



# Prospection of the quality and bioactive potential of the seedless watermelon

Prospecção da qualidade e potencial bioativo de híbridos de melancia sem sementes

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The present investigation aimed to evaluate the prospection of the quality and the bioactive potential of four seedless watermelon hybrids. Fruits were collected from the commercial farms located at the Jaguaribe-Açu agricultural Valley/RN and Jaguaribe Valley/CE, Brazil. Plant material included the hybrids 'Ashira', 'Extasy', 'Mickylee' and 'Valentino'. The following parameters were evaluated: fruit weight; longitudinal and transverse diameter; fruit shape index; pulp firmness; pulp color; shell thickness; soluble solids, titratable acidity, pH, soluble solids and titratable acidity ratio, total and reducers soluble sugars, vitamin C, total carotenoids, lycopene, yellow flavonoids, total anthocyanins and total polyphenols. The trial was carried out by a completely randomized design. The comparison of means was performed using one way ANOVA at the Tukey HSD test. All the hybrids showed fruits small, i.e., "icebox" type, with mean values lower than 5.5 kg, spherical shape and a higher portion of edible pulp. The fruits showed high pulp firmness leading a great resistance to mechanical injuries sustained due to transport, besides long postharvest shelf life. 'Ashira' showed the highest proportion of sugars present in the fruit due to the increase of 73% in the SS/AT ratio compared to the other hybrids. 'Extasy' presented high content of total carotenoids whereas 'Ashira' stood out in the content of total polyphenols. The hybrids are promising alternatives to the local and export watermelon market, in view of the high quality and bioactive potential linked to the good adaptability and stability under the growth conditions.

Keywords: *Citrullus lanatus*, postharvest, lycopene.

A presente investigação teve como objetivo avaliar a prospecção da qualidade e o potencial bioativo de quatro híbridos de melancia sem sementes. Os frutos foram coletados nas fazendas comerciais localizadas no Vale Agrícola de Jaguaribe-Açu/RN e Vale do Jaguaribe/CE, Brasil. Os híbridos utilizados foram: 'Ashira', 'Extasy', 'Mickylee' e 'Valentino'. Os seguintes parâmetros foram avaliados: massa do fruto; diâmetros longitudinal e transversal; índice de formato do fruto; firmeza da polpa; cor da polpa; espessura da casca; sólidos solúveis, acidez titulável, pH, relação sólidos solúveis e acidez titulável, açúcares solúveis totais e redutores, vitamina C, carotenóides totais, licopeno, flavonóides amarelos, antocianinas totais e polifenóis totais. O experimento foi realizado por um delineamento inteiramente casualizado com a comparação das médias realizada via ANOVA pelo teste Tukey HSD. Todos os híbridos apresentaram frutos pequenos, tipo "icebox", com valores médios inferiores a 5,5 kg, formato esférico e maior porção de polpa comestível. Os frutos apresentaram alta firmeza da polpa o que leva a uma maior resistência à lesões mecânicas sofridas durante o transporte, além de maior vida útil pós-colheita. 'Ashira' apresentou a maior proporção de açúcares presentes no fruto devido ao aumento de 73% na razão SS/AT em comparação com os outros híbridos. 'Extasy' apresentou alto teor de carotenóides totais, enquanto 'Ashira' se destacou no conteúdo de polifenóis totais. Os híbridos avaliados são alternativas promissoras para o mercado de melancia local e de exportação, devido à alta qualidade e potencial bioativo associado à boa adaptabilidade e estabilidade sob as condições de crescimento.

Palavras-chave: *Citrullus lanatus*, pós-colheita, licopeno.

## 1. INTRODUCTION

Watermelon [*Citrullus lanatus* (Thunb.) Matsum. & Nakai] is a widespread Cucurbitaceae, native to the drier areas of south-central Africa, near the Kalahari Desert (Namibia and Botswana). Watermelon has a great socioeconomic importance worldwide, being cultivated in many countries as China, Iran, Turkey and Brazil [1], in which together hold over 76 % of world production [2]. In

addition, watermelon has a narrow genetic base and the use of new hybrids has increased in commercial production [3].

In Brazil, the watermelon is the fourth most important crop, with a cultivated area of 105 thousand hectares and a yield of 2.3 million tons of fruit in 2017 [2]. The Brazilian Northeast region stands out as the main watermelon producer region [4], in which the harvested area in 2017 was 36.864 thousand hectares [5]. There are many traditionally watermelon cultivars available in the Brazilian commercial market, however, besides the genetic aspects, the selection of the cultivars is based on the logistics network by the selection of the transport-resistant and better appearance products [4]. Nowadays, attributes such as small fruit size, a trait that facilitates transport and packaging, as well as the absence of seeds in the fruits are aspects commercially exploited by companies as a market novelty and constitute key attributes for crop expansion [6, 7].

Watermelon fruits have chemical and functional compounds, especially  $\beta$ -carotene, total carotenoids and lycopene, potential antioxidant sources, which inhibit or retard the free radical activity in the human body, helping to minimize the occurrence or development of cancerous and degenerative diseases [8–10]. Changes in market trends have increased in the last decade [11], especially in the horticultural crops as watermelon. Besides good quality and functional compounds, the personal demand for mini (< 3 Kg) and midi (3–7 Kg) watermelon cultivars and especially for seedless watermelon cultivars have increased [12].

Seedless watermelons are technically known as triploid hybrids, contrary to the commercial varieties as Crimson Sweet and, the hybrids as 'Quetzali' and 'Boston', that show seeds [4]. The fruits are resultant of the hybridization process by crossing a combination of a tetraploid line as a female and, a diploid line as a male [13]. In breeding programs, specifically in the melon and watermelon breeding, the study of heterosis or "hybrid vigor" is a primary factor to be considered for the selection of the most promising seeds or seedless watermelons hybrid combinations [14] as it may present vigor or promising traits compared to non-hybrids [15].

Investigations regarding the performance of new commercial seedless hybrids cultivated in the Northeast region of Brazil are lack, especially on the postharvest quality and bioactive potential. Information on the physicochemical constituents and bioactive compounds of fruits of new hybrids is an important tool for the viability of consumption and value addition. Thus, the present investigation aimed to evaluate the prospection of the quality and the bioactive potential of four seedless watermelon hybrids ('Ashira', 'Extasy', 'Mickylee' and 'Valentino'), cultivated under conventional management in the climatic conditions of the Brazilian semiarid.

## 2. MATERIAL AND METHODS

Fruits of watermelon hybrids were collected from the commercial farms located at the Jaguaribe-Açu agricultural Valley, mesoregion of the Potiguar West, Rio Grande do Norte, Brazil (5°11'17"S, 37°20'39"W, tropical climate with a dry season, classified by Köppen-Geiger: As) and Jaguaribe Valley, located in the mesoregion of Ceará state, Brazil (5°4'40"S, 37°59'7"W, tropical climate with a dry season, classified by Köppen-Geiger: As).

Plant material included the hybrids 'Ashira', 'Extasy', 'Mickylee' and 'Valentino', both seedless. The fruits were monitored and harvested at the fully ripe. The harvest was carried out in the early morning, selected based on homogeneity and absence of defects. The fruits were sent to the postharvest laboratory at Brazilian Agricultural Research Corporation (EMBRAPA), Fortaleza-CE, Brasil, where they were previously sanitized, for further postharvest evaluation.

For the physical evaluations, fifteen fruits were taken and individual measurements were carried out for each fruit among all the studied hybrids. The fruits were divided into three portions (five fruits per repetition), processed in a multiprocessor for physicochemical and bioactive compounds analysis.

Physical variables: fruit weight (g) evaluation was carried out with the aid of semi-analytical scale and values expressed in grams; longitudinal and transverse diameter (cm) and shell thickness (cm) (thickness + white pulp) were determined with the aid of a millimeter ruler, with a reading for each half of the fruit; fruit shape index was established from the ratio between longitudinal and transverse diameter; pulp firmness, determined by using a hand-held penetrometer (Magness-Taylor model FT 011) with results expressed in Newton (N); pulp color, performed by a digital

colorimeter (MINOLTA, Chroma Meter Model CR-200B) using a CIELAB system ( $L^*$ ,  $a^*$  and  $b^*$ ) [16].

Physicochemical variables: soluble solids (SS), was determined by AOAC (2005) [17] using a digital refractometer (ATAGO® N1, Kirkland-USA), with the results expressed in °Brix; titratable acidity (TA) of the pulp was carried with the aid of a pH meter, using 0.1 N NaOH until reaching  $\text{pH} \pm 8,1$  [17]. One gram of juice was diluted to 50 mL of water under constant agitation. The results were expressed as a percentage of malic acid. The pH of the pulp was measured in the pure juice of the pulp using a digital pH meter (Mettler DL 12) [17]. The SS/TA ratio was obtained by the quotient between the two characteristics [17]; total soluble sugars (%), determined by the Antrona method, according to Yem and Willis (1954) [18], with modifications; Reducing sugars (%), determined by the DNS method, according to Miller (1959) [19], with modifications.

With modifications, Bioactive compounds and antioxidant activity Vitamin C was determined according to Arya et al. (2000) [20]; Total anthocyanins and yellow flavonoids ( $100\text{g}^{-1}$ ) according to Francis (1982) [21]; Total carotenoids ( $100\text{g}^{-1}$ ) determined by the Higby (1962) [22]; Total extractable polyphenols ( $100\text{g}^{-1}$ ) according to Larrauri et al. (1997) [23] and Lycopene ( $100\text{g}^{-1}$ ) according to Rodriguez-Amaya (2001) [24].

The experiment was carried out in a completely randomized design with three replications. Analysis of variance (F-test with significance level  $p < 0,05$ ) was performed by using the statistical software *JMP (SW-SAS)* version 13.0.

### 3. RESULTS E DISCUSSION

Significant differences were found on the physical characterization of the fruits (Table 1).

Table 1. Physical characteristics of the fruits of the different watermelon hybrids cultivated at the states of Ceará and Rio Grande do Norte, Brazil.

Hybrids	Physical characteristics					
	FW (g)	LD (cm)	TD (cm)	FSI	ST (cm)	F (N)
'Ashira'	2590,29 <sup>b</sup>	17,86 <sup>b</sup>	17,16 <sup>b</sup>	1,04 <sup>ab</sup>	1,18 <sup>ab</sup>	16,27 <sup>ab</sup>
'Extasy'	2335,26 <sup>b</sup>	16,91 <sup>c</sup>	16,42 <sup>b</sup>	1,03 <sup>b</sup>	1,27 <sup>ab</sup>	17,43 <sup>a</sup>
'Mickylee'	2582,91 <sup>b</sup>	17,82 <sup>b</sup>	17,17 <sup>b</sup>	1,03 <sup>b</sup>	0,99 <sup>b</sup>	13,46 <sup>c</sup>
'Valentino'	5398,80 <sup>a</sup>	23,06 <sup>a</sup>	21,53 <sup>a</sup>	1,07 <sup>a</sup>	1,55 <sup>a</sup>	14,43 <sup>bc</sup>
MV	3226,82	18,91	18,07	1,04	1,25	15,40
VC (%)	10,02	4,32	3,99	3,78	24,89	13,30

MV: mean values; VC: variation coefficient; FW: fruit weight; LD: longitudinal diameter; TD: transverse diameter; FSI (LD/TD): fruit shape index; ST: shell thickness; F: pulp firmness. Data represent mean values for different hybrids and different letters in the columns indicate significant differences, at  $p < 0.05$ .

Overall, 'Valentino' showed average fruit weight 53% higher than the other hybrids. However, all the hybrids evaluated in this study showed fruits considered small, i.e., "icebox" type, with mean values lower than 5.5 kg, according to the Maynard (2001) classification [9]. In the United States, in addition to the icebox type, commercial watermelon fruits are, in general, classified into four categories: small (5.5-8.0 kg), medium (8.1-11.0 kg), large (11,1-14.5 kg) and extra-large (greater than 14.5 kg) [9]. Martins et al. (2013) [25] reported average fruit weight around 3.7 kg under uses of biostimulants in the 'Quetzali' and 'Style' hybrids whereas Tavares et al. (2019) [3] investigated the effect of heterosis in 15 watermelon hybrids and reported average fruit weight ranging from 6 to 10 kg, both results outstanding 2-4-fold than all of our studied hybrids. In the Brazilian market, it still prevails the appreciation for fruits with weight above 6 kg, Crimson Sweet standard [25]. However, it is noteworthy that due to the reduction in family size, there is a growing demand for smaller fruits (under 6 kg), which facilitate consumption and avoid waste [4, 7], as long as stimulate and facilitates the breeding and selection of hybrids as those evaluated in our research.

The hybrid 'Valentino' also showed the highest average values for longitudinal and transverse diameters as well as fruit shape index, due to the larger size of its fruits in accordance with Yau et al. (2010) [26], evaluating changes in the physical properties of seedless watermelon during storage.

In the fruit shape index, it was observed that the hybrids presented FSI above 1, which suggests that all hybrids are spherical and, thus, they have a higher portion of edible pulp which lead them to advantages in boxed accommodation, i.e., facilities during the transportation, especially in this case, where fruits are considered small (average fruit weight less than 6 kg) [4, 26].

The 'Valentino' showed the highest average shell thickness (thickness+white pulp) (1.55 cm). Therefore, this genetic trait may decrease the response to external factors, in which higher postharvest resistance compared to the hybrid 'Mickylee', which exhibited the smallest ST (0.99 cm), a genetic trait inherent to the hybrid itself, which implies greater handling attention on the transportation. The results presented hence are in accordance with the findings of Fernandes et al. (2014) [27] in watermelon submitted to the frequencies of nitrogen irrigation and fertigation. The shell thickness is basically related to its strength due to the watermelon production system is predominantly made in bulk, requiring a shell thickness that supports the handling of the fruits [4].

The hybrid 'Extasy' showed the highest average pulp firmness (17.43 N). Thus, this hybrid may have a greater resistance to mechanical injuries sustained due to transport, besides a long shelf life compared to the hybrid 'Mickylee', which showed the lowest average pulp firmness for the same trait (13.46 N) among all the studied hybrids. Recent findings have reported that the variation in fruit firmness correlates with variation in cell composition, density and size, addition to polyuronide fractions, and possibly with the regulation of osmotic cell pressure by osmolytes such as citrulline [11, 28]. Araújo et al. (2016) [29], reported for 'Style' hybrids, average pulp firmness around 6.48 N and highlighted loses in the resistant.

Significant differences were found in the colorimetric analysis of the fruits (Table 2).

Table 2. Colorimetric analysis (CIELAB) ( $L^*$ ,  $a^*$ ,  $b^*$ ) and  $^{\circ}$ Hue of the pulp of different watermelon hybrids cultivated at the states of Ceará and Rio Grande do Norte, Brazil.

Hybrids	Colorimetric analysis			
	$L^*$	$a^*$	$b^*$	$^{\circ}$ Hue
'Ashira'	36,07 <sup>ab</sup>	20,36 <sup>ab</sup>	10,15 <sup>b</sup>	26,84 <sup>b</sup>
'Extasy'	33,05 <sup>b</sup>	22,44 <sup>a</sup>	16,73 <sup>a</sup>	36,86 <sup>a</sup>
'Mickylee'	37,94 <sup>a</sup>	17,21 <sup>b</sup>	9,00 <sup>b</sup>	27,59 <sup>b</sup>
'Valentino'	39,26 <sup>a</sup>	21,16 <sup>a</sup>	10,21 <sup>b</sup>	25,28 <sup>b</sup>
MV	36,58	20,29	11,52	29,14
VC (%)	9,44	17,30	18,08	14,02

MV: mean values; VC: variation coefficient;  $L^*$ : luminosity;  $a^*$ : green-red coordinate;  $b^*$ : blue-yellow coordinate;  $^{\circ}$ Hue: Hue angle. Data represent mean values for different hybrids and different letters in the columns indicate significant differences, at  $P < 0.05$ .

All the studied hybrids showed average values of luminosity ( $L^*$ ) below 50. The luminosity represents a well-reflected diffuser that probably is influenced by local climate conditions and cultivation in which the parameter  $L^*$  represents values from 0 (black or no light) to 100 (white) [30]. According to our results, 'Valentino' showed the maximum average value in the  $L^*$  component (39.26), among all the hybrids, indicating the presence of a brighter endocarp, in which the pulp may reflect more light than absorb, in accordance with findings of Oliveira et al. (2019) [4] for the hybrid 'Quetzali', which the maximum mean value for the  $L^*$  component was 41.10.

'Valentino' and 'Extasy' did not show significant differences between them for the coordinate  $a^*$ . This fact might be related to the high intense red color of the pulp that reveals a positive attribute for the watermelon fruit market, since  $a^*$  (+) represents red color and  $a^*$  (-) is linked to the green color [30].

In the CIELAB color space,  $b^*$  (+) represents yellow and  $b^*$  (-) reveals evolution to the blue [30]. Thus, according to our results, all hybrids showed yellow pulp color intensity with the emphasis being placed on the hybrid 'Extasy', even though the yellow color was masked by the high intense red color in the pulp.

Average Hue angle in all those studied hybrids, except 'Extasy', fit close to  $29^{\circ}$ , which can be considered as mature fruits, in accordance with the findings in 'Style' watermelon hybrid in which the average  $^{\circ}$ Hue fit  $28.17^{\circ}$  [29]. In the hybrid 'Extasy',  $^{\circ}$ Hue fit close to  $37^{\circ}$ . Thus, we can suggest that this genotype has particularities regarding color physiology, which might be related to the high

accumulation of carotenoids as well as lycopene, traits that may be considered for breeders during selection programs.

Significant differences were found on the physicochemical characterization, except for the pH measurement of the fruits (Table 3).

Table 3. Physicochemical characteristics of fruits of different watermelon hybrids cultivated at the states of Ceará and Rio Grande do Norte, Brazil.

Hybrids	Physicochemical characteristics					
	SS (°Brix)	TA (%)	SS/TA	pH	TSS (%)	RS (%)
'Ashira'	10,28 <sup>ab</sup>	0,08 <sup>b</sup>	131,02 <sup>a</sup>	5,64 <sup>a</sup>	5,82 <sup>bc</sup>	4,48 <sup>a</sup>
'Extasy'	9,06 <sup>b</sup>	0,13 <sup>a</sup>	70,13 <sup>b</sup>	5,51 <sup>a</sup>	4,38 <sup>c</sup>	2,40 <sup>b</sup>
'Mickylee'	9,91 <sup>b</sup>	0,12 <sup>ab</sup>	78,90 <sup>ab</sup>	5,45 <sup>a</sup>	7,36 <sup>ab</sup>	2,67 <sup>b</sup>
'Valentino'	11,58 <sup>a</sup>	0,15 <sup>a</sup>	77,04 <sup>ab</sup>	5,43 <sup>a</sup>	9,20 <sup>a</sup>	2,52 <sup>b</sup>
MV	10,21	0,12	89,27	5,50	6,69	3,02
VC (%)	5,69	14,04	25,16	3,19	12,50	13,85

MV: mean values; VC: variation coefficient; SS: soluble solids; TA: titratable acidity; SS/TA ratio; pH: hydrogen potential; TSS: total soluble sugars; RS: reducing sugars. Data represent mean values for different hybrids and different letters in the columns indicate significant differences, at  $P < 0.05$ .

The average soluble solids were about 10 °Brix over all those studied hybrids, ranging by 9 to 11.6 °Brix, for 'Extasy' and 'Valentino', respectively. These results are in line with related studies for commercial watermelon hybrids [26, 29], which highlight that those hybrids are within the standards found in the market. The soluble solids content is a measurement of the concentration of reducing and non-reducing sugars, so that, the relative concentration of these sugars is influenced by cultivation and stage of maturity [9].

The soluble solids are a valuable measurement due to the higher total soluble solids content being associated with the greater commercial performance of the selected hybrid [3]. It is also noteworthy that soluble solids are very influenced by environmental factors, among which stand out the genotype, planting location and crop management [31]. Overall, the evaluated hybrids presented results consistent with watermelon market requirements, which is 11 to 13 °Brix, an acceptable range for the most commercially prominent hybrids [9].

The SS content is routinely measured by growers to estimate fruit quality, associated with multi other traits [9]. Lately, it has been found that the absorption and accumulation of sugar in watermelon fruit pulp is associated with the expression of a sugar transport gene in the tonoplast (CITST2), in which the increase in the expression was considered an important mechanism of watermelon domestication [32].

Overall, the average titratable acidity was about 0,12 those studied hybrids, ranging by 0.08 to 0.15% of malic acid, for 'Ashira' and 'Valentino', respectively, in line with those which were reported by Yau et al. (2010) [26], who found average titratable acidity ranging from 0.09 to 0.13%, values within the acceptable limits for the consumer to market the fruit [33]. Overall, the watermelon fruits show more than 75% of malic acid followed by citrate (> 20%) and minimal concentrations of other organic acids [33]. Thus, all the studied hybrids showed low acidity, especially 'Ashira' when compared to the other hybrids, a particular genetic trait of each genotype and may also be a result of the influence of cultivation conditions.

Whereas changes in the soluble solids and in titratable acidity, variation in the mean values of the SS/TA ratio was obtained. The hybrid 'Ashira' had an increase over 73% in the SS/AT ratio compared to the other hybrids which represents a high proportion of sugars present in the fruit of 'Ashira' and low amount of organic acids present, being the hybrid considered more palatable compared to the others. Campagnol et al. (2012) [34], when evaluating the postharvest quality of the hybrid Smile, showed SS/TA presents ratio values close to the hybrids evaluated in this study (77.25 to 81.26). The SS/TA ratio provides indicative of the taste of the fruit, as they report the amount of sugars and acids present providing a good idea of the balance between these two components.

No statistically significant differences were found for the pH. However, the results for all hybrids are in line with the pH for watermelons harvested at commercial maturity which ranging from 5.5–

5.8 [4, 26, 35]. Genetic and environmental factors considerably influence the chemical composition of the fruits not only by the variety but also due to the degree of maturity before harvest and on the postharvest and storage conditions [4].

Significant differences were found for the total soluble sugar ranging from 4.38 to 9.20% for 'Extasy' and 'Valentino' hybrids, respectively. 'Valentino' could show the best sweet taste among the hybrids, since soluble sugars are the low molecular weight carbohydrates, components of soluble solids, responsible for the sweet taste of fruits [4]. Our results are in line with Araújo et al. (2016) [29] which observed average levels of 8.23% of total soluble sugars in watermelon fruits.

The average reducing sugars was about 3,02% over all those studied hybrids, ranging from 2.40 to 4.48% 'Ashira' and 'Extasy', respectively, in line with Araújo et al. (2016) [29] (5.52%). It is noteworthy that the main sugars present in cucurbits are, in general, glucose, fructose, and sucrose. Reducing sugars contribute with almost the majority of the total sugar content in the early stage of fruit development; However, sucrose can reach up to 50% of total sugars in the final maturation phase, with an approximate proportion of 25% for glucose and 25% for fructose [36].

Regarding the bioactive compounds, significant differences were found only for the contents of lycopene and total polyphenols content (Table 4).

Table 4. Bioactive compounds of fruits of different watermelon hybrids cultivated at the states of Ceará and Rio Grande do Norte, Brazil.

Hybrids	Bioactive compounds					
	VC	CT	FA	ANT	LYC	PET
'Ashira'	9,35 <sup>a</sup>	2,46 <sup>a</sup>	4,94 <sup>a</sup>	0,61 <sup>a</sup>	1,06 <sup>a</sup>	238,10 <sup>a</sup>
'Extasy'	8,67 <sup>a</sup>	2,57 <sup>a</sup>	5,52 <sup>a</sup>	0,54 <sup>a</sup>	1,09 <sup>a</sup>	96,94 <sup>b</sup>
'Mickylee'	7,97 <sup>a</sup>	1,72 <sup>a</sup>	5,97 <sup>a</sup>	0,64 <sup>a</sup>	0,55 <sup>b</sup>	219,06 <sup>a</sup>
'Valentino'	8,12 <sup>a</sup>	2,35 <sup>a</sup>	4,22 <sup>a</sup>	0,51 <sup>a</sup>	0,85 <sup>ab</sup>	229,95 <sup>a</sup>
MG	8,53	2,27	5,16	0,57	0,89	196,01
CV (%)	6,99	14,59	23,79	42,34	14,08	5,91

MV: mean values; VC: variation coefficient; VC: Vitamin C ( $\text{mg } 100 \text{ g}^{-1}$ ); TC = Total carotenoids ( $\text{mg } 100 \text{ g}^{-1}$ ); FA = yellow flavonoids ( $\text{mg } 100 \text{ g}^{-1}$ ); TA = total anthocyanins ( $\text{mg } 100 \text{ g}^{-1}$ ); LYC = ( $\text{mg } 100 \text{ g}^{-1}$ ); PET = Total extractable polyphenols ( $\text{mg } 100 \text{ g}^{-1}$ ). Data represent mean values for different hybrids and different letters in the columns indicate significant differences, at  $P < 0.05$ .

Watermelon provides a wide variety of antioxidants such as carotenoids (lycopene and  $\beta$ -carotene), phenols, vitamins (A, B, C and E) and specific amino acids (citrulline and arginine) believed to play a protective role in reducing of the risk of certain cancers, cardiovascular disease and age-related degenerative pathologies [9, 10].

The bioactive results related to the content of vitamin C, total carotenoids as well as anthocyanin and flavonoids fall in line with findings in other genotypes [4, 10, 29, 37], even though no significant differences were found for these characteristics. Vinson et al. (2001) [38] reported that watermelon is classified as one of the main fruits of consumption in the world market, highlighting, as the main marketing centers, America and Europe, which provide about 80 and 50% of the intake of such compounds daily. Thus, our seedless watermelon hybrids produced at northeastern semiarid have high-quality hence being indicated as market novelty due to the high phytochemical content.

Overall, 'Extasy' showed average lycopene content 49% higher than 'Mickylee' which presented the lowest mean value for this trait ( $0.55 \text{ mg } 100 \text{ g}^{-1}$ ) among the evaluated hybrids, indicating a genetic variation in the pigment synthesis in each material. Different environmental conditions, especially light and temperature may amplify this variability, contributing to differences in values observed under different geographical areas [39]. The variation in the lycopene content might be also due to a differentiated activation of the molecular mechanisms involved in the carotenogenesis regulation during ripening stages, followed by feedback inhibition of the pathway by end-products towards the end of fruit ripening [10].

In the watermelon fruits, the lycopene content may vary according to the ripening stage of the fruit, in which the highest rate of synthesis and accumulation in the chromoplasts can be detected in the transition phase between the "white-pink" and "pink" stages" [10]. In line with the findings reported by Perkins-Veazie et al. (2001) [40] in 11 seedless watermelon hybrids as well as for those

reported by Oliveira et al. (2019) [4] for the hybrid 'Boston' and 'Quetzali', but lower to the results found by Leão et al. (2006) [41] who evaluated 8 watermelon cultivars for lycopene content under commercial orchard of 'Charleston Gray' and 'Smile', respectively.

Significant differences were found for the total polyphenols in which 'Ashira' standing out compared to the 'Extasy' which showed the lowest content. Our findings are in line with those reported by Tlili et al. (2011) [10] as well as Oliveira et al. (2019) [4]. Haminiuk et al. (2012) [42] reports that phenolic compounds are metabolites widely found in fruits and that the interest in such substances is mainly due to antioxidant activity in preventing diseases. In general, it is observed that although polyphenol levels in watermelons are considered lower than other fruits, the high consumption of this fruit, can contribute considerably to the daily intake of such compounds.

#### 4. CONCLUSION

The fruits of the seedless watermelon hybrids cultivated under conventional management at the Brazilian semiarid area are promising alternatives to the local and export watermelon market, in view of the high quality and bioactive potential linked to the good adaptability and stability under the growth conditions.

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