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Cientific Paper

Physicochermical analyzes of garlic subjected to ultraviolet light (UV-C) and to modified atmosphere

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Abstract

Improper storage is the main cause of low quality of national garlic. The aim of this study was to evaluate the effect of modified atmosphere with different thickness of polyethylene packing and exposure of bulbs to ultraviolet light (UV-C) in the physicochemical properties of garlic. The treatments were arranged in a factorial scheme, 5x2, comprising five thicknesses of polyethylene film (control, 5 , 10 , 15 and 20 microns) and exposure to ultraviolet light (with exposure and no exposure). The experimental design was completely randomized, with four replications consisting of 15 bulbs. The parameters evaluated were: lost fresh mass lost, dormancy visual Index (DVI), total phenols, phenylalanine ammonia-lyase (PAL) activity, soluble acids content (SAC), total titratable acidity and diseases caused by pathogens. The use of modified atmosphere and UV-C had a positive effect on the reduction of lost fresh mass and on the DVI, with more significant reduction on DVI at thickness of 15 micron polyethylene film and exposed to UV-C. The use of modified atmosphere and UV-C acted in the PAL activity, phenolic compounds, SACTSS and titratable acidity. The treatments had no effect on incidence of decay.

Key words: post-harvest; storage; *Allium sativum*

Análisis físico-químico en el ajo sometido a la luz ultravioleta (UV-C) y atmósfera modificada

Resumen

El almacenamiento inadecuado es la causa principal de la baja calidad del ajo nacional. El objetivo de este estudio fue evaluar el efecto del envasado en atmósfera modificada con embalajes de polietileno de diferente espesor y la exposición de los bulbos a la luz ultravioleta (UV-C) en las características físico-químicas del ajo. Los tratamientos fueron dispuestos en un arreglo factorial 5x2 que consiste en cinco espesores del polietileno (control, 5, 10, 15 y 20 micras) y la exposición a la luz ultravioleta (expuestos y no expuestos). El diseño experimental fue completamente al azar con cuatro repeticiones consistidas de 15 bulbos. Los parámetros evaluados fueron: pérdida de masa, índice visual de latencia (IVD), fenoles totales, la actividad de la enzima fenilalanina amonio liasa (PAL), sólidos solubles totales (SST), acidez titulable y podredumbres causadas por patógenos. La atmósfera modificada y el uso de UV-C tuvieron un efecto positivo en la reducción de la pérdida de masa y en el IVD, con reducción más pronunciada del IVD en el espesor del polietileno de 15 micras y con exposición a la UV-C. El uso de atmósfera modificada y el uso de UV-C actuaron en la actividad de la PAL, en los compuestos fenólicos, SST y la acidez titulable. Los tratamientos no tuvieron efecto sobre la incidencia de las podredumbres.

Palabras clave: post-cosecha; almacenamiento; *Allium sativum*

Análises físico-químicas em alhos submetidos à luz ultravioleta (UV-C) e atmosfera modificada

Resumo

O armazenamento inadequado é a principal causa da baixa qualidade do alho nacional. O objetivo desse trabalho foi avaliar o efeito da atmosfera modifica com embalagens de polietileno de diferentes espessuras e exposição dos bulbos

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a luz ultravioleta (UV-C) sobre as características físico-químicas do alho. Os tratamentos foram arranjados em esquema fatorial 5x2, constituído de cinco espessuras do filme de polietileno (testemunha, 5, 10, 15 e 20 micras) e exposição à luz ultravioleta (com exposição e sem exposição). O delineamento experimental utilizado foi inteiramente casualizado, com quatro repetições constituídas de 15 bulbos. Os parâmetros avaliados foram: perda de massa total, índice visual de dormência (IVD), fenóis totais, atividade da enzima fenilalanina amônia-liase (FAL), sólidos solúveis totais (SST), acidez total titulável e podridões causadas por patógenos. A atmosfera modificada e o uso de UV-C tiveram efeito positivo na redução de perda de massa e sobre o IVD, com redução mais expressiva do IVD na espessura do filme de polietileno de 15 micras e com exposição à UV-C. O uso da atmosfera modificada e o emprego de UV-C atuou na atividade da FAL, nos compostos fenólicos, SST e acidez titulável. Os tratamentos não apresentaram efeito sobre a incidência de podridões.

Palavras chaves: pós-colheita; armazenamento; *Allium sativum*

Introduction

The national production of garlic (*Allium sativum*) in 2011 was of approximately 118.5 thousand tons, putting Brazil on the thirteenth position on the world ranking (FAO, 2013). The states of Goiás, Rio Grande do Sul, Santa Catarina, Minas Gerais and Bahia are the main producers, corresponding to 94% of the Brazilian production (MOURA et al., 2013). Brazil is also the second largest consumer and the major importer of garlic in the world (SOUZA and MACÊDO, 2009).

The national production is insufficient to meet the internal demand and it also does not present a satisfactory quality of bulbs, commercialized in its majority, in natural state. Among the factors related to the low quality of the national production is the improper storage. The bulbs can be stored for up to six months in non refrigerated storehouses, however, the use of this practice leads to, mainly, greater loss of mass, physicochemical alterations and occurrence of diseases, representing to a lower quality and elevating the post-harvest losses (LUENGO and CALDO, 2001).

The use of modified atmosphere (MA) can be presented as an option to avoid quantitative and qualitative losses on the garlic. Through the use of polyethylene packaging it is possible to regulate the metabolic processes which interfere on the vegetable quality, such as respiratory activity, ethylene production and mass loss, as well as eliminating undesired microorganisms (MANTILLA et al., 2010). In the storage system with MA, the gas concentrations are not controlled, varying with time, temperature, permeability of the film and respiratory activity of the product, being that the plastic film must present adequate selective permeability to the input of O_2 and output of CO^2, so that does not occur fermentation of the product (CHITARRA and CHITARRA, 2005). As each vegetable presents a respiration rate, it is important that the thickness of the used packing is adequate to the product characteristics.

Using ultraviolet radiation (UV-C) is post-harvest is another technique that can be used in order to maintain the physiologic quality of the garlic. The use of UV-C presents low cost and the application is fast and easy. The application of irradiation affected the physiological and biochemical parameters in the cv. Colorado garlic, including growth regulators, peroxidase, total DNA and RNA, proteins and soluble carbohydrates (PÉREZ et al., 1998). The use of UV-C also presents efficiency in the resistance induction with action on the phenylalanine ammonia-lyase – PAL enzyme (TERRY and JOYCE, 2004). The result of radiation use on resistance induction had been already reported in several crops, such as tobacco, tomato, arabidopsis (WOHLGEMUTH et al., 2002), kiwi, pepper, citrus, sweet potato, strawberry, apple, mango, peach, grape, among others (TERRY and JOYCE, 2004).

The objective of this research was to assess the effect of the modified atmosphere with polyethylene packaging (with different thicknesses), and to evaluate the result of the bulbs exposition to ultraviolet light on the garlic cv. Caçador physicochemical characteristics.

Materials and Methods

The used garlics (cv. Caçador) were obtained from the Experimental Station of Santa Catarina – EPAGRI – Caçador. The bulbs were previously classified by the size and health. After the classification, the garlics were separated in two batches, being that one of them had been exposed to ultraviolet light (UV-C) for 20 minutes, and the other one was not. Subsequently the bulbs were packed and sealed in polyethylene bags with different thicknesses,

referent to the treatments, being that each package was considered as a repetition. After packing, the bulbs were kept in controlled environment, with a temperature of 25°C ± 2, in absence of light.

The treatments were prepared in factorial scheme (5x2), constituted by 5 densities of plastic film (control, 5, 10, 15 and 20 micras) and two treatments with UV-C light (with and without exposition to UV-C light). The control consisted in the use of a polyethylene plastic net. The experimental design was entirely randomized, with four repetitions of 15 bulbs.

It was performed fortnightly assessments of mall loss in the bulbs during 56 days. By the end of the experiment, it was assessed the total mass loss, the visual index of dormancy (VID) and the total phenols through the method adapted from BIELESKI and TURNER (1966) and JENNINGS (1981). Phenylalanine ammonia-lyase (PAL) by the method described by RODRIGUES et al (2006), total soluble solids (TSS) with assistance from a digital refractometer, titratable acidity (TTA) through titration with solution of sodium hydroxide 0.1 N (ADOLFO LUTZ INSTITUTE, 1985) and ascorbic acid through the Tillmans method (ADOLFO LUTZ INSTITUTE, 1985). Rottenness was determined by visual evaluation of the pathogens presence, and confirmed with the assistance of a stereomicroscope.

The results obtained were submitted to variance analysis through the F test and, when it was obtained statistical significance, it was performed the comparisons between averages, for the factor exposition to ultraviolet (UV-C) we used the Tukey test at level of 5% of significance, and for the factor plastic film thicknesses it was used the regression analysis.

Results and Discussion

The use of modified atmosphere (MA) reduced the mass loss of the garlic bulbs, being that as thicker the packing was (in bulbs without exposition to UV-C light) smaller was the mass loss (Figure 1). When using the MA and UV-C the mass loss was significantly reduced with the thicknesses between 10 and 15 micras.

The greatest loss was observed in bulbs without plastic film, that is, in the polyethylene plastic nets. This fact is probably related to the high transpiration rates and respiration with higher loss of water, from the bulb to the environment. The package with plastic film favors a lower transpiration rate of bulbs and consequently lower rate of water loss to the environment (PEREIRA et al. 2006).

For bulbs that were not exposed to UV light, the visual index of dormancy (VID) presented reduction with the increase of plastic film thickness (Figure 2) The low level of oxygen in the environment reduces the cellular respiration, decreasing the energy supply necessary in order to occur the cellular division and, as a result, the sprouts growth (BRACKMANN et al., 2010). In this sense, the reduction of the VID in bulbs is related to the fact that the packing reduces the bulbs respiration, therefore

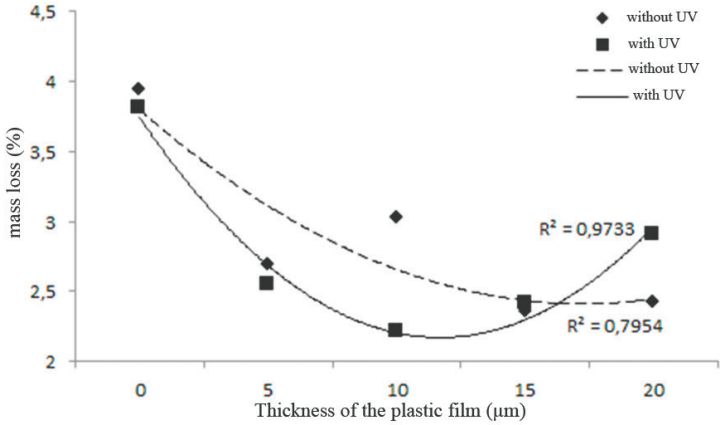

Figure 1. Mass loss (%) of the garlic bulbs submitted to different plastic film thicknesses, with and without exposition to ultraviolet light (UV-C).

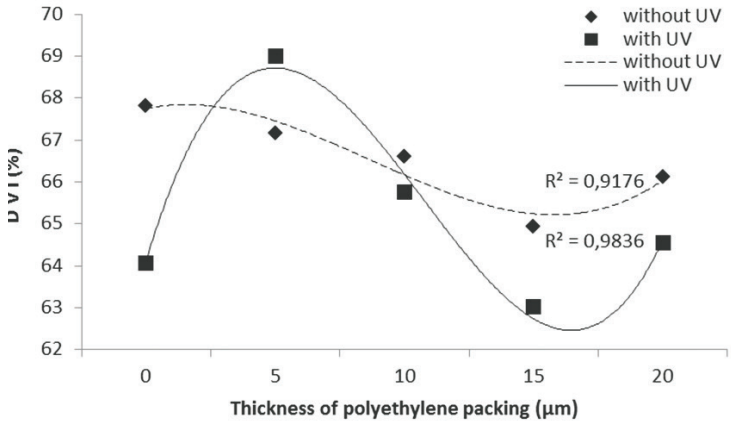

Figure 2. Visual index of dormancy (VID %) of the garlic bulbs submitted to different plastic film thicknesses, with and without exposition to ultraviolet light (UV-C).

reducing its metabolism, which resulted in a lower development of the shoots leaves.

On the other hand, the bulbs submitted to UV light exposition present higher VID when using a plastic packing of 5 micras of thickness, and lower values when it was used 15 micras of thickness (Figure 2). Such results show that the MA with plastic packing of 15 micras associated to UV-C presents potential in reducing the post-harvest activity of the bulbs.

For the activity of the phenylalanine ammonia-lyase (PAL) enzyme there was no significant difference between bulbs with and without application of UV. In relation to the different thickness of the plastic bags, the highest values of PAL were found with the thickness of 20 micras (Figure 3).

The PAL behavior can be related to the activation of the vegetal defense routes caused by the elevation of CO_2 and decrease of O_2 in the interior of packages, due to the lower gas exchange between the internal and external of the bags. According to CHITARRA and CHITARRA (2004), in the storage under MA the lower availability of O_2 and greater concentration of CO_2 favor the reduction of the rate of ethylene production and consequently the enzyme activity.

The total phenols presented higher concentrations in the treatment without application of MA, with decrease of the values as the plastic bag thickness was increased. There was no significant difference between the bulbs with and without exposition to UV light (Figure 4).

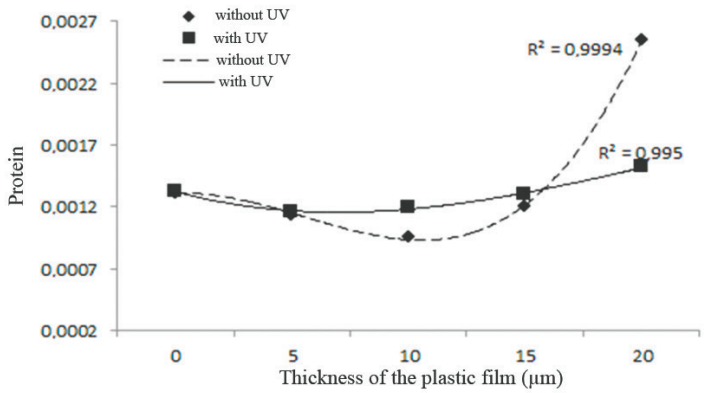

Figure 3. Concentration of ammonia lyase phenylalanine (PA) in garlic bulbs submitted to different plastic film thicknesses, with and without exposition to ultraviolet light (UV-C).

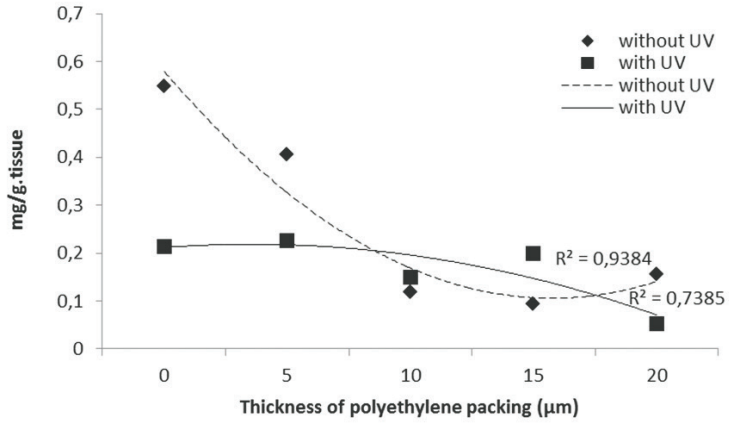

Figure 4. Concentration of total phenols in garlic bulbs submitted to different plastic film thicknesses, with and without exposition to ultraviolet light (UV-C).

According to ANTUNES et al. (2006), the increase of the concentration of total phenolic compounds is associated to the mass loss, because there is concentration of the compounds in the vegetal tissues. This behavior can be observed in Figure 1 and 4, where the bulbus which were not packed presented greater mass loss and higher concentrations of total phenols.

The total soluble solids (TSS) presented higher values when was not used the MA (Figure 5). In the same way that the phenols, the TSS are related to the loss of mass in the bulbs, because as thicker the package is, lesser is the mass loss and smaller are the values of TSS in the bulbs, which are less concentrated in the tissues. According to TAIZ and ZEIGER (2004) the vegetal respiration can be expressed as the oxidation of the molecule of sucrose and the reduction of the water molecule. Thus, it can be noticed that the greater values on the TSS levels without the use of packing are related to the higher respiratory rate of the bulbs in this treatment, because as thicker the plastic film is, shorter is going to be the respiration.

The total titratable acidity (TTA) presented reduction with the increase of the plastic film thickness, not existing significant difference between bulbs with and without application of UV light (Figure 6). According to OSHIRO et al. (2009), increases in the TTA concentrations are related to the

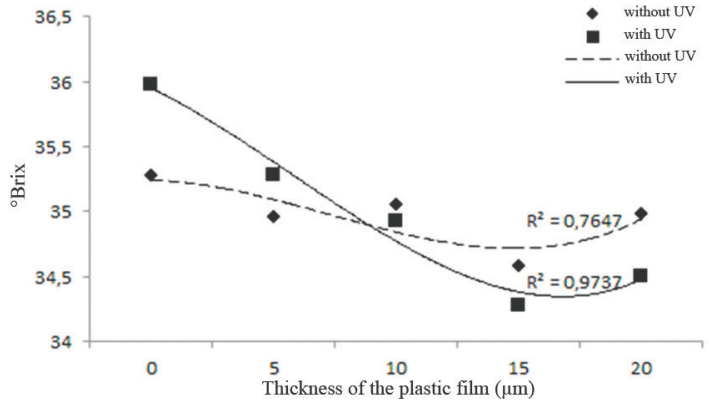

Figure 5. Total solid solubles (TSS) in garlic bulbs submitted to different plastic film thicknesses, with and without exposition to ultraviolet light (UV-C).

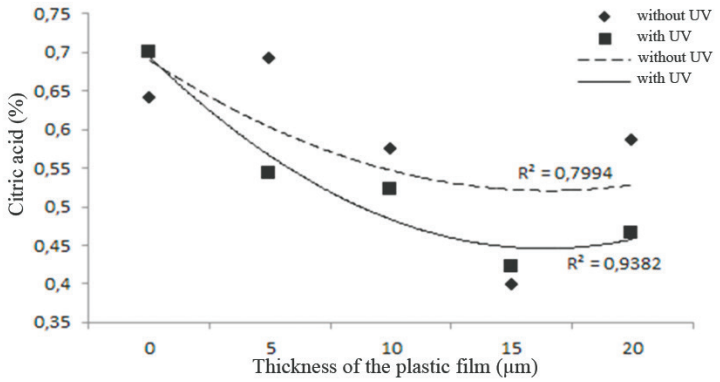

Figure 6. Total titratable acidity (TTA), of garlic bulbs submitted to different plastic film thicknesses, with and without exposition to ultraviolet light (UV-C).

respiratory increase, which triggers the production of citric acid. The reduction in the contents of TTA with the increase of the thickness is related to the reduction of the respiratory rate.

The incidence of rottenness was not affected by the treatments, maintaining low indexes, with an average percentage of 2% of bulbs in formation stage with characteristic symptoms of pathogens. The predominant plant pathogen was the *Penicilium* spp., which had been already observed in post-harvest garlic in other researches (CAMARGO et al., 1988).

We suggest new studies that aim to complement such results, because the data observed were promising, demonstrating the importance of these treatments in the maintaining of quality of garlic in post-harvest. Studies which involve the respiratory behavior with quantification of the levels of CO_2 and O_2 and ethylene production will be able to elucidate the physiochemical behavior of garlic in MA condition.

Conclusions

The modified atmosphere and the UV-C use had positive effect in the reduction of mass loss and on the visual index of dormancy, being the more expressive reduction of this index in the plastic package of 15 micras of thickness and with exposition to UV-C.

The use of modified atmosphere and the UV-C use acted in the activity of PAL, in the phenolic compounds, TSS and titratable acidity.

The treatments did not present effect on the incidence of rottenness caused by pathogens.

References

ANTUNES, L.E.C.; GONÇALVES, E.D.; TREVISAN, R. Alterações de compostos fenólicos e pectina em pós-colheita de frutos de amora-preta. R. Bras. Agrociência, v.12, n.1, p.57-61, 2006.

BIELESKI, R. L.; TURNER, N. A. Separation and estimation of amino acids in crude plant extracts by thin-layer electrophoresis and chromatograghy. Analitycal Biochemistry, v.17, p.278-293, 1966.

BRACKMANN, A.; GASPERIN, A.R.; WEBER, A.; ANESE, R.deO. Condições de temperatura, umidade relativa e atmosfera controlada para o armazenamento de cebolas da cultivar 'Crioula'. Ciência Rural, v.40, n.8, p.1709-1713, 2010.

CAMARGO, M.; PANIZZI R.C.; MENTEN J.O.M. Fungos associados a bulbilhos de alho (*Allium sativum L.*) (cultivar peruano e caiana branca) procedentes de araras, estado de São Paul. Revista Brasileira de Sementes, v.8, n.1, p.73-77, 1988.

CHITARRA, M.I.F.; CHITARRA, A.B. Pós-colheita de frutos e hortaliças: fisiologia e manuseio. 2.ed. Lavras: UFLA, 2005.

FAO (Food and Agriculture Organization). Agricultural production, primary crops: garlic. 2013. Disponível em: http://www.fao.org. Acesso em: 20 jul. 2013.

INSTITUTO ADOLFO LUTZ. Normas Analíticas do Instituto Adolfo Lutz. v.1: Métodos químicos e físicos para análise de alimentos, 3.ed. São Paulo: IMESP, 1985. 25 p.

JENNINGS, A. C. The determination dihydroxy phenolic compounds in extracts of plant tissues. Analitycal Biochemistry, n.118, p.396-398, 1991.

LUENGO, R. de F.A.; CALDO, A.G. Armazenamento de hortaliças. Brasília, DF: Embrapa Hortaliças, 2001. 242p.

MANTILLA, S.P.S.; MANO, S.B.; VITAL, H.C.; FRANCO, R.M. Atmosfera modificada na conservação de alimentos. Rev. Acad., Ciênc. Agrár. Ambient, v.8, n.4, p.437-448, 2010.

MOURA, A.P.; GUIMARÃES, J.A.; FERNANDES, F.R.; FILHO, M.M. Recomendações técnicas para o manejo integrado de pragas da cultura do alho. Brasília: Embrapa, 2013. 12p. (Circular técnica, 1).

OSHIRO, A.M.; SCALON, S. de. P.Q.; ARGANDONA, E.J.S; ZÀRATE, N.A.H. Conservação pós-colheita de goiabas 'Pedro Sato' em atmosfera modificada, associada ou não à refrigeração. Revista Agrarian, v.4, n.14, p.294-302, 2011.

PEREIRA, T.; CARLOS, L.de.A; OLIVEIRA, J.G.de; MONTEIRO, A.R. Influência das condições de armazenamento nas características físicas e químicas de goiaba (Psidium guajava), cv. Cortibel de polpa branca. Ceres, v.53, p.276-284, 2006.

PÉREZ, M.B.; CURZIO, O.A.; AVELDAÑO, M.I.; CROCI, C.A. Effects of γ-irradiation on the lipid composition of inner sprout of garlic Radiat. Phys. Chem., n.52, p.113–117, 1998.

RODRIGUES, A.A.C.; BEZERRA NETO, E.; COELHO, R.S.B. Indução de resistência a Fuzarium oxysporum f. sp. Tracheiphilum em caupi: eficiência de indutores abióticos e atividade enzimática elicitada. Fitopatologia Brasileira, v.31, p.492-499, 2006.

SOUZA RJD; MACÊDO FS. 2009. Cultura do alho: técnicas modernas de produção. Lavras: UFLA. 181p.

TAIZ, L.; ZEIGER, E. Fisiologia vegetal. 3.ed. São Paulo: Artmed, 2004. 719p.

TERRY, L.A.; JOYCE, D.C. Elicitors of induced disease resistance in posharvest horticultural crops: a brief review. Postharvest Biology and Technoly, v.32, p.1-13, 2004.

WOHLGEMUTH, H.; MITTELSTRASS, K.; KSCHIESCHAN, S.; BENDER, J. WEIGEL, H.J.; OVERMYER, K.; KANGASJARVI, J.; SANDERMANN, H.; LANGEBARTELS, C. Activation of an oxidative burst is a general feature of sensitive plants exposed to the air pollutant. Plant Cell & Environment, v.25, p.717-723, 2002.