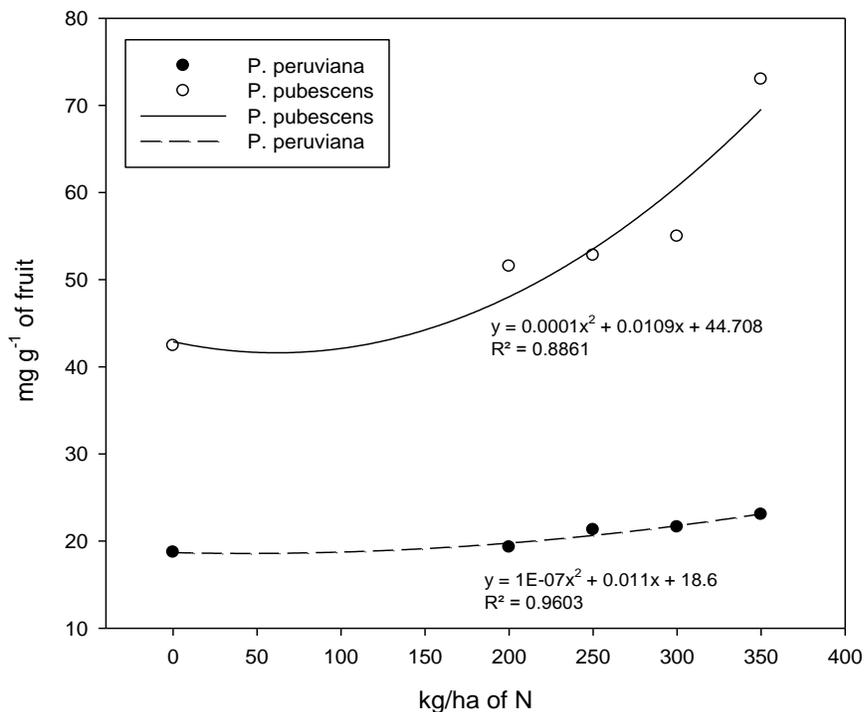


Figure 2. Concentrations of reducing sugars (RS) in fruits of *P. peruviana* and *P. pubescens* under different nitrogen levels.

and tomato in a study developed Valencia et al. (2003). In another experiment with tomato, reducing sugars

were present at higher concentrations in reduced levels of N (Bénard et al., 2009).

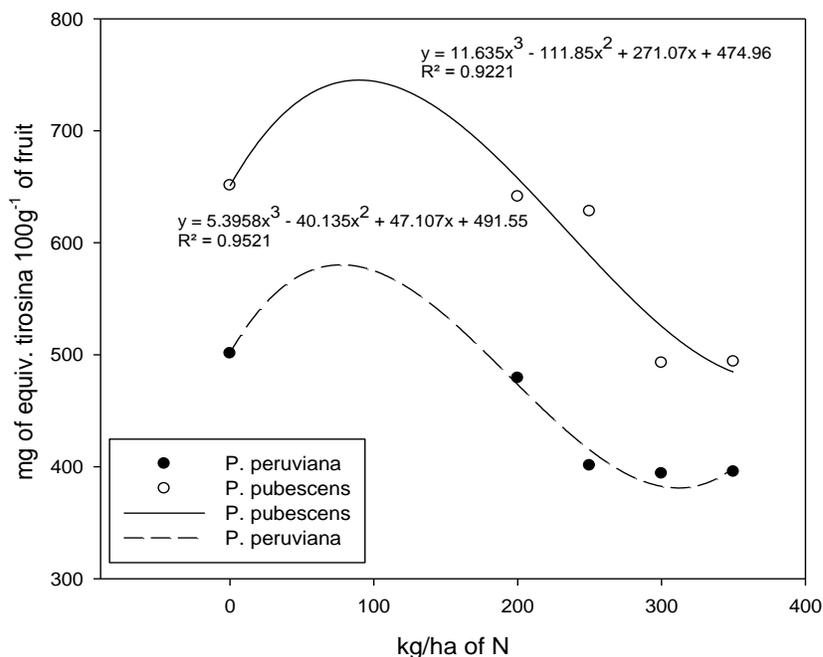


Figure 3. Total phenolic content in fruits of *P. peruviana* and *P. pubescens* under different nitrogen levels.

The sugar content in fruit of *Physalis*, especially in *P. pubescens*, imparts a sweeter flavor to this species, which was confirmed by taste tests conducted with the community (data not shown).

In the analyses of total soluble phenolic compounds, the results were the opposite of primary compounds (sugars). From the dose of 200 kg ha⁻¹ nitrogen in both *Physalis* species it was verified a cubic trend with increasing nitrogen levels. Between the two species, *P. pubescens* showed the highest values of phenols (Figure 3), similarly to that observed in tomato with higher concentrations of some phenolic compounds at lower nitrogen levels (Bénard et al., 2009).

The synthesis of phenolic compounds increases under stress, especially when the use of carbon for growth and/or reproduction decreases due to lack of nutrients (Kandil et al., 2004). When N limits growth of plants, there is an accumulation of carbohydrates in their tissues, according to the carbon/nutrient balance hypothesis (Bryant et al., 1983), thus this accumulation directs carbon to the synthesis of secondary metabolites (Hamilton et al., 2001), which seems to occur in *Physalis*. Coelho et al. (2012) also observed a decrease in the concentration of total phenolics with increasing level of N in leaves of potato plants, following a quadratic model.

The results are consistent with the inverse relationship between the synthesis of primary metabolites during the growth/development of plant and production of secondary metabolic compounds, including phenols. Thus, the phenol synthesis depends on the balance of sucrose and

fruit are the preferred sinks, and therefore nutrients and carbohydrates are directed to their development as well as to other parts of the plant, rather than to synthesis and accumulation of phenolic compounds.

In relation to citric acid in *Physalis* fruit, it was observed that the concentrations showed a quadratic response with increases up to 200 kg ha⁻¹ (Figure 4). *P. peruviana* showed the highest concentrations of citric acid, giving a more acidic flavor to fruit, when compared to *P. pubescens*, also confirmed by taste tests (data not shown).

Bénard et al. (2009) also obtained a reduced acidity with increasing nitrogen, resulting in less acidic characteristics to tomato fruit. Conversely, in muskmelon, there was an increase in the percentage of citric acid with higher N levels (Coelho et al., 2003). According to Blanco and Folegatti (2008) the citric acid content in tomato fruit increases with higher cation: Anion ratio in order to maintain electro neutrality in fruit tissues. As N is absorbed by plants preferentially in the form anion (NO₃⁻), may have occurred an imbalance in this ratio, with increased N uptake in relation to other nutrients, such as K⁺ (Marshner, 1995).

These changes were also proved by direct measurement of pH (Figure 5), with elevation in values with increase of N for both species, but smallest variations in pH values were observed for *P. pubescens*. The increase in N levels may have increased fruit turgidity indirectly causing a drop in acidity values, due to the dilution of acids (Paula et al., 1991), which may have

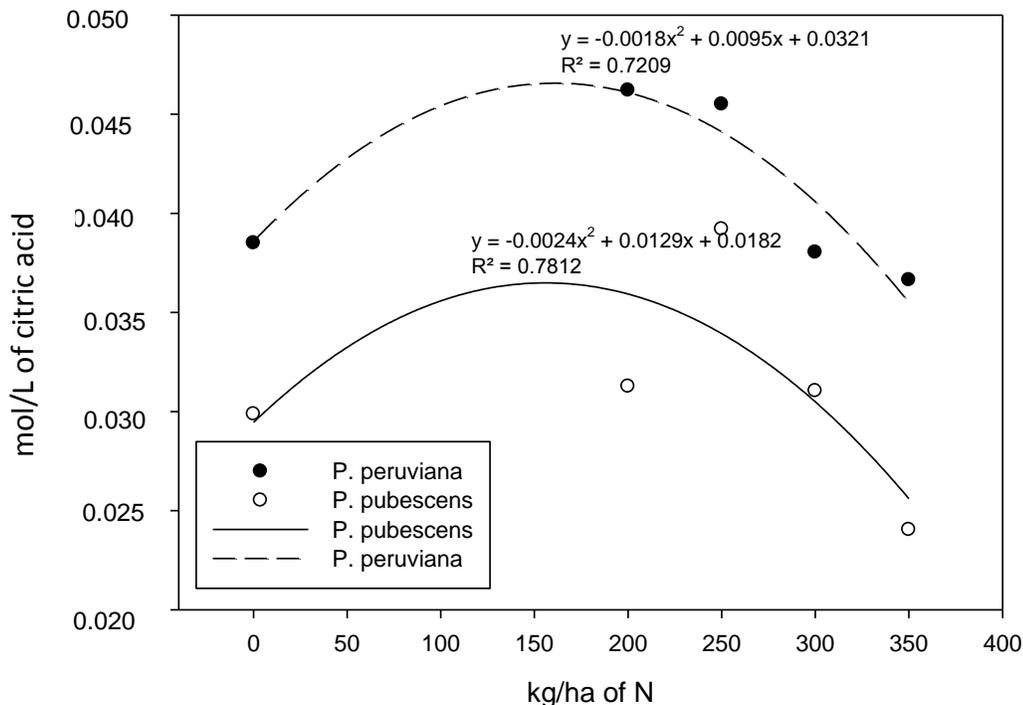


Figure 4. Titratable acidity in fruits of *P. peruviana* and *P. pubescens* under different nitrogen levels.

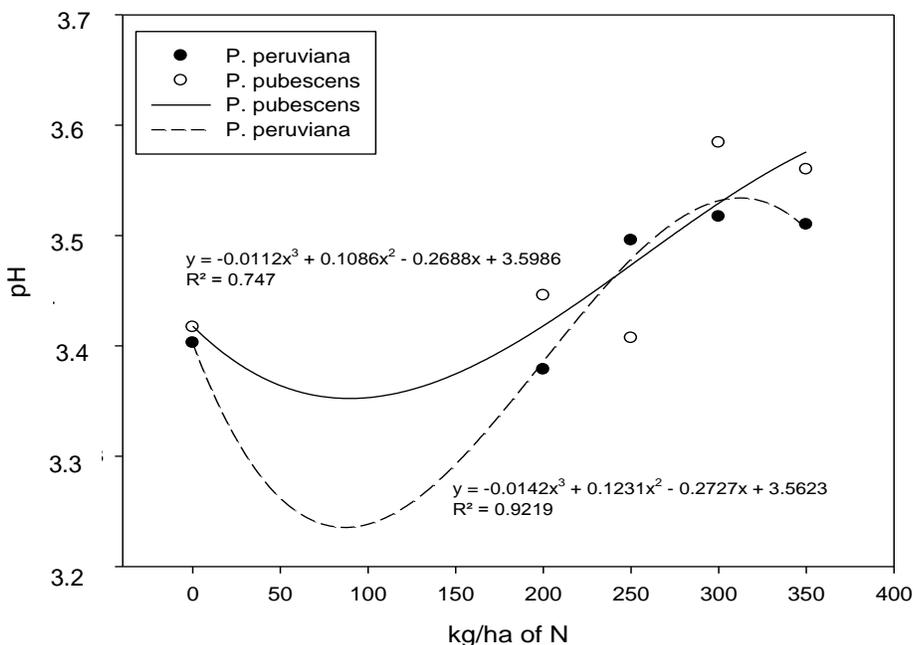


Figure 5. Values of pH in fruits of *P. peruviana* and *P. pubescens* under different levels of nitrogen fertilization.

occurred in *Physalis*.

Similar results were verified by Silva et al. (2008), which registered that the increase in pH with increasing N

levels is justified by the lower concentration of acids accumulated in guava fruit.

Fruit quality comprises chemical characteristics, size

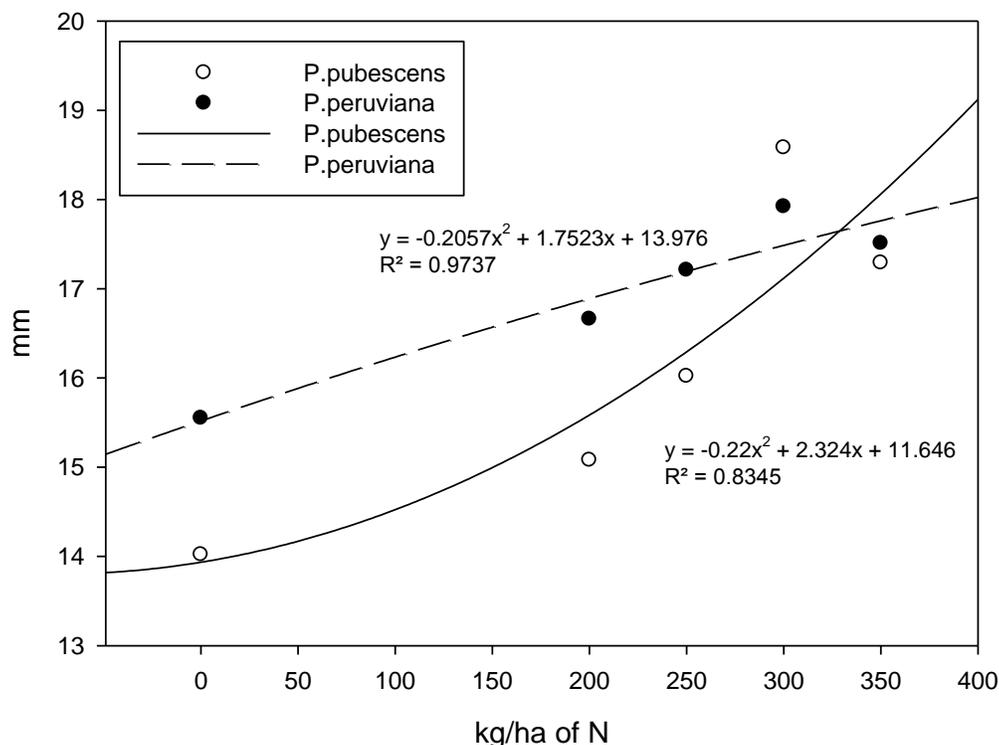


Figure 6. Diameter of fruits of *P. peruviana* and *P. pubescens* under different levels of nitrogen fertilization.

and number of fruit. In this way, we measured the diameters of the fruits of *Physalis* and as a result, the nitrogen positively affected this parameter up to the level of 300 kg ha⁻¹, as shown in Figure 6. Fruit size was increased with fertilization, which was expected until reaching the threshold of nutritional need of the plant, from which the excess promoted no increased yield, which indicates that above the optimal value occur waste and losses, if the main goal is fruit production.

Increases in fruit diameter with increase in nitrogen fertilization were also reported by Coelho et al. (2003) and Queiroga et al. (2007), working with melon, by Pedrosa et al. (2012) with pumpkin, and by Brito Neto et al. (2011) with sunrise solo papaya, however with a decrease in size from a given level of nitrogen. According to these authors, the deficiency or excess of N affects the size and quality of the fruit, since high levels tend to increase the number rather than the size of the fruit, which seems to occur slightly in *P. peruviana* at a level of 350 kg ha⁻¹.

Conclusions

In short, the results evidenced the positive effect of nitrogen in greenhouse cultivation for two species of *Physalis*. In general, 300 kg ha⁻¹ can be considered the

best level under the conditions of the experiment, which led to the set of positive characteristics that determine fruit quality, especially for *P. pubescens*.

Conflict of Interests

The authors have not declared any conflict of interests.

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