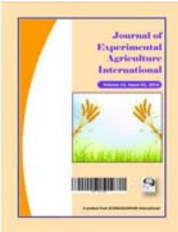


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# Growth, Yield and Phytochemical Characterization of Small Watermelon Varieties in Hydroponics


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***Authors' contributions***

*This work was carried out in collaboration between all authors. Author GNM designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RMNP and CVR managed the analyses of the study. Authors LP and FC managed the literature searches. All authors read and approved the final manuscript.*


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## ABSTRACT


Although the information about hydroponics for growing several vegetable crops is abundant, published data on small watermelon crop are scarce. Considering that the responses of the crop depend on the genotypic characteristics, the aim of this research was to study plant growth, fruit yield, basic composition and content of main phytochemical compounds of four small watermelon hybrid varieties (Extasy Hazeera®, Ki Kodama, Beni Kodama and Tayo Sakama®) grown in the hydroponic NFT system. The obtained results indicated that the varieties presented similar plant dry matter production and partitioning. On average, the fruits comprised 72% of the total dry matter production. The highest fruit yields were attained by 'Extasy' and 'Ki Kodama' (17.02 and 16.07 kg $m^{-2}$). The fruits were very similar in pH, total soluble solids and total titratable acidity. In the pulp of variety 'Ki Kodama' (yellowish color), the lowest levels of ascorbic acid (AA=48.0 µg $g^{-1}$), folic acid



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(FA=0.025 μg $g^{-1}$), total lycopene (TL =8.0 μg $g^{-1}$) and total carotenoids (TC=43.0 μg $g^{-1}$) were detected; besides the lowest antioxidant activity (20.23%). On the other hand, the fruits of 'Ki Kodama' presented the highest ß-carotene content (31.0 μg $g^{-1}$). Varieties of reddish pulp ('Beni Kodama', 'Extasy' and 'Taiyo') did not differ in phytochemicals content, with the following ranges: from 70.7 to 80.0 μg $g^{-1}$ of AA; from 0.046 to 0.054 μg $g^{-1}$ of FA; from 56.4 to 65.7 μg $g^{-1}$ of TL; from 9.7 to 11.0 μg $g^{-1}$ of ß-carotene and from 70.0 to 80.0 μg $g^{-1}$ of TC. The results show that varieties present similar plant growth and basic composition of fruits, but 'Extasy' and 'Ki Kodama' demonstrate larger fruit yield potential. The fruits of the yellow pulp Ki Kodama variety present low levels of phytochemicals, except the high content of ß-carotene, and reduced antioxidant activity. Varieties of reddish color pulp have proper levels of phytochemicals in fruits.

*Keywords: Citrullus lanatus; soilless cultivation; post-harvest; quality; lycopene; dry matter partitioning.*

## 1. INTRODUCTION

Although there is virtual consensus about the importance of eating fruits and vegetables to prevent chronic diseases [1], the consumption of these foods has not increased in Brazil [2]. Several reasons are pointed out for this situation, which includes cultural, socio-educational and economic features besides factors intrinsic to the product itself [3]. With respect to the latter, the appearance and practicality have been named as fundamental to the intention to purchase and consumption of fruits and vegetables [4]. In this sense, watermelon [*Citrullus lanatus* L. (Thunb.) Matsum & Nakai] is a widely accepted fruit vegetable by appearance, crunchiness, flavor and freshness, but it is an unpractical product, especially by its excessive size. In this sense, the cultivation of the small watermelons may be an interesting alternative.

In addition to fruits of smaller size, the cultivation of small watermelon plants should produce good-appearance fruits and present high agronomic yield. In this case, the hydroponic cultivation in greenhouse condition has enabled the increased yield and quality of small watermelon crop [5]. Moreover, cultivation in hydroponic systems, such as the NFT (Nutrient Film Technique), reduces the waste of water and nutrients. However, it is widely known that the cultivation systems should be tested for each crop and variety [6,7].

The NFT system is well established for some crops and was able to provide high yield and quality of leafy vegetables and some fruit vegetables such as tomato [8,9]. Nevertheless, with respect to the small watermelon varieties included in this work, there is no information concerning the plant growth, fruit yield and quality in this cultivation system. The hypothesis is that the small watermelon grown in protected environments and NFT system can generate high fruit yield with consistent quality.

Regarding the actual intrinsic fruit quality, watermelon is an important source of carotenoids, phenolic compounds and organic acids, which provide antioxidant potential [6,1,10,11]. These groups of compounds act as a plant defence mechanism to biotic and abiotic stressor agents [12] and are widely known as promoters of in vitro and in vivo functional properties. They are commonly named molecules resulting from secondary metabolism and have their synthesis and accumulation strongly associated with genotypic characteristics and cultivation conditions. Therefore, the characterization of the varieties in each cultivation system is very important in order to quantify the presence of these compounds.

The aim of this study was to characterize different varieties of small watermelon in hydroponic cultivation. In this sense, agronomic [plant growth, fruit yield and basic composition (pH, the total content of soluble solids and total titrable acidity)] and phytochemical (ascorbic acid, folic acid, total lycopene, beta carotene, total carotenoids and antioxidant activity) variables were evaluated.

## 2. MATERIALS AND METHODS

### 2.1 Experimental Site

The experiment was conducted from October 30$^{th}$, 2011 (sowing) to February 14$^{th}$, 2012 (final harvest) at the Didactic and Experimental Field of the Department of Plant Science (Federal University of Pelotas), located in the city of Capão do Leão, RS, Brazil. The climate of this region is tempered with well distributed rainfall and hot summer. The climate is Cfa type according to Köppen classification.

The plants were grown inside a North-South oriented symmetric roof structure greenhouse (10.0 m x 21.0 m and 5.0 m maximum height), covered with polyethylene plastic film (150 µm thickness).

### 2.2 Planting Materials

Four small watermelon hybrid varieties were studied: ‘Beni Kodama’ (Sakama®), ‘Extasy’ (Hazera®), ‘Ki Kodama’ (Sakama®) and ‘Taiyo’ (Sakama®). Seeds were sown in phenolic foam cubes (2.5 cm x 2.5 cm x 3.8 cm). Ten days later, when seedlings presented completely open cotyledons, irrigation with nutrient solution in ½ concentration started, keeping it until seedlings reached from three to four true leaves. Twenty-nine days after sowing, plants were set in NFT gullies.

### 2.3 Experimental Design and Crop Management

Randomized blocks experimental design was used with four treatments (varieties) and three biological replications.

The greenhouse contained 12 wood-made gullies (0.30 m wide and 7.50 m long) internally recovered by double face (black-white) plastic channels. Gullies were arranged in pairs sloping 2%. The gullies were connected to a nutrient solution catchment tank of 1000 liters. The pairs of double rows were 1.20 m apart with 0.50 m between-row distance. Spacing plants 0.37 m within-row distance imposed plant density at 3.1 plants $m^{-2}$.

The irrigation system was conducted automatically by an electric pump fixed to the catchment tank. The nutrient solution was supplied to the NFT gullies by a PVC pipe for 30 minutes every 1 hour during the period from 8 a.m. to 19 p.m.

The nutrient solution recommended by Marques et al. for watermelon crop was used, with electrical conductivity (EC) of 1.8 dS $m^{-1}$ and the following macronutrients composition (mmol $L^{-1}$): 12.8 $NO_3^-$; 1.4 $H_2PO_4^-$; 2.0 $SO_4^{2-}$; 0.8 $NH_4^+$; 6.0 $K^+$; 4.0 $Ca^{2+}$; 1.7 $Mg^{2+}$; and micronutrients (mg $L^{-1}$): 4.00 Fe; 0.56 Mn; 0.26 Zn; 0.22 B; 0.03 Cu; 0.05 Mo.

Nutrient solution supplied to the crop was monitored daily by measuring EC and pH. The adjustment of the EC was performed by water or stock concentrated nutrient solution addition when EC showed variation of 10% above or below 1.8 dS $m^{-1}$, respectively. The pH was maintained in the range of 6.0±0.5 by addition of correction solution based on potassium hydroxide (1N KOH) or sulfuric acid (1N $H_2SO_4$).

Plant training was done through plastic stake nets. All side shoots were removed until 8th leaf axil. Fruits were allowed to grow only from the 12th leaf axil side shoots. All hermaphrodite flowers of the main stem were removed. Fruits were sustained through plastic nets bags fixed in the stake nets.

### 2.4 Data Collection and Analysis

All plants were harvested 78 days after setting (107 days after sowing) in order to evaluated plant growth and dry matter partitioning. The fresh and dry weights (after drying at 65ºC in a forced air oven until constant weight) of roots, leaves (including petioles), stem and fruits (including peduncles) of 4 plants per replication (12 plants per treatment) were measured. At the end of the experiment, cumulative weights including all previous harvests were calculated. The cumulative leaf area was also evaluated by leaf area measurement equipment (LI-COR, model 3100).

The fruits composition evaluation was performed employing three technical analysis of each biological replication. The eatable pulp of the small watermelons was considered as working sample. The pulp color was determined with the aid of Minolta® colorimeter, model CR-300 and the parameters of color converted to the Hue angle (H0=tan-1b/a). The total soluble solids content (TSS) was determined by refractometry, and the results expressed as ºBrix. The pH was measured directly from the extracted fruit juice. The total titratable acidity (TTA) was determined using a 5mL aliquot of juice, in duplicate, which was added 50 mL of distilled water and three drops of alcoholic phenolphthalein 1% and then titrated with 0.1N NaOH solution to the turning point; with the same sample. Ascorbic acid content (AA) was determined spectro-photometrically following Stevens et al. [13]. Antioxidant activity was determined using the DPPH radical scavenging method described by Brand-Williams et al. [14]. Folic acid content (FA) was determined by HPLC-UV based on an external calibration against 5-methyltetra-hydrofolic acid monoglutamate and 5-methyltetrahydrofolic acid diglutamate obtained from the reduction of pteroyl-diglutamate following a method described by Delchier et al. (2012) [15]. The total carotenoids content (TC) and the individual carotenoids [ß-carotene and lycopene (TL)] were obtained by the methodology of Tiecher et al. who have optimized the conditions for tomatoes [16]. These were considered suitable for small watermelons, once it was evidenced by preliminary tests that the methodological procedures were efficient and effective for this fruit.

The data were analysed by analysis of variance and means were compared according to Tukey test ($P<0.05$).

## 3. RESULTS AND DISCUSSION

### 3.1 Plant Growth

Unexpectedly, the different studied varieties did not affect the dry matter production and partitioning among plant organs (Table 1). No statistical differences related to the following growth variables were detected: total dry matter (TDM), fruit dry matter production (FDM) and dry matter partitioning among the plant organs (root, stem, leaves and fruits). The accumulated TDM was 341.72; 397.14; 375.81 and 331.61 g plant$^{-1}$, respectively, in 'Beni Kodama', 'Extasy', 'Ki Kodama' and 'Taiyo' plants. On average, the fruits comprised 72% of the total dry matter production, which demonstrated they are very strong sink of assimilates. On average, leaves comprised 14.8%, followed by stems (10.4%) and roots (only 2.5%).

High values of TDM production (Table 1) were obtained, with the experimental average of 361.57 g plant$^{-1}$ (equivalent to 1120.86 g m$^{-2}$). The data reported by some authors [17] related to Smile small watermelon variety in soil cultivation showed only 200.62 g plant$^{-1}$ (321.0 g m$^{-2}$). This outstanding difference on total DM accumulation can be assigned to the high availability of water and mineral nutrients of the NFT system associated with the intrinsic characteristics of the varieties used in the study which provided a high plant growth.

Regarding DM distribution to the roots, usually they represent a small fraction of the total DM of plant [18]. In hydroponics, a high growth of shoot with a reduced root system is usually expected [9], as observed in this study (Table 1). This fact can be attributed again to the high supply of water and mineral nutrients of the NFT system which reduced the need for roots to develop.

The average value of 72.2% of DM distributed to the fruits was very high when compared to the figure of 42% observed by Aumonde et al. (2011a) when studying the small watermelon 'Smile' in soil cultivation under greenhouse. Researches on conventional watermelons grown in soil indicated that fruits represent from 64% [7] to 69% [19] of the total plant DM. Thus, a high capacity to distribute photoassimilates for the fruits was attested in hydroponics.

'Extasy' presented leaf area index (LAI) of 2.85, statistically similar to the value of 'Beni Kodama' (2.23) and higher than 'Ki Kodama' (1.97) and 'Taiyo' (1.86) (Table 1). The LAI is an important parameter to be considered in crop varieties choice, since it represents the development of photosynthetic organs. The interception of solar radiation by the crop depends on it strongly. In this sense, 'Extasy' stood out.

**Table 1. Total dry matter production (TDM), leaf area index (LAI), dry matter partitioning, fruit dry matter production (FDM) and fruit dry matter content (FDMC) of small watermelon varieties in hydroponics**

| Varieties | TDM (g plant$^{-1}$) | LAI | Dry matter partitioning (%) | | | | FDM (g plant$^{-1}$) | FDMC (%) |
|---|---|---|---|---|---|---|---|---|
| | | | Root | Stem | Leaves | Fruits | | |
| Beni Kodama | 341.72 a* | 2.23 ab | 2.6 a | 11.0 a | 15.4 a | 71.0 a | 242.32 a | 6.84 a |
| Extasy | 397.14 a | 2.85 a | 2.6 a | 10.1 a | 15.7 a | 71.6 a | 285.92 a | 5.31 b |
| Ki Kodama | 375.81 a | 1.97 b | 2.0 a | 9.0 a | 12.8 a | 76.2 a | 287.63 a | 5.66 ab |
| Taiyo | 331.61 a | 1.86 b | 2.8 a | 11.5 a | 15.5 a | 70.2 a | 233.18 a | 6.34 ab |
| CV (%) | 10.47 | 11.80 | 22.5 | 13.0 | 9.7 | 4.3 | 13.53 | 8.45 |

** Means followed by the same letter in the column do not differ at 5 % probability by the Tukey test*

On the other hand, fruits of 'Extasy' (5.31%) had lower dry matter content than 'Beni Kodama' fruits (6.84%). These both varieties did not differ from 'Taiyo' (6.34%) and 'Ki Kodama' (5.66%) in this feature (Table 1).

### 3.2 Yield Components and Marketable Characteristics

'Extasy' presented higher fruit yield (Table 2) than 'Beni Kodama' and 'Tayo', despite its lower fruit dry matter content (Table 1). The greater fruit yield of 'Extasy' indicates a greater fresh matter accumulation per unit of fruit dry matter. Also, these results corroborate the knowledge that the accumulation of water in the fruits can occur at a different rate from the DM accumulation.

As expected, a great difference regarding fruit appearance was observed among the varieties (Table 2). Externally, except the fruits of variety 'Taiyo', whose peel color is yellow, the fruits of all other varieties showed light green peel colouring with dark green rifling in greater or lesser rate. Except 'Ki Kodama', which has yellow pulp, the other varieties presented a reddish color pulp, varying only on tone. Taking into account that the Hue angle considers the value 0º to the red color and 90º to the yellow color, the pulp of 'Ki Kodama' appears as yellow (Hue angle = 100.67º). The varieties 'Taiyo' (Hue angle = 39.57º), 'Beni Kodama' (Hue angle = 32.69º) and 'Extasy' (Hue angle = 27.47º) appear as reddish. According to the Hue angle, 'Extasy' presents the more intense red pulp. Furthermore, fruits of small watermelon triploid hybrid 'Extasy' differ by the absence of seeds (Table 2).

Significant differences were not evident for fruit number (FN) and average fruit fresh weight (AFW) (Table 2). FN ranged from 2.5 to 3.2 fruits plant$^{-1}$ and AFW from 1.29 to 1.83 kg fruit$^{-1}$. Despite the absence of differences among varieties regarding the yield components, the highest FN in combination with the greatest AFW led to a higher fruit yield of 'Extasy' and 'Ki Kodama', respectively, 17.02 and 16.07 kg m$^{-2}$.
The genotypic characteristics, climatic conditions and crop management are the main determinants of both fruit number and average fruit fresh weight. In accordance with this information, the fruit number and the average fruit weight found by some authors for different small watermelon varieties [10,5] ranged, respectively, from 1.7 to 3.8 fruits plant$^{-1}$ and from 1.7 to 4.2 kg fruit$^{-1}$. The Brazilian market demands AFW from 1 to 3 kg per fruit [20]. This goal was reached in the study (Table 2).

The obtained fruit yields ranged from 11.0 to 17.0 kg m$^{-2}$, respectively, for 'Beni Kodama' and 'Extasy' (Table 2), which corresponded to 110 t ha$^{-1}$ and 166 t ha$^{-1}$. The average yield was 109% higher than those obtained in the open field production system [21], 142% higher than those referenced in greenhouse on soil cultivation [22] and 126% higher than the obtained yield in hydroponics previous research [5].

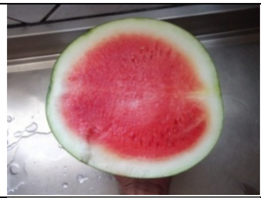
### 3.3 Physical-Chemical Characteristics and the Phytochemicals Content of the Fruits

Despite the strong phenotypic differences observed (color of skin and pulp, presence or absence of seeds), the TSS, as well as pH and TTA were similar (Table 3). On average, the TSS was 9.8°Brix; the pH was 5.7 and the TTA was 0.13% of citric acid.

The TSS content ranged from 9.23 to 10.27ºBrix (Table 3) which is considered adequate for the market requirement (minimum TSS of 9ºBrix) [20]. The narrow range of TSS content indicated a similarity of the varieties in photosynthetic potential, since the main components of the TSS (sugars and organic acids) are products from photosynthesis [23]. This is corroborated by the similar DM production of the varieties (Table 1).
Several studies [21,10,6,24] showed that the TSS content depends on the environmental conditions, the cultivation systems, as well as the watermelon varieties. For example, Marques et al. obtained 10.3ºBrix for small watermelon 'Rapid Fire'. Rodrigues et al. detected only 8.8ºBrix in fruits of the same variety. Both types of research took place in the same location, in the same greenhouse and growing season. But, they were carried out in different years, which means that different climatic conditions often can play a more significant role in determining the TSS content than the genetic material.

Varieties of reddish pulp ('Beni Kodama', 'Extasy' and 'Taiyo') did not differ in relation to the phytochemicals content, with the following ranges: from 70.7 to 80.0 µg g$^{-1}$ of AA; from 0.046 to 0.054 µg g$^{-1}$ of FA; from 56.4 to 65.7 µg g$^{-1}$ of TL; from 9.7 to 11.0 µg g$^{-1}$ of ß-carotene and from 70.0 to 80.0 µg g$^{-1}$ of TC (Table 3).

**Table 2. External and internal image, color pulp (CP), fruit number (FN), average fruit weight (AFW) and fruit yield of small watermelon varieties in hydroponics**

| Varieties | External image | Internal image | CP | | FN (Fruit Plant$^{-1}$) | AFW (Kg) | Fruit yield (Kg m$^{-2}$) |
|---|---|---|---|---|---|---|---|
| | | | °Hue | C | | | |
| Beni Kodama |  |  | 32.69 c* | 25.58 a | 2.50 a | 1.42 a | 11.01 b |
| Extasy |  |  | 27.47 c | 29.09 a | 3.00 a | 1.83 a | 17.02 a |
| Ki Kodama |  |  | 100.67 a | 30.63 a | 3.20 a | 1.62 a | 16.07 a |
| Taiyo |  |  | 39.57 b | 27.02 a | 2.80 a | 1.29 a | 11.20 b |
| CV (%) | - | - | 4.37 | 16.37 | 13.90 | 16.29 | 9.28 |

** Means followed by the same letter in the column do not differ at 5 % probability by the Tukey test*

**Table 3. Physical-chemical characteristics and the content of the main phytochemicals present in fruits of four small watermelon varieties in hydroponics**

| Varieties | TSS (ºBrix) | pH | TTA (%) | AA (µg $g^{-1}$) | FA (µg $g^{-1}$) | TL(µg $g^{-1}$) | ß-carotene (µg $g^{-1}$) | TC (µg $g^{-1}$) | Antioxidant Activity (%) |
|---|---|---|---|---|---|---|---|---|---|
| Beni Kodama | 10.27 a* | 5.60 a | 0.14 a | 80.0 a | 0.054 a | 56.4 a | 10.3 b | 72.3 a | 33.77 ab |
| Extasy | 9.57 a | 5.73 a | 0.15 a | 76.0 a | 0.049 a | 65.7 a | 11.0 b | 80.0 a | 38.77 a |
| Ki Kodama | 10.23 a | 5.85 a | 0.11 a | 48.0 b | 0.025 b | 8.0 b | 31.0 a | 43.0 b | 20.23 c |
| Taiyo | 9.23 a | 5.68 a | 0.12 a | 70.7 a | 0.046 a | 58.6 a | 9.7 b | 70.0 a | 32.53 b |
| CV (%) | 6.55 | 2.06 | 14.3 | 5.37 | 15.82 | 10.25 | 13.39 | 7.49 | 6.35 |

** Means followed by the same letter in the column do not differ at 5% probability by the Tukey test. CV= coefficient of variation; TSS= Total Soluble Solids; pH= hydrogen potential; TTA= total titratable acidity; AA= Ascorbic Acid; FA= Folic Acid; TL= Total Lycopene; TC= Total Carotenoids; AA= Antioxidant Activity (% of inhibition)*

In the pulp of the variety ‘Ki Kodama’ (yellowish color), the lowest levels of ascorbic acid (AA=48.0 μg $g^{-1}$), folic acid (FA=0.025 μg $g^{-1}$), total lycopene (TL =8.0 μg $g^{-1}$) and total carotenoids (TC=43.0 μg $g^{-1}$) were detected; besides the lowest antioxidant activity (20.23%) (Table 3). Therefore, the main phytochemical compounds analysis emphasized the negative aspects of the pulp of ‘Ki Kodama’. On the other hand, the fruits of ‘Ki Kodama’ presented the highest ß-carotene content (31.0 μg $g^{-1}$; Table 3) which is consistent with the yellow pulp color (Hue angle = 100.67º) (Table 2).

The levels of AA obtained ranged from 48.0 to 80.0 μg $g^{-1}$ (Table 3), which means moderately fruits rich in vitamin C. In general, watermelons are not a rich source of AA, containing from 10 to 80 μg $g^{-1}$ [11,25]. Exceptionally, there is a reference to higher levels [22].

Despite the reduced amount, the presence of FA (from 0.025 to 0.054 μg $g^{-1}$) in the chemical constitution of the small watermelons was identified (Table 3). The dark green leafy vegetables, asparagus, corn, peanuts, yeast, citrus fruits as well as whole grains, which have levels from 0.2 to 1.6 μg $g^{-1}$ [26] are considered the main natural sources of this phytochemical. Although the FA relatively low content detected, this is an important molecule, because contributes to functional properties and highlights the relevance of the watermelon consumption – mainly reddish pulp varieties– in the prevention and cancer therapy [27].

It was expected that red pulp varieties had more lycopene, which effectively occurred. The TL content ranged from 56.4 to 65.7 μg $g^{-1}$ in reddish pulp varieties (‘Beni Kodama’, ‘Extasy’ and ‘Taiyo’). It is known that the red colour is due to the lycopene accumulation [6,10,28]. The values are high when compared to the range from 9.5 to 30.1 μg $g^{-1}$ found in previous studies [6,29,30] with conventional red pulp varieties. Nevertheless, specifically for seedless watermelon variety ‘Extasy’, Perkins-Veazie et al. (2006) found TL content of 93.0 μg $g^{-1}$. As expected, in the yellowish pulp of the "Ki Kodama" variety, the FA content was the lowest among the four varieties.

On the other hand, the ß-carotene, vitamin A precursor, was detected at the highest level in the yellow variety (‘Ki Kodama’= 31.0 μg $g^{-1}$). This content is approximately three times greater than those found in the red pulp varieties (from 9.7 to 11.0 μg $g^{-1}$; Table 3). These figures were similar to that obtained by Perkins-Veazie et al. (2006), which detected a maximum value of 10.2 μg $g^{-1}$ of ß-carotene among 50 red pulp watermelon varieties. In contrast, Aumonde et al. (2011 b) obtained only 0.39 μg $g^{-1}$ for red pulp small watermelon ‘Smile [30]. Thus, in general, the varieties studied in this work can be considered good sources of provitamin A, even those of red pulp.

The lowest TC values were found in ‘Ki Kodama’ fruits (43.0 μg $g^{-1}$; Table 3). The varieties ‘Beni Kodama’, ‘Extasy’ and ‘Taiyo’ presented 72.3, 80.0 and 70.0 μg $g^{-1}$ of TC, respectively (Table 3). Total carotenoids of the studied small watermelons were represented, mostly, by lycopene and ß-carotene sum, which corresponded, on average, from 90.7 to 97.6% of TC. In ‘Ki Kodama’ fruits, lycopene corresponded to only 18.6%, while ß-carotene corresponded to 72.1% of TC content. In an opposite way, ß-carotene was equivalent to a small fraction of TC content (13.7 – 14.2%), whereas lycopene was around 80% of TC in the red pulp varieties. The results indicated that, although this qualitative difference, small watermelons can be considered a good source of TC, based on levels commonly found in other foods mentioned as sources of those compounds [31].

The antioxidant activity determined in vitro was consistent with the composition of phytochemicals. There was an emphasis on varieties ‘Beni Kodama’ and ‘Extasy’, followed by ‘Taiyo’ and ‘Ki Kodama’ (Table 3). ‘Ki Kodama’ fruits presented low AA, FA and TL contents and, consequently, the lowest antioxidant activity (20.23%; Table 3). The other three studied varieties, which were richer in AA, FA and TL, presented 35.02% of antioxidant activity on average (Table 3).

## 4. CONCLUSION

The results show that the varieties present similar plant growth and basic composition of fruits (TSS, pH and TTA). However, ‘Extasy’ and ‘Ki Kodama’ demonstrate larger fruit yield potential. The fruits of the yellowish pulp Ki Kodama variety present low levels of phytochemicals, except the high content of ß-carotene, and reduced antioxidant activity. Varieties of reddish colour pulp (Extasy, Beni Kodama and Taiyo) have proper levels of phytochemicals in fruits.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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