Qualitative performance of lettuce cultivars in four seasons in Mossoró, Rio Grande do Norte State, Brazil[1]

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ABSTRACT

The major challenge in producing good quality lettuce in the semiarid region is the climatic factors such as high temperature, high luminosity and low air relative humidity, which affect the quality characteristics of leafy vegetables. Thus, the objective of this study was to evaluate the quality of lettuce cultivars of Crisphead (Angelina, Amelia and Taina), Mimosa (Mila, Mimosa and Lavinia), Green-leaf (Scarlet, Vera, Isabella and Vanda) and Loose-leaf (Elisa and Regiane) in four seasons: summer (12/21/2012), autumn (3/21/2013), winter (06/21/2013) and spring (09/23/2013) in the conditions of Mossoró, Rio Grande do Norte state. The experimental design was a complete randomized block with four replications. The following characteristics were quantified: pH, titratable acidity, soluble solids (SS) and total soluble sugars. The quality of the lettuce was influenced by the cultivar and environmental conditions. Lower titratable acidity was recorded for Green-leaf and Loose-leaf groups in the summer and for Crisphead groups in the autumn. The highest content of soluble solids were achieved in autumn for cultivars Vera, Vanda, Isabela, Elisa and Regiane; to Lavinia, Angelina, Amelia and Tainá, and summer and autumn stood out from the other growing seasons for this trait. Cultivars Scarlet, Angelina and Amelia had higher levels of total soluble sugars in the summer; Mila and Lavinia in spring; Elisa and Regiane in winter and Tainá in spring.

Key words: *Lactuca sativa* L.; quality; climatic factors.

RESUMO

Desempenho qualitativo de cultivares de alface em quatro épocas do ano em Mossoró, Rio Grande do Norte

A grande dificuldade para a produção de alface de qualidade na região semiárida se deve aos fatores climáticos, como temperatura elevada, alta luminosidade e baixa umidade relativa do ar, que afetam as características de qualidade das hortaliças folhosas. Diante disso, o objetivo da pesquisa foi avaliar a qualidade de cultivares de alface dos grupos Americana (Angelina, Amélia e Tainá), Mimosa (Mila, Mimosa e Lavínia), Crespa (Scarlet, Vera, Isabella e Vanda) e Lisa (Elisa e Regiane) em quatro épocas do ano: verão (21/12/2012), outono (21/03/2013), inverno (21/06/2013) e primavera (23/09/2013) nas condições de Mossoró, RN. O delineamento experimental adotado foi o de blocos casualizados completos com quatro repetições. Foram quantificadas as características: pH, acidez titulável, sólidos solúveis (SS) e açúcares solúveis totais. A qualidade da alface foi influenciada pela cultivar e condições ambientais. Os grupos Crespa e Lisa registraram menor acidez titulável no verão e as Americanas no outono. Os maiores teores de SS foram obtidos no outono para as cultivares Vera, Vanda, Isabela, Elisa e Regiane; para Lavínia, Angelina, Amélia e Tainá, o verão e outono se destacaram das demais épocas de cultivo, para esta característica. As cultivares Scarlet, Angelina e Amélia apresentaram maior teor de açúcares solúveis totais no verão, Mila e Lavínia na primavera, Elisa e Regiane no inverno e Tainá na primavera.

Palavras-chave: *Lactuca sativa* L.; qualidade; fatores climáticos.

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INTRODUCTION

The demand and consumption of vegetables, among them lettuce, has increased in the last years. This is not only because of population growth, but also because of the change in eating habits. According to Silva *et al.* (2011), at the end of the last decade, food quality was regarded as food and nutritional safety factor, and this quality is not related only to the food production in sufficient amount, but also to promote the health of those who consume it. Lettuce is a very perishable leafy vegetable, as it has high water content and large leaf area (Santos *et al*., 2001). The senescence process in leafy vegetables occurs mainly due to water deficit, from the rapid water loss (Wills *et al*., 1981) and the action of various catalytic enzymes (Santos *et al*., 2001), that is, the main cause of loss of quality of this vegetable is endogenous, although some external factors such as temperature, relative humidity and the presence of disease-causing organisms (Resende, 2004) may also affect the quality of commercialized lettuces.

According to Vieira & Cury (1997), the air temperature is the climatic element that influences physiological processes of lettuce plants the most by accelerating or slowing down the metabolic reactions, directly affecting growth and quality. The use of lettuce cultivars adapted to the environmental conditions of high temperatures as well as the use of practices aimed at reducing the thermal effect may contribute to the increase in the crop yield, improving the quality of the product (Cavalcante, 2008). Besides that, other climatic factor affecting the quality of the lettuce is the length, quality and intensity of light, which modifies quality characteristics such as color, leaf thickness, size, soluble solids, vitamin C and the mass of fruits and vegetables (Chitarra & Chitarra, 2005).

Post-harvest quality of vegetable crops is evaluated mainly by the soluble solids, total titratable acidity and pH (Chitarra & Chitarra, 2005). Studies that evaluate these characteristics in lettuce cultivars, especially in different growing seasons (Resende, 2004; Zizas *et al*., 2002; Ohse *et al*., 2001; Silva *et al*., 2011) are scarce and the importance of this work is because it clarifies the qualitative behavior of lettuce cultivars when the cultivation is carried out in different growing seasons.

Thus, the objective of this study was to evaluate the quality of lettuce cultivars of the following groups: Green-leaf, Crisphead, Mimosa and Loose-leaf in four growing seasons in the environmental conditions of Mossoró, Rio Grande do Norte state.

MATERIAL AND METHODS

Four experiments were carried out in the garden of the Department of Plant Sciences at Universidade Federal Rural do Semi-Árido (UFERSA), in Mossoró, Rio Grande do Norte state, which is located at 5º12'27"S, 37º19'05"W, at 26 m above sea level. According to Thornthwaite, the climate in the region is semi-arid and according to Köppen, the climate is BSwh', dry and very hot, with the following climatic seasons: a dry season, which usually goes from June to January and a rainy season from February to May, with an average annual temperature of 27.4 ºC, average irregular annual rainfall of 673 mm and relative humidity of 68.9% (Carmo Filho *et al*., 1991). The soil of the experimental area is classified as Red-Yellow Eutrophic Abrupt Argisol, loamy-sand texture (Embrapa, 2013).

The treatments consisted of 12 lettuce cultivars of the following groups: Crisphead (Angelina, Amelia and Taina), Green-leaf (Scarlet, Vera, Isabella and Vanda), Mimosa (Mila, Mimosa and Lavinia), and Loose-leaf (Elisa and Regiane), which were evaluated in complete randomized block design with four replications.

The four experiments were carried out from November/ 2012 to September/ 2013, beginning with the production of seedlings in expanded polystyrene trays of 200 cells. The seedlings were transplanted when they presented four to six true leaves. The transplantings were performed at the beginning of each weather station: 1st season - summer (12/21st to 3/21st), 2nd season – autumn (3/21st to 6/ 21st), 3rd season - winter (6/21st to 09/23rd) and 4th season – spring (9/23rd to 12/21st).

To evaluate the weather effect, a micrometeorological tower was set in the experimental area. The sensors were connected to an automatic data collection system enabling to measure air temperature at 50 cm from the surface (°C) and relative humidity (%), rainfall (mm) and global solar radiation (W m^{-2}) which were stored in a Campbell Scientifique datalogger, model CR 1000, with data collected every 5 seconds and stored every 20 minutes. The datalogger was programmed to provide daily average of data already cited during the experimental period. The daily maximum, minimum and average values of air temperature, relative humidity and solar radiation (Figure 1) were quantified over the experiments, except the rainfall values due to lack of rain in the experimental periods.

The plots were formed by beds of 0.20 m of height, 1.20 m in width and 1.85 m in length, with five rows of plants spaced by 0.20 m between rows and by 0.20 m between plants. The useful area of each plot was constituted by the three central rows, excluding a plant from each end of the central rows, resulting in an area of 0.84 m^2.

A pre-planting soil solarization for pest control in the experimental area was carried out using transparent plastic. After solarization, a soil sample was collected from the 0-20 cm layer for chemical analysis. The fertilization was

performed according to recommendations for the crop in the State of Pernambuco (Cavalcanti, 1998).

For base fertilization, it was applied 40 kg ha^{-1} of N, 60 kg ha^{-1} of P_2O_5 and 30 kg ha^{-1} of K_2O, using urea, superphosphate and potassium chloride as sources, respectively, and as organic fertilizer, 23 t ha^{-1} of Pole Fértil were applied, consisting of cattle manure and chicken manure. In topdressing, urea (40 kg ha^{-1} of N) was used by applying it 15 days after transplanting (DAT) and two leaf fertilizations were carried out at 10 and 20 DAT with Rizammina, which has in its composition 13% of N, 8% of P_2O_5, 21% of K_2O, secondary macronutrients (2% of magnesium, 5.5% of sulfur) and micronutrients (0.03% of boron, 0.05% of copper, 0.2% of iron and 0.1% of zinc).

During the experiment, manual weeding was carried out and irrigation was performed by micro sprinkler system, applying water-depths in the morning and afternoon daily, according to the demands of the crop.

Harvest was performed when the plants were at commercial standard, with no flowering evidence and at

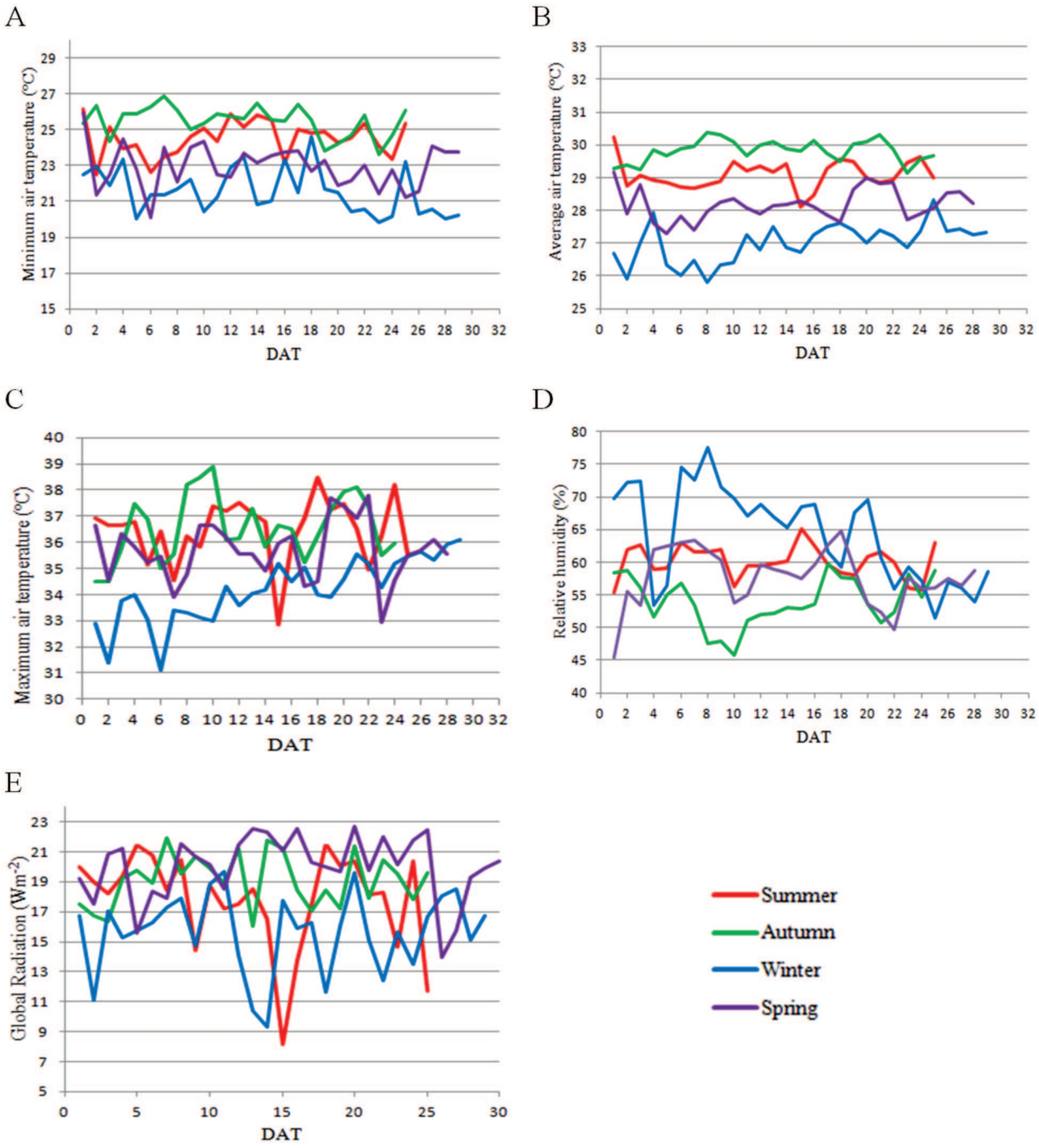

Figura 1: Temperatura mínima (A), média (B) e máxima do ar (C), umidade relativa média do ar (D) e radiação global (E) durante a condução do experimento, dias após o transplantio (DAT), nas quatro épocas de plantio. Mossoró-RN, 2013.

maximum vegetative growth. The procedure used for harvest consisted in plucking the plants, and thereafter, the root part was separated from the aerial part with all the external leaves.

For the determination of quality characteristics, a sample of eight plants from the useful area was taken. The plants were washed in running water to remove the excess of soil, then leaves were detached from the stem and processed until juice, which was used to analyze the following: pH, titratable acidity (mEq H_3O^+ 100 g^{-1}), soluble solids (%) and total sugar (%).

For the evaluation of hydrogenionic potential (pH), a digital potentiometer with glass membrane electrode, model LS 300 - HH was used according to the methodology of Institute Adolfo Lutz Institute (IAL, 2005).

Titratable acidity (TA) was determined in duplicate using na aliquot of leaf juice (0.5 mL), which was completed to 50 mL of distilled water and three drops of alcoholic phenolphthalein at 1% was added into the solution. Then, titration of the sample was performed with a 0.01 N NaOH solution, previously standardized until the turning point, characterized by a pink color. The results were expressed in mEq H_3O^+ 100 g^{-1}, according to the IAL norms (2005).

Soluble solids (SS) were determined directly from the homogenized leaf juice by reading in a digital refractometer (PR model - 100, Palette, Atago Co., LTD, Japan), with automatic temperature compensation. The results were expressed in percentage (%) according to standards of the Association of Official Analytical Chemistis – AOAC (2002).

Soluble sugars (SS) were determined from the samples of juice of lettuce leaves. The method used was Antrona, according to Yemm & Willis (1954), from a 1 mL aliquot of the lettuce juice already filtered, diluted into 100 mL with distilled water. After that, na aliquot of 350 µL was taken from this solution and 650 µL of distilled water, which were then placed in a tube, which was after placed in an ice bath so that the anthrone reagent could be added (2 mL). Subsequently, the tubes were subjected to the boiling water bath for 8 minutes. The tubes were cooled in ice water. Reading was performed in a spectrophotometer at 620 nm.

The data from the four experiments were submitted to jointly analysis of variance using SISVAR v.5.3 software (Ferreira, 2008). The means of the groups, cultivars and season in the unfolding of interactions were grouped by the Scott-Knott method at 5% of probability.

RESULTS AND DISCUSSION

A triple interaction was found between the factors seasons versus cultivar and groups, and a double interaction for the factors season and group. A significant effect was observed for all evaluated characteristics by the F test, with a significant response at the level of 1% level of probability. These results show that the growing season influences the qualitative performance of lettuce cultivars of groups Crisphead, Green-leaf, Mimosa and Loose-leaf.

Regarding the pH (Table 1), it was found that, by observing the groups within each season that in the summer crop, lettuce groups did not differ among each other. In autumn, Loose-leaf group showed pH higher than others. For the crop growing in winter, Green-leaf group stood out, and in the spring Mimosa presented higher pH, followed by Green-leaf, Crisphead and Loose-leaf lettuces.

When each group was individually evaluated in the seasons, (Table 1), it was observed that for Crisphead, Loose-leaf and Green-leaf groups, the pH was higher in the summer, ranging from 6.14 to 6.15, while for Mimosa group, the highest values were observed in the spring. For all lettuce groups, the lowest pH means were found in the winter. These results are in agreement with Freire *et al*. (2009), who working in a protected environment in salty conditions in Mossoró, Rio Grande do Norte state, found pH values ranging from 5.87 to 6.22 for cultivars of Green-leaf, Crisphead and Loose-leaf groups, which were very close to those observed for the same groups evaluated in this study.

For cultivars of Green-leaf group (Table 1) it was found that, in the summer and spring crops, Vera and Vanda (6.19; 6.16 and 6.19; 6.11 respectively) showed higher pH than Isabela and Scarlet (6.06; 5.99 and 6.12; 6.00 respectively); however in winter, Vera, Vanda and Scarlet did not differ from each other and were superior to cultivar Isabela. Yet, no statistical differences were found among cultivars of that group in autumn. The pH values are close to those found for cultivar Veronica of Green-leaf group by Stertz *et al*. (2005), who presented pH in the order of 6.05 in fresh samples in hydroponics system.

Regarding pH, Cultivar Mila (Table 1) stood out from Mimosa and Lavinia when grown in summer and spring; it did not differ from them in autumn and together with Lavinia, it was lower than Mimosa in the winter crop. However, In the Crisphead group, Tainá stood out from Angelina and Amelia when grown in summer and spring, but was similar to them in autumn and winter. For Loose-leaf group, cultivar Regiane presented pH values higher than cultivar Elisa in summer, autumn and spring crops but in the winter, the cultivars did not differ from each other.

By observing the pH values (Table 1) for the cultivars, it can be seen that the evaluated cultivars presented pH

values within the range considered optimal, which varies from 5 to 7 according to Menezes *et al.* (2005). When the cultivation was carried out during autumn, which was a season that presented the highest temperature and relative humidity, on average, ranging from 45.76% to 59.82% (Figure 1) over the experiment, pH values did not vary much among cultivars. For other growing seasons, a larger variation of pH values is found; in addition, the average temperatures were lower with respect to autumn and the relative humidity ranged from 45.43% to 77.50% (Figure 1), therefore, it is evident that the pH of lettuce is influenced by environmental conditions and changes among cultivars (Freire *et al*., 2009).

For titratable acidity (Table 2), when the groups were evaluated in each growing season, it was found that, in summer and spring, Green-leaf, Mimosa and Loose-leaf did not differ among each other and were superior to the Crisphead. On the other hand, in autumn and winter, the Loose-leaf group stood out, showing to be superior to Green-leaf, Mimosa and Crisphead. By assessing the seasons for each lettuce group, it was found that Crisphead and Green-leaf lettuces showed higher titratable acidity when the cultivation was carried out in winter, whereas Mimosa stood out in winter and spring, and Loose-leaf in the autumn and winter.

For titratable acidity observed in cultivars of each group (Table 2), it is found that in the Green-leaf group, Isabela (2.27 mEq H_3O^+ 100 g^{-1}) stood out from the others in summer crop, Vanda (2.45 mEq H_3O^+ 100 g^{-1}) and Scarlet (2.45 mEq H_3O^+ 100 g^{-1}) in the autumn and the latter also in the spring, with mEq H_3O^+ 100 g^{-1} of titratable acidity. However, no significant differences were observed in winter among cultivars of this group.

When working with Vera cultivar in summer and winter in Uberaba, Minas Gerais state, Honório *et al*. (2010) found that the higher titratable acidity values were observed when the crop was carried out in the summer (2.72 mEq H_3O^+ 100 g^{-1}), than in winter (1.75 mEq H_3O^+ 100 g^{-1}), which was a different behavior from the one observed in this study for cultivars of the same lettuce group, where the highest values of titratable acidity values were found in autumn and winter and the lowest values in summer and spring. This can be explained by the difference in climate conditions between the regions in the study, with maximum temperatures of up to 38.87°C in autumn and low relative humidity of 45.76% (Figure 1). These values are different from those observed in Minas Gerais state, which has a milder climate with average annual temperature of 21°C (Pizolato Neto *et al*., 2011), evidencing that chemical composition of plants can vary according to the cultivar

Table 1: pH of lettuce plants in each group and in the cultivars of each group in the four crop seasons. Mossoró, Rio Grande do Norte state, 2013

Group	Summer	Autumn	Winter	Spring
		pH		
Green-leaf	6.14 a A[1]	6,00 b C	5.99 a C	6.06 b B
Mimosa	6.16 a B	6,00 b C	5.96 b D	6.21 a A
Crisphead	6.15 a A	6,01 b B	5.96 b C	5.96 c C
Loose-leaf	6.14 a A	6,05 a B	5.94 b C	5.90 d D
		Green-leaf group cultivars		
Vera	6.19 a[1]	6.00 a	6.00 a	6.16 a
Vanda	6.19 a	6.00 a	6.00 a	6.11 a
Isabela	6.06 b	6.00 a	5.95 b	5.99 b
Scarlet	6.12 b	6.00 a	6.04 a	6.00 b
		Mimosa group cultivars		
Mimosa	6.15 b	6.00 a	6.02 a	6.17 b
Mila	6.29 a	6.00 a	5.95 b	6.34 a
Lavínia	6.05 c	6.00 a	5.91 b	6.12 b
		Crisphead group cultivars		
Angelina	6.18 b	6.02 a	5.94 a	5.96 b
Amélia	6.05 c	6.00 a	5.97 a	5.88 c
Tainá	6.24 a	6.00 a	5.98 a	6.06 a
		Loose-leaf group cultivars		
Elisa	6.09 b	6.00 b	5.95 a	5.84 b
Regiane	6.19 a	6.09 a	5.94 a	5.97 a

[1]Means followed by the same lower case letter in the column and upper case letter in the row are not different from each other by the Scott-Knott test ($p < 0.05$).

and also with environmental conditions to which they are submitted during the growing season (Taiz & Zeiger, 2013).

In relation to Mimosa group (Table 2), cultivar Lavínia stood out in the summer and autumn crops, with titratable acidity value of 2.37 and 2.29 mEq H_3O^+ 100 g^{-1}, respectively. In winter, the cultivar that stood out was Mila (2.62 mEq H_3O^+ 100 g^{-1}), but in spring, no statistical differences between cultivars of Mimosa group were found. Angelina and Tainá of Crisphead did not differ from each other and stood out when the cultivation was carried out during summer and spring. Cultivar Angelina stood out in winter crop, but in autumn, it was lower than Tainá and Amelia, which had 1.61 and 1.72 mEq H_3O^+ 100 g^{-1} of titratable acidity, respectively.

For Loose-leaf group (Table 2), when the cultivation was carried out in summer, no statistical differences were found among cultivars, but in autumn and spring, Regiane presented higher performances than Elisa, and in winter, Elisa was the cultivar that stood out. Titratable acidity values shown in Table 2 were higher than those found by Morais *et al*. (2011) and Santos *et al*. (2010), who evaluated cultivars of Green-leaf group in Mossoró, Rio Grande do Norte state and in Botucatu, São Paulo state, respectively, in different farming systems, and found that titratable acidity varies according to the cultivar and the cultivation environment.

For the characteristic soluble solids, when the groups were evaluated in each growing season (Table 3), it was observed that Green-leaf lettuce achieved the greatest contents of soluble solids when grown in the summer; in autumn and spring, Green-leaf and Loose-leaf groups stood out, in which the latter reached the highest contents of soluble solids when grown in winter. When growing seasons were evaluated for each lettuce group, (Table 3), it was found that for Green-leaf and Loose-leaf, when grown in the autumn, the highest contents of soluble solids were found. Mimosa and Crisphead groups stood out in the summer and autumn.

Santos *et al.* (2010), evaluating cultivars of the Green-leaf group in Botucatu, São Paulo state, in the organic, conventional and hydroponics systems, found soluble solids ranging from 3.61 to 3.38%, which were values close to those observed for the lettuce groups in winter crop (Table 3). Freire *et al*. (2009), evaluating Green-leaf, Crispehead and Loose-leaf cultivars in saline conditions in Mossoró, Rio Grande do Norte state, found soluble solids from 3.6 to 5.1%. Working with the cultivar Lorca of Crisphead group in Campinas, state of São Paulo, Darezzo (2004), obtained values ranging from 2.9 to 3.10%. For

Table 2: Titratable acidity in lettuce plants in each group and in the cultivars of each group in the four crop seasons. Mossoró, Rio Grande do Norte state, 2013

Group	Summer	Autumn	Winter	Spring
	Titratable acidity (mEq H_3O^+ 100 g^{-1})			
Green-leaf	1.98 a C[1]	2.19 b B	2.25 b A	2.15 a B
Mimosa	1.91 a B	1.98 c B	2.19 b A	2.14 a A
Crisphead	1.67 b C	1.58 d D	2.21 b A	1.81 b B
Loose-leaf	1.97 a C	2.48 a A	2.50 a A	2.18 a B
	Green-leaf group cultivars			
Vera	1.88 c[1]	2.15 b	2.33 a	1.70 c
Vanda	1.78 c	2.45 a	2.24 a	1.77 c
Isabela	2.27 a	1.98 c	2.22 a	2.48 b
Scarlet	1.99 b	2.45 a	2.22 a	2.66 a
	Mimosa group cultivars			
Mimosa	1.81 b	1.63 c	2.08 b	2.19 a
Mila	1.55 c	2.01 b	2.62 a	2.06 a
Lavínia	2.37 a	2.29 a	1.87 c	2.17 a
	Crisphead group cultivars			
Angelina	1.74 a	1.42 b	2.55 a	1.87 a
Amélia	1.57 b	1.72 a	2.01 b	1.69 b
Tainá	1.71 a	1.61 a	2.08 b	1.87 a
	Loose-leaf group cultivars			
Elisa	1.91 a	2.38 b	2.62 a	2.01 b
Regiane	2.04 a	2.57 a	2.38 b	2.36 a

[1]Means followed by the same lower case letter in the column and upper case letter in the row are not diferente from each other by the Scott-Knott test ($p < 0.05$).

Iceberg cultivar, Bolin & Huxsoll (1991) found values ranging from 2.8 to 2.4%. Probably this divergence between the results is due to the cultivar used in the study, to the climatic conditions to which the crop is exposed during the cycle and also to the amount of water, which can interfere with the soluble solids content of lettuces (Freire *et al*., 2009).

By observing cultivars of each group (Table 3), it was found that for the characteristic of soluble solids, cultivars Vera, Vanda and Scarlet (5.28, 5.23 and 5.38%, respectively) stood out when grown in summer. Moreover, the first two (Vera, 5.41% and Vanda, 5.44%) stood out in the autumn along with cultivar Isabela (5.58%). However, in winter and spring, cultivars of this group did not differ from each other. Silva *et al.* (2011), when assessing the quality of Green-leaf lettuce produced in conventional, organic and hydroponic systems, obtained values ranging from 2.9 to 4.0% of soluble solids, for those cultivation systems in Rio Branco, Acre state, which were values close to those found in this study for the same lettuce group when grown in winter. However, in summer, autumn and spring crops, values of soluble solids were higher than those found observed by these authors.

Cultivars Lavinia (Table 3) stood out from other cultivars of Mimosa group, when grown in summer and autumn, showing values of soluble solids of 4.71 and 5.18% respectively, nevertheless, in the other seasons, cultivars of this group did not differ from each other. In summer and autumn, cultivars of the Crisphead group did not differ from each other, but in winter, cultivar Angelina (4.20%) showed the highest soluble solid contents, and in spring, Tainá (4.28%) stood out from the other in this group. Cultivars of the Loose-leaf group did not differ from each other in any of the growing seasons.

By evaluating soluble solids content of lettuce cultivars, it is observed that the winter crop showed the lowest contents of soluble solids, which can be explained by the fact that in this season, it was observed radiation values slightly lower than in other crop seasons (Figure 1). It is known that the higher the light radiation, there more intense is the production of soluble solids (Chitarra & Alves, 2001), although this is not a quality characteristic in lettuce because the consumer does not expect to taste a sweet lettuce, contrary to the expectation of tasting a typical fruit for dessert, for example (Silva *et al*., 2011).

For total soluble sugars (Table 4), when the groups were evaluated in each growing season, no statistical differences in the content of total soluble sugars were found for the Crisphead group in the four growing seasons. During autumn, this group, along with Green-

Table 3: Soluble solids of lettuce plants in each group and in the cultivars of each group in the four crop seasons. Mossoró, Rio Grande do Norte state, 2013

Group	Summer	Autumn	Winter	Spring
	Soluble solids (%)			
Green-leaf	5.13 a B[1]	5.33 a A	3.78 b D	4.79 a C
Mimosa	4.45 b A	4.53 b A	3.62 b C	4.18 b B
Crisphead	4.22 c A	4.22 c A	3.81 b C	4.03 b B
Loose-leaf	4.46 b B	5.45 a A	4.16 a C	4.63 a B
	Green-leaf group cultivars			
Vera	5.28 a[1]	5.41 a	3.73 a	4.60 a
Vanda	5.23 a	5.44 a	3.83 a	4.79 a
Isabela	4.65 b	5.58 a	3.84 a	5.01 a
Scarlet	5.38 a	4.88 b	3.74 a	4.79 a
	Mimosa group cultivars			
Mimosa	4.29 b	4.24 b	3.39 a	4.00 a
Mila	4.35 b	4.19 b	3.84 a	4.23 a
Lavínia	4.71 a	5.18 a	3.63 a	4.33 a
	Crisphead group cultivars			
Angelina	4.38 a	4.28 a	4.20 a	3.93 b
Amélia	4.19 a	4.29 a	3.55 b	3.88 b
Tainá	4.10 a	4.10 a	3.68 b	4.28 a
	Loose-leaf group cultivars			
Elisa	4.40 a	5.41 a	4.08 a	4.51 a
Regiane	4.53 a	5.49 a	4.24 a	4.75 a

[1]Means followed by the same lower case letter in the column and upper case letter in the row are not different from each other by the Scott-Knott test ($p < 0.05$).

leaf and Mimosa groups, did not differ from each other, with values higher than those found in Loose-leaf lettuce segment. However, Loose-leaf and Crisphead groups stood out from the others when grown over winter. Thus, it is found that the cultivars of the Crisphead group had the highest percentage of total sugars, standing out in all seasons.

When crop seasons were evaluated for each lettuce group (Table 4), it is found that Green-leaf lettuce segment stood out only in the summer (0.88%), while Mimosa group had the highest percentage of total sugars when grown in spring (0.79%). For the Crisphead group, crops conducted during spring and summer (1.04 and 1.09% respectively) did not statistically differ from each other, and showed higher values than the crops conducted in other seasons. Loose-leaf group stood out in winter, statistically superior to crops carried out in other seasons.

By generally observing the behavior of lettuce groups (Table 4), it can be seen that smaller percentages of total soluble sugars were obtained when the crop was grown during autumn, which presented average, maximum and minimum temperatures always higher than in the other growing seasons (Figure 1). According to Chitarra & Alves (2001), high temperature actives respiratory metabolism, which reduces the content of sugars, since they are used as a substrate for respiration. The respiration rate increases with the temperature and the interaction between photorespiration and photosynthesis becomes apparent in the responses to the temperature (Taiz & Zeiger, 2004), evidencing that even when photosynthesizing, the respiratory metabolism of plants is affected by temperature, reducing sugar content inasmuch as it is consumed during respiration.

When total soluble sugars of lettuce cultivars in each group were evaluated (Table 4), it was found that Scarlet was superior to the others in its group (Vera, Vanda and Isabela), in summer and autumn crops (1.26 and 0.94%, of total soluble sugars, respectively). In spring, it stood out with Isabella among the other cultivars. However, in the cultivation carried out in winter, Vanda and Isabela had the highest content of total soluble sugars (0.76 and 0.79% respectively), excelling from the others. Mila and Lavínia of Mimosa group did not statistically differ from each other and excelled in relation to cultivar Mimosa, when grown during summer, winter and spring. During autumn, Lavinia excelled Mila and Mimosa, however.

For cultivars of the Crisphead group (Table 4), it was found that Angelina did not differ from Amelia when grown during summer, presenting the highest levels of total soluble sugars, the latter also stood out

Table 4: Total soluble sugars in lettuce plants in each group and in the cultivars of each group in the four crop seasons. Mossoró, Rio Grande do Norte state, 2013

Group	Summer	Autumn	Winter	Spring
		Total soluble sugars (%)		
Green-leaf	0,88 b A[1]	0.58 a C	0.67 b B	0.69 c B
Mimosa	0,68 c B	0.63 a B	0.69 b B	0.79 b A
Crispead	1,04 a A	0.67 a C	0.87 a B	1.09 a A
Loose-leaf	0,65 c C	0.48 b D	0.92 a A	0.79 b B
		Green-leaf group cultivars		
Vera	0.84 b[1]	0.38 b	0.52 b	0.46 b
Vanda	0.51 c	0.49 b	0.76 a	0.55 b
Isabela	0.92 b	0.51 b	0.79 a	0.93 a
Scarlet	1.26 a	0.94 a	0.61 b	0.82 a
		Mimosa group cultivars		
Mimosa	0.47 b	0.46 b	0.43 b	0.68 b
Mila	0.79 a	0.58 b	0.82 a	0.82 a
Lavínia	0.79 a	0.84 a	0.82 a	0.86 a
		Crisphead group cultivars		
Angelina	1.17 a	0.58 b	0.85 b	0.79 b
Amélia	1.05 a	1.03 a	0.77 b	0.85 b
Tainá	0.91 b	0.39 c	0.99 a	1.64 a
		Loose-leaf group cultivars		
Elisa	0.87 a	0.43 a	0.90 a	0.59 b
Regiane	0.42 b	0.53 a	0.94 a	0.99 a

[1]Means followed by the same lower case letter in the column and the same upper case letter in the row are not different from each other by the Scott-Knott test ($p < 0.05$).

in autumn. For the crop carried out in winter, Tainá had the highest total soluble sugars, with a similar behavior in spring.

Cultivar Elisa of the Loose-leaf group (Table 4), excelled when compared to cultivar Regiane when grown during summer. A different behavior was observed in the spring when cultivar Regiane showed the highest values for that characteristic. During autumn and winter, cultivars of this group did not differ from each other.

França (2011) evaluated the content of total soluble sugar in cultivars of Green-leaf group stored at 5 or 22 °C, with or without application of hidrocooling during the first 48 hours of post-harvest storage and found values ranging from 1.62% to 2.72%. These results are well above those observed in this study, which can be explained by climatic differences among the cultivation environments, as well as the treatments applied after harvest of the experiments.

CONCLUSIONS

The quality of the lettuce was influenced by the cultivar and environmental conditions.

Cultivars of Green-leaf and Loose-leaf groups recorded the lowest titratable acidity during summer and Crisphead group, over autumn.

The highest contents of soluble sugars were obtained in autumn for Vera, Vanda, Isabela, Elisa and Regiane cultivars; for Lavinia, Angelina, Amelia and Taina, summer and autumn excelled the other growing seasons for this characteristic.

Cultivars Scarlet, Angelina and Amélia had the highest contents of total soluble sugars in summer; Mila and Lavínia in spring; Elisa and Regiane in winter and Tainá in spring.

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