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Physicochemical characterization and sensory evaluation of lettuce cultivated in three growing systems

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ABSTRACT

There exists a growing demand and promising market for new lettuce varieties in Brazil. Cv. Brunella is an innovative lettuce variety which mixes crisp lettuce and head lettuce characteristics besides being adapted to the Brazilian growing conditions. The physicochemical and sensory quality of this lettuce, cultivated under different growing systems, was evaluated. The conventional planting and the hydroponic systems were carried out in the experimental area of the Universidade Federal de São Carlos, São Paulo State, Brazil and the organic system was done by certified organic producer in the municipality of Cordeirópolis. After harvesting, leaf area, leaf size, unit leaf area, fresh mass, mass loss, turgor pressure, instrumental color, pH, total titratable acidity (TTA), total soluble solids (TSS), total phenolic compounds (TPC), and sensory characterization were evaluated. We verified that the growing system influenced on physicochemical traits producing lettuces of different sizes, weights and stability. For pH, TSS and TPC, difference among the three growing systems was not observed. For TTA, the hydroponic sample showed higher acidity. About sensory evaluation, the testers noticed difference for green color, thickness, size and leaf crispness, grass aroma and bitter taste. The samples cultivated in conventional and hydroponic systems showed greater preference and purchase intention.

Keywords: *Lactuca sativa*, organic cultivation, hydroponics, sensory.

RESUMO

Caracterização físico-química e avaliação sensorial de alface produzida em três sistemas de cultivo

No Brasil há um mercado crescente e promissor que explora novas variedades de alface. A cv. Brunela é uma variedade inovadora que mescla características da alface crespa e americana além de ser adaptada às condições brasileiras de cultivo. O objetivo deste estudo foi verificar a qualidade físico-química e sensorial desta alface produzida em diferentes sistemas de cultivo. O plantio dos sistemas convencional e hidropônico foi conduzido na área experimental ds UFSCar (Araras-SP) e o do sistema orgânico foi realizado por produtor orgânico certificado do município de Cordeirópolis-SP. Após a colheita, as amostras foram avaliadas quanto a área foliar, tamanho da folha, área foliar unitária, massa fresca, perda de massa, pressão de turgescência, cor instrumental, pH, acidez total titulável (ATT), sólidos solúveis totais (SST), compostos fenólicos totais (CFT), e caracterização sensorial. Verificou-se que o sistema de cultivo influenciou em características físico-químicas produzindo alfaces com tamanhos, pesos e estabilidade diferentes. Para pH, SST e CFT não verificou-se diferença entre os três sistemas de cultivo. Para ATT a amostra hidropônica apresentou maior acidez. Na análise sensorial, os julgadores perceberam diferença nos atributos cor verde, espessura, tamanho e crocância da folha, aroma de grama e sabor amargo. As amostras produzidas em sistema convencional e hidropônico apresentaram maior preferência e intenção de compra.

Palavras-chave: *Lactuca sativa*, cultivo orgânico, hidroponia, sensorial.

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Lettuce is the most widely cultivated leafy vegetable in the Country. It is also the preferred variety of vegetables to be grown, due to its wide adaptation to different climatic conditions, possibility of successive crops in the same year, as well as consumer preference and demand (Ferreira *et al.*, 2009). According to Lopes *et al.* (2007), lettuce is considered the most important leafy vegetable for Brazilian diet, which ensures to the species expressive economic importance.

Lettuce production systems present high technological level being commonly grown in the field, in a greenhouse, in hydroponics and organic system which allows harvesting plants with good quality all over the year (Prela-Pantano *et al.*, 2015).

In conventional lettuce production system, the use of synthetic inputs is recommended. This system favors productivity to detriment of the quality of the food. In this system, the producers use 30% of the total volume of agrochemicals commercialized in Brazil, from 4 to 8 liters per cultivated hectare (Echer *et al.*, 2016).

The hydroponic system represents

advantages, such as, better control of nutrients provided to plants, shorter crop cycle and higher productivity, lower water and fertilizer use, better pest control, fewer number of cultural practices, as it also dispenses crop rotation, reduces climatic risks, off-season production, better quality and price of the product, production close to the consumer and quick capital return (Bezerra Neto & Barreto, 2012).

The organic farming is an alternative to the current production model, considering that this system avoids and excludes the use of synthetic fertilizers, pesticides, hormones and food preservatives (Miguel *et al.*, 2008). According to Camargo-Filho *et al.* (2007), organic food producers are divided into small family farmers linked to associations, to groups of social movements which represent 90% of total producers, responsible for 70% of organic production in Brazil; 10% of them are large corporate growers linked to private companies.

Many lettuce cultivars can be found in the market, presenting different shapes, sizes and colors (Suinaga *et al.,* 2013). According to Sala (2011), breeding programs allowed the release of tolerant cultivars to bolting, adapted to the summer climatic conditions such as high rainfall and resistant to the main diseases; these factors have allowed growing these cultivars, contributing to keep the sustainability of lettuce crop.

One of the major changes in the Brazilian lettuce cropping in the last decades was the adoption of crisp lettuce type *Grand Rapids* in the detriment to the traditional looseleaf type, considering that, in relation to the consumption the former holds more than 50% of the market, whereas looseleaf type holds 10%. The consumption of head lettuce in Brazil began in the 1990s and from 9% in 1995 it reached over 34% in 2010, considering the market demand (Sala & Costa, 2012).

A promising market for not yet exploited segments (Sala & Costa, 2012) as well as for innovative types of lettuce with great potential for growth, such as mini lettuce, baby leaf, frizze and crispy has been increasing in Brazil. For crispy segment, new varieties were developed and released in the last years in the Country. These varieties, which mix characteristics of crisp lettuce and head lettuce, are considered innovative. The difference of these lettuces is to present thicker leaves and, consequently, being more crispy and tasty.

Cultivar Brunela is a new cultivar adapted to Brazilian climatic conditions, it means, high temperatures and high rainfall, and it can be grown throughout the national territory. This cultivar shows appearance of crisp lettuce, as an open plant with no head formation, and thick leaves, like the head lettuce, and it is crispy, with a sweet taste. As it is considered medium sized, allows being planted at spacing less than the conventional allowing a maximum use of the area available for production, in addition to being highly adapted to hydroponic cultivation (Sala & Costa, 2014).

Thus, considering that the quality of lettuce can be influenced by the production system, the aim of this study was to determine the effect of different growing systems (conventional, hydroponics and organic) on physical, chemical and sensory parameters of lettuce cv. Brunela.

MATERIAL AND METHODS

The tested cultivar, Brunela, was developed at Universidade Federal de São Carlos, São Paulo State, Brazil. Seedlings were produced in disposable plastic trays of 200 cells each, filled with coconut fiber substrate and kept in a protected environment for intermittent micro-sprinkler production during approximately 30 days. After this period, the seedlings were transplanted in three growing systems: conventional, hydroponics and organic.

In the conventional system, the seedbeds were previously prepared with a plow. Planting fertilizer, top-dressing and other cultural practices were performed according to Filgueira (2008) for lettuce crop. Spacing between plants and rows was 25x25 cm, respectively. The cultivation was done in the experimental area of Universidade Federal de São Carlos, in Araras (22°30’84”S; 47°38’11”W; 663 m altitude).

For hydroponic cultivation, the seedlings were kept in nursery for approximately ten days and later were taken to the definitive hydroponic profiles. The NFT type (laminar flow of nutrients) hydroponic system was used, with trapezoidal polypropylene profiles (TP90) with 9% slope, which allowed the nutrient solution to drain down, with spacing of 25x25 cm between plants and profiles. The solution recommended by Furlani *et al.* (1999) was used to grow the lettuce hydroponically. In order to prepare 1000 L of the solution, the authors used: 750 g of calcium nitrate; 500 g of potassium nitrate; 150 g of monoammonium phosphate (MAP); 350 g of magnesium sulphate, and 20 g of Conplant micronutrient, Standard type. The cultivation was carried out in the hydroponics of the Universidade Federal de São Carlos, in Araras. The hydroponic system was installed under red roof (35% shading). The pH was kept ranging from 5.5 to 6.5, and the electrical conductivity was kept ranging from 1.5 to 3.5 miliSiemens cm^{-1}, which corresponds to 1000 to 1500 ppm of total ion concentration in the solution.

For organic cultivation, the seedlings were sent to an organic farmer in the municipality of Cordeirópolis (22º46’99’’S; 47º41’03’’W; 715 m altitude), certified by ECOCERT (Office of Inspection and certification) being the production performed according to local procedures.

The soil chemical characterization was obtained in depth 0-20 cm for conventional planting and for organic planting. For the conventional planting the soil presented: organic matter (39 g cm^{-3}); pH in H_2O (6.1); resin phosphorus (137 mg dm^{-3}); potassium resin (11 $mmol_c$ dm^{-3}); calcium (63 $mmol_c$ dm^{-1}); magnesium (15 $mmol_c$ dm^{-3}); potential acidity (25 $mmol_c$ dm^{-3}), sum of bases (89 $mmol_c$ dm^{-3}), cationic capacity (114 $mmol_c$ dm^{-3}), and base saturation index (78 $mmol_c$ dm^{-3}). And for organic farming: organic matter (42 g cm^{-3}); pH in H_2O (6.6); resin phosphorus (322 mg dm^{-3}); potassium resin (18 $mmol_c$ dm^{-3}); calcium (75 $mmol_c$ dm^{-3}); magnesium (30 $mmol_c$ dm^{-3}); potential acidity (25 mmol$_c$ dm^{-3}), sum of bases (123 mmol$_c$ dm^{-3}), cationic capacity (148 mmol$_c$ dm^{-3}), and base saturation index (83 mmol$_c$ dm^{-3}).

The seedling planting in the three systems was performed on the same week (from May 11 to May 15, 2015). The plant growth lasted 35 days approximately for the three systems, being harvested from May 22 to May 26, 2015. After harvesting, the samples were carefully transported in food-grade plastic bags for analyzes, described below.

Leaf area was determined soon after plant harvesting. A Li-color 3000A leaf area integrator (Licor Inc., Lincon, Nebraska, USA) was used. Five lettuce leaves were selected on one plant of each cultivation system. The leaf area was determined three times on each leaf, totalizing fifteen readings, per sample. The size was measured using a ruler, checking the measurements (cm) in the horizontal (width) and vertical (length) position of the leaf used to obtain the area. The unit leaf area (AFU) was calculated using the length (cm) and width (cm) ratio of the leaf (AFU = C x L), according to the methodology proposed by Linhares *et al*. (2013).

The mass loss and turgor were determined at the Post Harvest Technology Laboratory of Fruits and Vegetables (Embrapa Instrumentação, São Carlos). Mass loss was evaluated on three lettuce plants of each cultivar system, and the mass per plant was monitored daily during nine days. Samples were stored during the analysis in a controlled cooling chamber at 8±1ºC with relative humidity (RH) controlled between 85 and 90%. The samples were stored in polyethylene plastic bags, opened during the period. The mass loss was determined by the difference between the initial and the final masses of the sample in a semi-analytical scales (Micronal, model B3600), with an accuracy of 0.01 g, and the results expressed as percentage (%).

The turgor was monitored daily until turgor pressure value equal to zero (after nine days). During the analysis the samples were stored in a controlled cooling chamber at 8±1ºC with relative humidity (RH) controlled between 85 and 90%. The samples were placed in polyethylene plastic bags kept open during the whole period.

Turgor pressure was analysed using the equipment Wiltmeter (Embrapa, São Carlos, São Paulo, Brazil). Two whole lettuce leaves were selected in order to be monitored, and each leaf was measured at room temperature (~20ºC). The leaves were not removed from the plants. The result of loss of turgor pressure was expressed in percentage (%).

The color was analysed at the Post Harvest Technology Laboratory of Fruits and Vegetables (Embrapa Instrumentação, São Carlos) using the Konika Minolta colorimeter model CR400s (Konica Minolta Sensing Americas, Inc., New Jersey, USA). Three leaves from two lettuce plants of each growing system were selected for reading, resulting in six readings. Changes in color, brightness and color saturation were recorded through the L (brightness) value, which ranges from black (L = 0) to white (L = 100); a* value, which characterizes color in the red region (+a*) to green region (-a*); and b* value, which indicates the range from yellow color (+b*) to blue (-b*). Then, the parameters a* and b* were transformed into Hue angles indices [H° = arc tg (a/b)] and Chroma ($C=a^2+b^2)^{1/2}$, which mean color tone and intensity, respectively. The equipment was previously calibrated on white surface, according to International Commission of Lighting (CIE 1976 L, a*, b* – CIELAB) (Minolta, 1998).

The color differences among the samples in the three growing systems

$$\Delta E = [(\Delta L^*)^2 + (\Delta a^*)^2 + (\Delta b^*)^2]^{1/2}$$

were determined, and these differences were compared according to the classification: ΔE between 0.0 and 0.5 are no noticeable differences in color; between 0.6 and 1.5 are indelible color differences; between 1.6 and 3.0 are visible color differences; between 3.1 and 6.0 are appreciable color differences; between 6.1 and 12.0 are very great differences in color; and indices greater than 12.1, represent very obvious differences in color among samples (Chen & Majumdar, 2008).

The physicochemical analyzes were performed at the Post-Harvest Technology Laboratory of Fruits and Vegetables (Embrapa Instrumentação, São Carlos). Two lettuce plants grown in each growing system were crushed separately using a food processor. The ground pulp was centrifuged using a Hettich refrigerated benchtop centrifuge model Routine 380R at 8000 rpm at a temperature of 4°C during fifteen minutes. After centrifugation, the supernatant was separated and stored under refrigeration at a temperature of 8±1°C in screw tubes. Physical and chemical analyzes of pH, total soluble solids, total titratable acidity and total phenolic compounds content were performed for each replicate.

The pH was measured by direct reading on the benchtop pHmeter of the Edutec brand model EEQ9003-110 at 20ºC. Two readings in each sample preparation were performed. Total soluble solids were determined through a direct reading of the supernatant preparation using a benchtop digital refractometer Atago model RX-5000α-Plus. The results were expressed in ºBrix at 25ºC. Two direct readings were done in each sample preparation. The total titratable acidity was determined by titration with a standard solution of 0.1 N sodium hydroxide. The pH of the solution during titration was monitored by potentiometer to pH 8.1 according to method nº 942.15 from the Association of Official Analytical Chemists (AOAC, 1997). The results were expressed in grams of organic acid per 100 mL of extract. Two titrations were performed on each prepared sample. The content of total phenolic compounds was determined according to the Folin Ciocalteau spectrophotometric method with modifications, based on gallic acid and results expressed in mg EAG/100 g, according to Singleton & Rossi (1965). The readings were performed at 725nm in a PerkinElmer ultraviolet-visible spectrophotometer model Lambda 25. Three readings were done on each prepared sample.

For the accomplishment of sensorial analysis, this research was submitted and approved by the Committee of Ethics in Human Beings of UFSCar under protocol nº 26075213.2.0000.5504. The lettuce was received in the Laboratory of Sensory Analysis of Universidade Federal de São Carlos, in Araras, in a room with controlled temperature at 18±1ºC, to avoid leaf wilting. The plants were defoliated, pre-washed, sanitized using 100 ppm of active chlorine for 15 minutes, centrifuged, and then stored in plastic bags kept open under refrigeration at 8±1°C before being submitted to sensory tests, which were performed on the same day.

Before the beginning of the sorting test [Brazilian Association of Technical Standards (ABNT, 1994)], the attributes of lettuces were evaluated using the Repertory Grid Method described by Kelly (1955), cited by Moskowitz (1983). This survey is justified since this is a new cultivar in the market.

A session where the samples were presented to ten testers was held. The testers were supposed to describe and record on an evaluation form the perceived sensory attributes. After the survey of the descriptive terms, another assessment form was elaborated to evaluate the samples, which presented the attributes most cited by the testers.

Sensory tests were carried out in individual cabins under white light. Twenty eight non-trained testers took part in this sensory test (ABNT, 1994). The testers were not the same who did the survey on the attributes. A leaf of lettuce produced in each culture system was presented to each judge in three-digit coded disposable dishes. Completely randomized blocks, with no replicate, were used for each tester. Three samples were evaluated simultaneously and each tester was asked to rank the leaves in increasing order considering each described attribute in order to show their preference. Purchase intention was measured considering the observation of whole lettuce plants.

The data were evaluated using the variance analysis (ANOVA) and Tukey test to verify the differences among the averages ($p\leq0.05$), using the statistical software SAS/STAT (2003). The coefficient of variation {CV (%)} was determined by the relation between the standard deviation and the mean of each parameter, and the results were expressed in percentage (%).

The interpretation of the data obtained in the ordering tests was done according to Friedman's test (Newell & MacFarlane, 1987), which indicates whether there is a significant difference between the samples at the 5% level of significance. If the difference between the sums of the ranks is greater than or equal to the tabulated value, according to the number of testers who took part in the analysis, it is concluded that there is a significant difference between the samples.

RESULTS AND DISCUSSION

In relation to leaf area and unit leaf area, the lettuce leaf grown in hydroponic system showed the highest value, differing statistically from the leaves of the plants grown in conventional system and from the leaves of the plants grown in organic system (Table 1).

In relation to initial fresh mass, the plant grown under organic system showed the lowest initial weight differing statistically from the plants grown under the conventional and hydroponic systems (Table 1). According to Hortibrasil (2007) which establishes the norms of the Brazilian Program for Standardization of Horticulture, the lettuce plants can be classified according to the inferior and superior weight limit in grams per plant (classes 5= <100 g; 10= 100 to <150 g; 15= 150 to <200 g; 20= 200 to <250 g; 25= 250 to <300 g; 30= 300 to <350 g; 35= 350 to <400 g; 40= 400 to <450 g; 45= 450 to <500 g; the classes go up to 100= >1000 g). Considering this aspect, conventional lettuce cv. Brunela and hydroponic lettuce cv. Brunela were classified as class 15 and organic lettuce cv. Brunela class 5, according to the values of initial fresh mass obtained in this study. These results can influence prices in terms of commercialization, since, according to Ferreira *et al.* (2009), lettuces with higher fresh mass values can reach higher prices, since this is generally considered per unit (bunch or head).

Significant statistical difference was noticed when analyzing the mass loss. The lettuce grown under organic growing system showed higher mass loss than the lettuce samples grown in the conventional and hydroponic growing system (Table 1). The post-harvesting storage, even under controlled temperature and humidity, leads to mass loss of green leafy vegetables, resulting from water stress.

In Figure 1, the authors verified that the samples grown in the three growing systems showed progressive water stress, as longer the storage period was. The lettuce sample produced in conventional system reached higher values at 10% mass loss between 5th and 6th storage day; the sample grown in hydroponic growing system reached higher values at 10% mass loss between 6th and 7th days of storage; and, the organic sample reached higher values at 10% mass loss on the third day of storage, resulting, consequently, in a

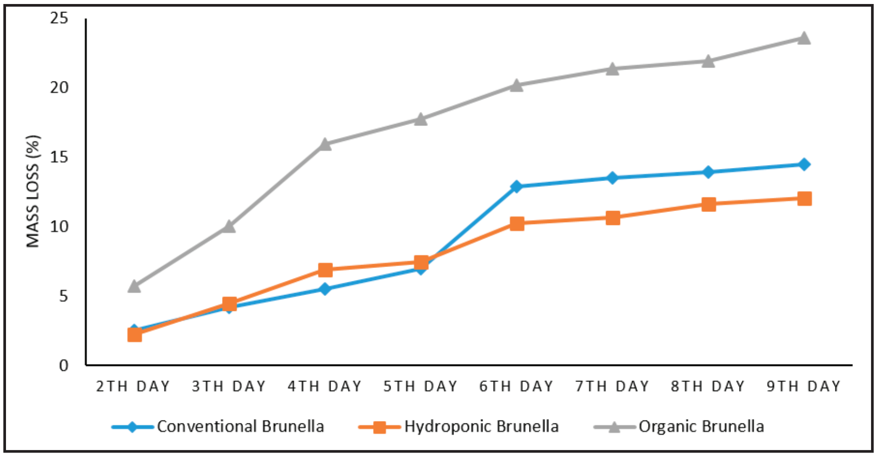

Figure 1. Stability of lettuce cv. Brunella during 9 days of storage. São Carlos, Embrapa Instrumentação, 2015.

Table 1. Physical characteristics of lettuce cv. Brunella, submitted to three growing systems: conventional, hydroponic and organic. São Carlos, Embrapa Instrumentação, 2015.

Characteristics	Conventional	Hydroponic	Organic	DMS[1]	CV (%)[2]
Leaf area (mm)	54.3a (±14.3)	72.8b (±12.8)	47.9a (±6.0)	16.8	18.7
Leaf length (cm)	13.3a (±0.4)	16.8b (±1.2)	13.1a (±0.4)	1.6	4.8
Leaf width (cm)	16.6a (±1.7)	18.8a (±1.0)	14.5b (±0.9)	2.5	7.1
Unit leaf area (cm^2)	220.5a (±19.5)	317.4b (±34.6)	189.8a (±15.0)	49.4	9.5
Initial fresh mass (g per plant)	198.8a (±48.7)	169.4a (±13.6)	44.1b (±7.4)	62.1	16.9
Final fresh mass (g per plant)	170.0a (±48.1)	148.9a (±11.4)	34.5b (±4.6)	60.3	18.2
Mass loss (%)	14.8a (±6.1)	12.0a (±0.4)	23.7b (±1.0)	7.5	14.6
Turgor pressure loss (%)	31.7a (±26.4)	17.3a (±8.4)	39.3a (±26.4)	45.6	68.0

Averages followed by the same letters in lines did not differ statistically among them, by Tukey test ($p \leq 0.05$). Values of mass loss, loss of turgor pressure are relative to the end of storage period (9 days). [1]Minimum Significant Difference; [2]Coefficient of Variation.

higher mass loss for this sample when compared to plants grown in the two other growing systems. Despite the difference in mass loss between the sample grown in the organic system and the samples grown in the other two systems, the authors did not notice any significant difference in turgor pressure analysis considering the three growing systems. These results show that the lettuce grown in the organic system was the one which lost the most water during storage, however it kept turgor which shows that organic plants have good resistance during this period.

The instrumental color analysis showed that for a*, the three lettuce samples evaluated in this experiment showed negative results considering green color, and did not show any significant difference among them (Table 2). For b*, all the lettuce samples showed positive values, considering the yellow color, and did not show any significant difference. Values of h complement the results obtained in a* and b*. Values of h for lettuce cv. Brunela were close to 120º and did not show any significant statistical difference among the three growing systems showing that the samples ranged from yellow to green color (Table 2). The lettuce color is what was expected to be, since, according to Filgueira (2008), the color should range from yellowish green to dark green.

For C* values, the authors did not verify any significant statistical difference among the samples produced in the three growing systems, that means, the lettuces did not show any difference in relation to color intensity (Table 2). L* values showed that among the conventional lettuce cv. Brunela and the lettuces produced under hydroponic and organic systems no significant statistical difference was noticed and, among the samples produced under hydroponic and organic systems, the authors observed significant statistical difference, considering that, the organic sample showed lower value of L (60.6, the darker sample) and hydroponic samples showed higher value of L (67.7, lighter sample) (Table 2).

Table 2. Instrumental color and physicochemical parameters of lettuce cv. Brunella in three growing systems. São Carlos, Embrapa Instrumentação, 2015.

Parameters	Conventional	Hidroponic	Organic	DMS[1]	CV (%)[2]
Color L*	65.3ab (±5.0)	67.7a (±4.3)	60.6b (±4.8)	7.1	7.3
Color a*	-14.6a (±4.5)	-17.3a (±2.8)	-16.5a (±3.2)	5.1	21.7
Color b*	31.8a (±8.1)	36.1a (±4.5)	34.3a (±5.7)	8.9	17.9
Hue	114.7a (±2.5)	115.6a (±1.4)	115.7a (±1.1)	3.1	1.4
Chroma	34.9a (±9.1)	40.0a (±5.2)	38.1a (±6.5)	13.2	18.4
pH	5.8a (±0.08)	5.9a (±0.04)	5.9a (±0.04)	0.03	0.9
TSS	2.4a (±0.13)	2.4a (±0.02)	2.7a (±0.07)	0.3	2.9
TTA	1.38a (±0.2)	1.72b (±0.1)	1.47a (±0.1)	0.2	7.8
TPC	27.1a (± 2.8)	25.7a (± 3.9)	27.4a ±(1.5)	4.1	10.2

TSS = Total soluble solids (ºBrix); TTA = Total titratable acidity (mg citric acid kg^{-1}); TPC = Total phenolic compounds (GAE 100 mg g^{-1}). Values followed by the same letters in the same line, do not differ by Tukey test ($p \leq 0.05$). [1]Minimum significant difference; [2]Coefficient of variation.

Values of ΔE show total color difference of the lettuce samples produced in the three growing systems. Analysis of values of ΔE showed noticeable color difference between the lettuce sample cv. Brunela produced in the conventional system and the sample produced in the hydroponic system (ΔE = 5.6); noticeable color difference between the lettuce sample cv. Brunela produced in the conventional system and the sample produced in the organic system (ΔE = 5.6); and very great color difference between the lettuce sample cv. Brunela produced in the hydroponic system and the sample produced in the organic system (ΔE = 7.4) (Table 2).

The variation of pH values among lettuces produced in conventional, hydroponic and organic growing system was small. No significant statistical difference was noticed (Table 2).

In relation to total soluble solid content, the authors did not observe any significant statistical difference among the samples produced in the three growing systems (Table 2). In the study of Silva *et al.* (2011), the total soluble solid contents were similar in the lettuces produced in organic and conventional systems and, both presented higher contents than the plants produced in hydroponic system.

In relation to total titratable acidity, the authors noticed that the sample produced in hydroponic system showed the highest value and differed significantly from the samples produced in conventional and organic systems (Table 2). The organic acids are important for respiratory metabolism and as reserve compounds in vegetables.

For total phenolic compounds, the authors did not observe any significant statistical difference among the lettuces produced in the three growing systems (Table 2). Arbos *et al.* (2010) found values of total phenolic compounds of 126.84 mg EAG/100 g in lettuces produced in organic system and 92.15 mg EAG/100 g in lettuces produced in conventional system. For these values, a significant statistical difference was noticed ($p \leq 0.05$).

The sensory test showed that, in the tester evaluation, for the green color the lettuce sample produced hydroponically presented lighter color, since this sample showed the smallest rank-sum value. This sample differed significantly from the conventional lettuce, which showed the highest rank-sum value, indicating that this lettuce is the darkest one; however it did not differ significantly from the organic lettuce (Table 3).

For sensory attributes which is related to the plant development, such as thickness and size, the authors observed that the samples produced in the conventional and hydroponic system did not differ significantly (Table 3). The leaf of the lettuce cv. Brunela produced in the organic growing system was significantly smaller and less thick than the lettuce produced in the other systems. The lettuces produced in the conventional and hydroponic systems showed to be crisper than the samples produced in the organic system. This attribute is related to the leaf thickness, that means, the thicker the lettuce leaf is, the crisper the lettuce leaf is (Table 3).

In relation to grass aroma, the authors concluded that the lettuces produced in conventional and organic systems presented higher rank sum, indicating that the samples show stronger aroma, when it is compared to the sample produced in hydroponic system. This factor is related to the growing system, since the samples grown in the field, conventional and organic, were the samples which showed to have this attribute in a more significant way (Table 3). For the sweet flavor, no significant difference among the lettuces produced in the three growing systems for cv Brunela was observed. For bitter flavor, significant difference was observed between the lettuce produced in the conventional system and the ones produced in the organic system which presented the smallest rank-sum value, being considered less bitter when compared to the lettuce produced in the conventional growing system (Table 3).

Table 3. Sum of the ranks of lettuce by the 28 non-trained testers. Araras, UFSCar, 2015.

Attributes	Growing system		
	Conventional	Hydroponic	Organic
Green color	77a	39b	52b
Leaf thickness	65a	62a	41b
Leaf size	71a	62a	36b
Leaf crispness	65a	66a	37b
Grass aroma	65a	47bc	56abc
Sweet taste	58a	53a	57a
Bitter taste	67a	55ab	46b
Preference	63a	65a	40b
Purchase intention	63a	67a	38b

Sum of the ranks followed by different letters in the same line, differ statistically by Friedman test. Minimum difference = 18.

In relation to preference test, in the tester evaluation, the samples produced in the conventional and hydroponic system were the ones which obtained better acceptance. According to the attribute analysis, the samples produced in the conventional and hydroponic systems are the ones which showed larger leaf size, thicker and crisper leaves, showing the consumer preference for lettuce with these characteristics (Table 3). Using the hedonic scale Favaro-Trindade *et al.* (2007), the authors carried out the sensory acceptance of lettuce produced in conventional, hydroponic and organic growing systems. The authors did not observe any significant difference between the samples produced in conventional and hydroponic systems; however, the organic sample received significantly lower note in comparison to the others, probably due to the fact that organic food normally presents a greater number of injuries and imperfections. For the texture, the hydroponic samples were significantly better accepted in relation to organic samples.

Using the results of rank-sum test of purchase intention through observation of the whole plants, the authors observed a correlation with preference test, since the best accepted samples (conventional cv. Brunela and hydroponic cv. Brunela) were the ones which presented greater purchase intention, differing significantly from the sample produced in the organic system (lower purchase intention) (Table 3).

Under the conditions of this study, the authors conclude that the growing system used to produce lettuce influences the plant physicochemical characteristics resulting in lettuce with different sizes and weights. The authors also verified that stability of the post-harvest plant was different when comparing the different growing systems. In this study, the authors could also obtain the lettuce sensory characterization as well as preference and purchase intention according to the plant characteristics. Thus, the sample produced in the conventional and hydroponic systems showed greater preference and purchase intention.

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