



Evaluation of physical-chemical characteristics and acceptance of crocantela lettuce produced in hydroponic system in Araras city, São Paulo

Avaliação das características físico-químicas e aceitação da alface crocantela produzida em sistema hidropônico na cidade de Araras, São Paulo

Carolina Medeiros Vicentini-Polette¹

Fernando César Sala²

Marta Helena Fillet Spoto³

Marcos David Ferreira⁴

Karla Rodrigues Borba⁵

Marta Regina Verruma-Bernardi⁶

¹ Universidade Federal de São Carlos, Centro de Ciências Agrárias, Curso de Pós-graduação em Agroecologia e Desenvolvimento Rural. Araras, SP, Brasil.

² Universidade Federal de São Carlos, Centro de Ciências Agrárias, Departamento de Biotecnologia e Produção Vegetal e Animal. Araras, SP, Brasil.

³ Universidade de São Paulo, Escola Superior de Agricultura Luiz Queiroz, Departamento de Agroindústria, Alimentos e Nutrição. Piracicaba, SP, Brasil.

⁴ Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA Instrumentação). São Carlos, SP, Brasil.

⁵ Universidade Estadual de São Paulo, Faculdade de Ciências Farmacêuticas. Araraquara, SP, Brasil.

⁶ Universidade Federal de São Carlos, Centro de Ciências Agrárias, Departamento de Tecnologia Agroindustrial e Socioeconomia Rural. Araras, SP, Brasil.

Correspondence

Carolina Medeiros Vicentini-Polette

E-mail: vicentini-polette@outlook.com

Abstract

The Crocantela lettuce, from the group of crisp lettuce, was developed with similar characteristics to the crisp, ruffled leaf cultivars, with high yield both in field and hydroponic cultivations. In addition to the productive efficiency, it is important that this vegetable also has nutritional quality and consumer acceptance. This study aimed to evaluate the physical-chemical characteristics and acceptance of Crocantela lettuce and commercial Crisp, ruffled leaf cultivars (SVR-2005) and Vanda (TE-112) cultivated in a hydroponic system. Physical-chemical analyzes of pH, soluble solids, ascorbic acid, chlorophyll, instrumental color, turgor pressure, mass loss and acceptability were performed. The cv. Crocantela crisp lettuce had high turgor, resulting in good appearance and quality for traders and consumers, mainly due to its greater post-harvest durability, and the crisp ruffled varieties presented characteristics very similar to Crocantela, which also stood out for having a higher chlorophyll content and dark color. The cv. Vanda was positively distinguished for taste, due to its high soluble solids content, and its light color, aroma and overall impression. Thus, with high acceptance by consumers similar to the cultivars already established in the market, Crocantela presented characteristics favorable to the good appearance and quality of the product for both merchants and consumers.

Keywords: Consumer behavior. Hydroponics. Food composition.

Resumo

A alface crocantela, do grupo de alfaces crocantes, foi desenvolvida com características similares às cultivares crespas crocantes, com rendimento alto tanto em cultivo em campo quanto hidropônico. Além da eficiência produtiva, é importante que a folhosa possua também qualidade nutricional e aceitação do consumidor. O objetivo do estudo foi avaliar as características físico-químicas e aceitação da alface crocantela e das cultivares comerciais crespa crocante (SVR-2005) e vanda (TE-112), cultivadas em sistema hidropônico. Foram realizadas análises físico-químicas de pH, sólidos solúveis, ácido ascórbico, clorofila, cor instrumental, pressão de turgescência, perda de massa e aceitabilidade. A alface crocantela apresentou alta turgescência, resultando em boa aparência e qualidade para comerciantes e consumidores, devido, principalmente, a sua maior durabilidade pós-colheita, sendo que a crespa crocante apresentou características bastante similares à crocantela, que também se destacou por apresentar maior teor de clorofila e coloração escura. A alface vanda se destacou positivamente pelo sabor, devido ao seu alto teor de sólidos solúveis, e por sua cor clara, aroma e impressão global. Desta forma, com alta aceitação pelos consumidores semelhantes às cultivares já estabelecidas no mercado, a crocantela apresentou características favoráveis à boa aparência e qualidade do produto tanto para comerciantes quanto para consumidores.

Palavras-chave: Comportamento do consumidor. Hidroponia. Composição de alimentos.

Introduction

Consumption of vegetables has increased not only as a result of population growth but changing trends in eating habits, which makes production of this kind of food inevitable.¹ The great demand for vegetables throughout the year makes that the hydroponic cultivation system gains a significant share of consumers preference due to the availability of a high-quality product.²

The most consumed leafy green in Brazil today is lettuce, and consumers demand it in quality and quantity all year round, which is possible by hydroponics.

The crisp, ruffled green leaf lettuce does not form a head like the iceberg lettuce and is more advantageous in summer cultivation, when lettuce growers face great losses.³ The cv. Crocantela has a characteristic that is similar to the commercial cultivars Vanda and the ruffled green leaf lettuce but has benefits of tolerance to the *Bremia lactuvae* fungus (lettuce mildew), a large size and high yield.⁴

The seasonality of leafy greens, flowers and fruits occurs due to environmental conditions that cause damages to the plants such as the impact of raindrops on the leaves and movement of soil particles.² But this can be overcome with the use of hydroponic systems, through which any plant species can be cultivated, on condition that suitable structures for growing are provided.⁵

Hydroponics comes from the need to produce foods in lands where the soil is not fertile for growing plants and without water sources in ideal conditions for irrigation, and it is a cropping method that does not use soil, but a nutritious solution.⁶ Because it is a planting method with controlled conditions, it is possible to take more advantages of this technique. Among its diverse benefits, Silva et al.⁶ cite the reduced need for large planting areas, less susceptibility to soil pathogens and a decreased use of pesticides.

The food overall quality and safety conditions are key elements in the consumers buying process. The quality of a food is based on multiple pillars, among them productive efficiency, nutritional quality and consumer perception.⁷

For consumers, quality can be associated with price when deciding to purchase some food, which can mean the basis for acceptance. The shelf life of a vegetable has influence on the market value, and its appearance is a decisive factor in the consumers' purchasing choice, added to the fact that it is directly associated with food wastes in supermarkets.⁸ Therefore, it is necessary to develop cultivars with longer shelf life, i.e. vegetables that last longer after being harvested. In order to achieve continuous quality evolution, it must be known how much consumers are satisfied with the products they are buying.

This work aimed to evaluate the physicochemical characteristics and consumer acceptance of lettuce cultivars, namely Crocantela, Crisp, ruffled leaf cultivar (SVR-2005) and Vanda (TE-112) grown hydroponically.

Methodology

Lettuces production

The lettuce species were produced at GEHort - *Grupo de Estudos em Horticultura* (Group of Studies in Horticulture), Universidade Federal de São Carlos, *Centro de Ciências Agrárias* (Center of Agricultural Sciences) (UFSCar/CCA), in the city of Araras/SP. The lettuce cultivars Crocantela, the crisp, ruffled green leaf (cv. SVR-2005), and Vanda (TE-112) were used. Seedlings were produced in 200-cell plastic trays, one tray for each cultivar, filled with coconut fiber substrate and kept in a protected environment. Micro-sprinkler irrigation was provided intermittently for approximately 30 days. After this period, the seedlings were kept in a nursery for ten days and then taken to the hydroponic profiles.

It was used the NFT (nutrients film technique) hydroponic system with trapezoidal polypropylene profiles (TP90) with a 9% slope for the solution to run down, with spacing of 25 cm x 25 cm between the plants and profiles. The hydroponic solution used was the one recommended by Furlani et al.⁹ The hydroponic system was installed under a 35% red screen, pH value between 5.5 and 6.5, and the electrical conductivity of the hydroponic system was maintained in the range of 1.5 to 3.5 miliSiemens/cm. After 35 days, lettuce heads were harvested and taken to the laboratory, where they were selected, and the leaves were removed, washed, centrifuged and analyzed. Planting and analyses were conducted in 2015.

Physicochemical analyses

The physicochemical analyses of pH, soluble solids, ascorbic acid, color, chlorophyll and instrumental color were carried out at the *Laboratório Frutas e Hortaliças na Escola Superior de Agricultura Luiz de Queiroz* (Laboratory of Fruits and Vegetables, Luiz de Queiroz School of Agriculture), University of São Paulo (ESALQ-USP), Piracicaba-SP.

The pH value was determined using a TECNAL potentiometer, model TEC3-MP (Piracicaba, Brazil), after pulp homogenization according to the method no. 981.12 of the *Association of Official Analytical Chemists* (AOAC).¹⁰

Determination of soluble solids was performed by direct reading of the supernatant in a Kruss portable digital refractometer, model DR201-95 (Hamburg, Germany), and the results were expressed in °Brix at 25 °C.

Content of ascorbic acid was determined by the method proposed by Strohecker & Henning,¹¹ which consisted in titration with a 0.02% DFI solution (2,6 dichlorophenolindofenol) until reaching a light pink color.

The leaf chlorophyll contents were analyzed using a Chlorophyll Meter SPAD-502 equipment, Konica Minolta Sensing trademark (Tokyo, Japan), using five lettuce plants, and reading was taken in three leaves per plant, totalizing 15 replicates per cultivar.

The instrumental color analysis was conducted using a Konika Minolta colorimeter, model CR400s (*Konica Minolta Sensing Americas, Inc.*, New Jersey, USA). Changes in leaf color, brightness and color saturation were recorded through the L, a* and b* values. The colorimeter was calibrated on a white background according to the International Commission on Illumination.¹² The color was measured directly on the lettuce leaf, using five lettuce plants, and reading was taken on three leaves per plant, totalizing 15 replicates per cultivar.

Analyses of turgor pressure and weight loss were carried out at the *Laboratório da Embrapa Instrumentação* (Embrapa Instrumentation Laboratory) in São Carlos-SP. The lettuce samples were

stored during the analysis under controlled refrigeration at $8\text{ }^{\circ}\text{C} \pm 1\text{ }^{\circ}\text{C}$, in open plastic bags. Measurements were carried out during five days.

To estimate the leaf turgor pressure, it was used the Wiltmeter® equipment. Two whole leaves of two heads of lettuce were selected for the monitoring and measurement of turgor, or rigidity dependent on the turgor pressure. For measurement, the leaf was compressed at room temperature ($\pm 22\text{ }^{\circ}\text{C}$) against a porous flattening plate until its flattening obstructed minimally the air flow through the pores.¹³ The smallest leaf compression that blocks the air flow toward zero is the estimate of the leaf turgor.¹⁴

For determination of mass loss, three heads of lettuce of each cultivar were used, and the difference between the initial weight and final weight (after five days) of the samples was determined using a semi-analytic scale (Micronal, model B3600), precision of 0.01g, and the results were expressed as a percentage.

Sensory analysis

The project was approved by the Ethics Committee for Human Research of the Federal University of São Carlos (UFSCar), no. 26075213.2.0000.5504.

The sensory tests were conducted at the laboratory of sensory analysis of UFSCar in Araras-SP, in individual cabins with white lights. Each participant (tester) received two leaves of each sample on coded plates. To assess acceptance, 50 lettuce consumers were invited to participate in the test. Aspects such as appearance, aroma, flavor, texture and overall impression were assessed, using a seven-point hedonic scale. The lettuce samples were served at the same time.

Convenience sampling was used for characterization of the participants, as described by Mourão Júnior.¹⁵ The participants' gender, age, eating habits, lettuce purchasing habits, without specifying the kind or cultivar, were verified. This questionnaire aimed to identify the demographics of the population with a greater or lower tendency of consumption of this food. The information was obtained by a simple questionnaire, simultaneously with the acceptance analysis, with 50 consumers available to answer the questions and taste the samples.

Statistical analysis

The data from the physicochemical analyses were subjected to analysis of variance followed by the Tukey test ($p < 0.05$), using the *software* R. For characterization of the participants, the percent values found for each range or option of the assessed attributes were presented, as well as the mean values of the scores obtained in the acceptance test.

Results and Discussion

Physicochemical analyses

With respect to the physicochemical parameters (Table 1), the lettuce cultivars exhibited differences for soluble solids (Brix°) and turgor loss. For pH, there was no difference between the cultivars, considering the optimal pH range of 5 to 7 for plant tissues.¹⁶ Thus, the cultivars analyzed are suitable considering this parameter.

Table 1. Results of the physicochemical analyses of lettuce cultivars Crocantella, Crisp ruffled green leaf (SVR-2005), and Vanda (TE-112) in the state of São Paulo, 2005.

Parameter	Cultivar		
	Crocantella	Crisp (SVR-2005)	Vanda
pH	5.9 ^a	5.8 ^a	5.8 ^a
Soluble solids (°Brix)	2.1 ^b	2.1 ^b	3.1 ^a
Ascorbic acid (mg/100g)	6.5 ^a	6.1 ^a	6.5 ^a
Turgor loss (%)	45.1 ^c	50.0 ^b	66.7 ^a
Weight loss (%)	4.74 ^a	4.67 ^a	3.36 ^a
Chlorophyll (mg/g ⁻¹)	33.0 ^a	30.2 ^a ^b	19.3 ^b
Color L	56.7 ^b	59.1 ^a	57.3 ^{ab}
Color a*	-20.7 ^a	-21.0 ^a	-23.3 ^b
Color b*	34.3 ^b	34.6 ^b	40.0 ^a

Values followed by different letters on the same row differ from each other by the Tukey's test ($p < 0.05$)

The cultivar Vanda exhibited the highest Brix value, which may be directly related to the best consumer acceptance for taste in the sensory test (Table 3), whereas the taste of fresh vegetable results from the combination of volatile compounds with sugar and acids.¹⁶

The three lettuce cultivars showed no difference regarding ascorbic acid. However, the values found are below those cited by Silva et al.,¹⁷ who found that the contents of ascorbic acid varied from 26.4 mg/100g in the hydroponic system to 42.9 mg/100g in organic system. This difference may be due to the hydroponic cultivation medium added with nitrogen, considering that the increasing application of nitrogen fertilizers tends to decrease the contents of ascorbic acid in most of the leafy vegetables.¹⁸

In a study with lettuce cv. Crocantela produced in hydroponic system, 5.9 and 2.6 pH and °Brix values, respectively, were reported.¹⁹

Concerning the weight loss variable, in five days of analysis, all cultivars exhibited a low weight loss, not differing from each other. These results suggest a similarity of cv. Crocantela with the other kinds of lettuce already marketed. During five days of assessment, the cv. Crocantela had a 4.74% weight loss. In other study, it was found a 15.3% loss in nine days of assessment.¹⁹ Brecht et al.²⁰ described that, for the commercialization of leafy greens, they cannot lose more than 3 to 10% of weight due to the importance of water in these foods, which represents most of its composition. Therefore, it is vital that within this period of days, lettuce has quality to be handled and marketed, without a significant loss of crispness or appearance.

Weight loss in leafy greens results from the loss of water and is directly related with its shelf life, which comprises the period of time that elapses from production or handling and the time that the product preserves its required characteristics of quality for consumption,²¹ both directly related with the product turgor loss.

Regarding turgor, the greatest loss was found in cultivar Vanda. After the fifth day, its leaves could no longer be analyzed due to rapid wilting. For this parameter, cv. Crocantela exhibited the lowest values, indicating a better product quality in five days of shelf life, thus contributing to less waste and better use of the product and more profits to the farmer and merchant.

Chlorophylls are the most abundant natural pigments in plants.²² Contents might have differed due to several factors, such as salts composition and concentration, stress duration, differences between genotypes and lettuce precocity.²³ A relationship between the chlorophyll content in the leaves and the values found for color a^* , which defines the tone of color, and color b^* , which defines its saturation, was also observed.

The instrumental color values found for the lettuces are between yellow and green, but already in the green quadrant boundary.²⁴ The fact that cv. Vanda received the highest scores for color a^* and color b^* in the consumers preference suggests that the public is more interested in lettuce having a tone color close to green, but less saturated.

The parameter L^* indicates luminosity and refers to the capacity of the object to reflect or transmit light, ranging from black (zero) to white (100).²⁴ For this attribute, cv. Crocantela differed from the crisp ruffled cultivar, while Vanda was similar to the first two cultivars, suggesting median luminosity, while Crocantela was the darkest.

In a similar study with lettuce cv. Crocantela, the following values for color L^* , a^* and b^* were found: 65.1, -17.7 and 35.8, respectively,¹⁹ which corroborates the results of this study.

Sensory analysis

The acceptance tests, together with the testers' characterization (Table 2), allowed to obtain relevant data on potential consumers of lettuce cv. Crocantela. Of 50 participants, 62% were women aged between 18 and 65 years. More than half of the testers (54%) reported that they consumed lettuce three to five days a week, and 86% purchased this product zero to twice a week. These results are in agreement with the ones found by Verruma-Bernardi et al.,²⁵ where the majority (61.6% women and 56.7% men) of the respondents purchased this product once or twice a week, consuming it three times a week.

Considering home consumption alone, this result indicates the importance of offering lettuce with great post-harvest durability, so that consumers, by purchasing it few times in the week (Table 2) may have a product that will last longer.

Table 2. Characterization of testers (n=50) and lettuce consumption and purchasing habits. 2015.

	n	%		n	%
Gender			Weekly consumption		
Male	19	38	0-2	11	22
Female	31	62	3-5	27	54
			6-7	12	24
Age			Weekly purchase		
18-25	40	80	0-2	43	86
26-40	6	12	3-5	7	14
41-65	4	8			

Regarding acceptability, it was found that for texture, the testers used the same portion of the scale ("liked it a little") and for the other attributes, cv. Vanda obtained higher scores, but closer to the scale used for the other two cultivars (Table 3).

The highest score for flavor and overall impression was given to cv. Vanda, which may be due to the highest content of soluble solids, which provides a sweet flavor to the product, and the lighter color compared to the other cultivars, respectively. However, its shelf life was shorter because of the fast weight loss and turgor loss in this cultivar. So, it is necessary to conduct this acceptability study in different post-harvest times.

Table 3. Results of the scores* of the acceptance test of cultivars Crocantela, Crisp (SVR-2005) and Vanda (TE-112) lettuce in the state of São Paulo, 2015.

Kind of lettuce	color	aroma	flavor	texture	Overall impression
Crocantela	5.4	4.5	3.6	5.0	4.8
Crisp	5.3	4.7	4.2	5.3	5.1
Vanda	6.6	5.0	5.2	5.1	5.5

*mean assessment values of 50 consumers

As the crisp, ruffled and Vanda species are already established in the market, the acceptance assessment showed the importance of cv. Crocantela to have similar attributes to the other cultivars studied, but also with benefits such as more turgidity, which provides a crisp texture, typical of this lettuce group. It is worth noting that the three cultivars were well scored with overall impression scores close to 5, i.e., in the positive band of the scale.

Fontana et al.¹⁹ showed that, for cv. Crocantela, there was more acceptance for the hydroponic cultivation system than the organic one. Thus, it is possible to combine the intrinsic benefits of the cultivar with an efficient and profitable system, in the search of production alternatives without chemicals, which may compete with the traditional organic products in a sustainable manner and with the quality desired by consumers all over the year.

Conclusion

Given that 54% of the consumers in this study eat lettuce three to five days a week but 86% of the them purchase it twice a week at the most, it becomes clear the need for long-lasting greens.

Regarding the consumer acceptance, it is vital that lettuce not only has durability but also a uniform and not too dark green color, a sweet flavor and a crisp texture, providing a good experience to consumers. Thus, cultivar Crocantela is distinguished for providing these qualities in whole or partially, being an alternative among the commercial cultivars, also for presenting less turgor loss in a period of five days.

Contributors

Vicentini-Polette CM participated in the sensory and physicochemical analyses, interpretation of data and manuscript drafting. Sala FC participated in the cultivar development, planting and data reporting. Spoto MHF, Ferreira MD and Borba KR contributed to physicochemical analyses, data

interpretation and drafting. Verruma-Bernardi MR contributed to the project conception and design, data analyses, interpretation and drafting, and to the revision of the intellectual content of the manuscript and the final version to be submitted.

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