VISUAL QUALITY AND PHYSICAL-CHEMICAL CHARACTERISTICS IN POTATO TUBERS TREATED WITH HYDROGEN PEROXIDE

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ABSTRACT

Unconventional techniques such as the use of visible ultraviolet light (UV-C) and physical treatments have been used to combat post-harvest diseases. Attention has been focused on the use of hydrogen peroxide, but little is known about its effects on the control of bacteria causing soft rot. The objective of this study was to evaluate the incidence of soft rot and physical-chemical and visual characteristics in potato tubers (*Solanum tuberosum* L.) treated with hydrogen peroxide. The experiment was conducted following a completely randomized design in subdivide plots scheme with four treatments: 0, 50, 100 and 150ppm of hydrogen peroxide whit an inoculated plot and a non inoculated. The visual aspects were evaluated by for to the incidence of soft rot appearance of shoots. pH, titratable acidity (% citric acid), soluble solids content, pulp firmness and total sugar content were used to determine post-harvest quality. Hydrogen peroxide was not effective in controlling soft rot in potato tubers, but increased the metabolic activity of tubers leading to an increase in soluble solids content and reduced in titratable acidity.

Keywords: *Solanum tuberosum L*; hormesis; soft rot*;* total sugars.

QUALIDADE VISUAL E CARACTERÍSTICAS FÍSICO-QUÍMICAS EM TUBÉRCULOS DE BATATA TRATADOS COM PERÓXIDO DE HIDROGÊNIO

RESUMO

As técnicas não convencionais como o uso de luz ultravioleta visível (UV-C) e tratamentos físicos tem sido utilizadas para combate às doenças pós-colheita. Atenção tem se voltado para o uso de peróxido de hidrogênio, mas pouco se conhece sobre os seus efeitos no controle de bactérias causadoras de podridão-mole. Objetivou-se com este estudo avaliar incidência de podridão mole e as características físico-químicas e visuais em tubérculos de batata (*Solanum tuberosum* L.) tratados com peróxido de hidrogênio. O experimento foi conduzido seguindo um delineamento inteiramente casualizado, em esquema de parcelas subdivididas, com quatro tratamentos 0, 50, 100 e 150ppm de peróxido de hidrogênio com uma parcela inoculada e uma não inoculada. Os aspectos visuais foram avaliados quanto a incidência de podridão mole aparecimento de brotações. Para determinação da qualidade pós-colheita, foram utilizados os parâmetros pH, acidez titulável (% de ácido cítrico), teor de sólidos solúveis, firmeza de polpa e teor de açúcares totais. O peróxido de hidrogênio na concentração de 50ppm foi efetivo no controle da podridão mole nos tubérculos de batata, e aumentou a atividade metabólica dos tubérculos levando a um aumento nos teores de sólidos solúveis e redução da acidez titulável.

Palavras-Chave*:* *Solanum tuberosum* L; hormesis; podridão mole; açúcares totais.

INTRODUCTION

The climatic diversity in Brazil allows the planting of a wide variety of crops ranging from cereals to fruits and vegetables. Among the vegetables grown in the national territory, the potato (*Solanum tuberosum* L.) is considered the main vegetable in Brazil (ABBA, 2005). In last decade Brazil surpassing in 21% the world productivity (16.93t ha^{-1}) with 3.867.681 tons produced in 2015 (IBGE, 2016). In the world scenario the potato is considered one of the most important sources of food of vegetable origin, behind only corn, rice and wheat (FAO, 2011).

The large production volume combined with an inefficient production runoff and an often precarious marketing system makes fruits and vegetables be affected by several diseases in the post-harvest period, caused by a large number of phytopathogenic agents (USALL et al., 2016). Among them, the soft rot caused by pectinolytic bacterias of the genus *Pectobacterium*, are responsible for significant economic losses in the potato crop (WALERON et al., 2014). Over the past few years, the development of unconventional techniques to control post-harvest diseases has been sought such as the use of visible ultraviolet light (UV-C) which arouses interest due to its action on both host and pathogen as well as the use of treatments such as water, hot air and also the use of microwave energy (FALLIK, 2004; BEM-YEHOSHUA; PORAT, 2005; THOMPSON, 2015; ROMANAZZI et al., 2016).

Another promising alternative still lacking in studies is the use of hydrogen peroxide to control bacteria that cause soft rot. Free radicals including reactive oxygen species such as hydrogen peroxide are produced by plants as a short-term defense response against the attack of pathogens (DEIGHTON et al., 1999; MORKUNAS et al., 2004). Previous studies conducted by Morkunas et al. (2004) evaluating the response of yellow lupine seeds to *Fusarium oxysporum* F. infection showed an increase in the hydrogen peroxide production in the seed embryo, ranging from 15% to 24% as a function of infection.

The accumulation of reactive oxygen species is associated with the induction of defense reactions of plants systems against pathogen attack (MORKUNAS et al., 2004). The hydrogen peroxide molecule (H_2O_2) is relatively stable and the fact that the amount of H_2O_2 required to eliminate pathogens is considerably lower than that required to cause cell death of the plant tissues acting as a cellular strengthening action. This effect is known as “homesis” which is defined as the stimulus of a beneficial activity by the use of low doses of potentially harmful agent, similar to that happens in exposure to low doses of UV-C light (USALL et al., 2016).

Based on the need to find alternative ways of control that are both effective and maintain the desirable characteristics, this study aimed to evaluate the effects of hydrogen peroxide on the control of soft rot preserving the physical-chemical quality in potato tubers for in natura marketing.

MATERIAL AND METHODS

Potatoes, cultivar Agata, were produced in a private property located in Cristalina - GO (16º 46’ 07” S; 47º 36’ 49” W; 1189m of altitude), where they were harvested and packed in 60kg bags and then transported to the experiment site. The experiment was conducted in the Instituto Federal Goiano-Campus Morrinhos (17°48’48,93” S; 49°12’15,56” W; 753m of altitude). When they arrived at the campus, the potatoes were taken to the Post-Harvest Laboratory where they were selected according to their uniformity of size, color, and absence of physical and physiological injuries.

The experiment was conducted following a completely randomized design in subdivide plots scheme with four treatments (H_2O_2 concentrations) and four replicates. The potatoes were inoculated using infective material taken from another potato with severe symptoms of soft rot. Immediately after inoculation the potatoes were sprayed with H_2O_2 at concentrations of 0, 50, 100 and 150ppm.

After imposition of the treatments the tubers were packed in identified plastic bags and then stored at room temperature. Tubers were evaluated daily for the percentage of tubers with symptoms, greenish and appearance of shoots. During the storage period the tubers with exudation were counted and discarded. On the fourteenth day of evaluations the great majority of the tubers already presented advanced symptoms of infection, being finalized then the period of visual evaluations. Subsequently the tubers were evaluated for their physicochemical characteristics

The potatoes were evaluated for pulp firmness, pH, total sugars (% AST), titratable acidity (% citric acid) and soluble solids content (°Brix). The firmness of pulp was obtained by the applanation method, and its values expressed in Kgf (CALBO; NERY, 1995). To determine the pH, juice extraction from the potatoes was carried out with the aid of a domestic food centrifuge. The pH values were obtained using a digital bench pHmetre (mPA-210, Tecnopon, Piracicaba, Brazil) previously calibrated with pH 4.0 and 7.0 buffer solution. The total sugars content was obtained through the phenol-sulfuric method (DUBOIS et al., 1956), where 1g samples were taken from the tubers of each treatment and then transferred to the vessel with 80% ethanol at a temperature of 70 °C. After thirty minutes, the samples were crushed with crucible aid and filtered on filter paper and the volume completed to 15 ml. The alcohol extract was transferred to vials with stopper, sealed with parafilm and stored in a freezer.

The extract was prediluted five times and then a 500 µL sample was withdrawn and transferred to a screw-type test tube. Then 500 µL phenol was then added, stirred, and then added 2.5 mL of concentrated sulfuric acid. The samples were homogenized in a vortex and taken to the water bath at 30 ° C for 20 minutes. After this period the tubes were again homogenized and left at room temperature for 30 min and the absorbance was then measured in a spectrophotometer (IL-226-BI, Kasuaki, Japan) at the wavelength of λ = 490 ηm using a standard 1% sucrose curve. The acidity was determined by neutralization titration (AOAC, 2010). The soluble solids value was obtained using a portable refractometer (ATAGO, Japan) where two drops of the extracted juice were placed on the prism of the refractometer and then the refractive index was read and its value expressed in °Brix.

The data were submitted to analysis of variance and the means compared by the Scott-Knott test. And when necessary the data were submitted to regression analysis.

RESULTS AND DISCUSSION

The values of the discarded due to the appearance of soft rot tubers are shown in Table 1. It was observed that the concentration of 50 ppm of hydrogen peroxide was effective in controlling soft rot, while the concentrations of 100 and 150ppm were not. The highest loss values were concentration of 150 ppm, probably due to damages caused by hydrogen peroxide to the tubers.

Table 1. Percentage of tubers with exudation aspects in response to hydrogen peroxide concentration.

Hydrogen Peroxide (ppm)	%Discarded	
	Not Inoculated	Inoculated
0	0.0	12.5
50	12.5	0.0
100	0.0	12.5
150	0.0	50.0

The visual evaluations allowed to identify that the concentrations of hydrogen peroxide were not efficient in reducing the greening of the tubers, and that until the eighth day of storage the concentration of 100ppm was efficient in inhibiting the appearance of shoots. From the ninth day storage all potatoes were already shoots, however, the sprouting of tubers subjected to 100ppm concentration had senescence aspect. Finding ways to reduce the occurrence of greening and sprouting in potatoes is of paramount importance for the entire potato production chain as these factors are linked to the production of solanine, which is a highly toxic substance, and in addition these characteristics are taken into account by the consumer when buying the product (EVANGELISTA et al., 2011).

Among the physicochemical characteristics evaluated, the values of pulp firmness, pH and total sugar content did not show a significant difference, however the parameters titratable acidity (% citric acid) and soluble solids (° Brix) presented significant difference by the test of Scott-Knoot between the applied hydrogen peroxide concentrations (Table 2).

Table 2. Values of Firmness (Kgf), pH, titratable acidity, soluble solids (SS, °Brix) and percentage of total sugars (% AST) of the inoculated and control non inoculed treatments in function of different doses of hydrogen peroxide (H_2O_2).

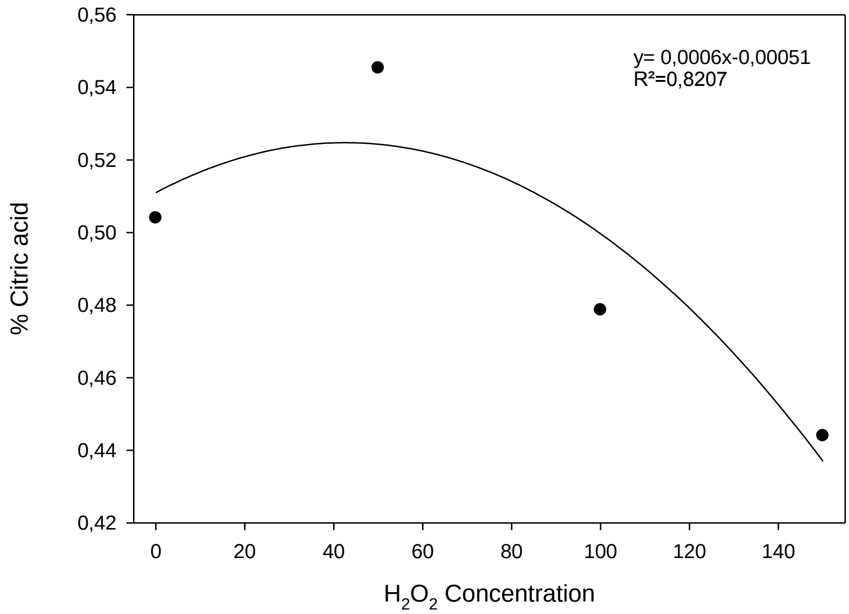
Not Inoculated					
Hydrogen peroxide	Firmness	pH	Titratable Acidity	Soluble Solids	%AST
0	10.41±5.6a	6.05±0.2a	0.49±0.08a	4.08±0.09b	0.30±0.03a
50	6.90±2.0a	5.95±0.04a	0.56±0.01a	4.60±0.27a	0.31±0.05a
100	6.90±1.9a	5.98±0.04a	0.46±0.06b	4.73±0.02a	0.38±0.08a
150	10.96±4.7a	6.05±0.03a	0.44±0.05b	4.53±0.17a	0.34±0.03a
Inoculated					
Hydrogen peroxide	Firmness	pH	Titratable Acidity	Soluble Solids	%AST
0	12.24±7.7a	5.97±0.1a	0.50±0.03a	4.30±0.14b	0.39±0.13a
50	13.04±11.03a	6.06±0.02a	0.53±0.02a	4.45±0.41a	0.36±0.04a
100	7.30±2.03a	5.98±0.02a	0.49±0.05b	4.58±0.28a	0.49±0.15a
150	14.49±8.7a	5.96±0.1a	0.44±0.06b	4.48±0.41a	0.34±0.07a

Averages in the same columns followed by the same letter do not differentiate among themselves by the Scoot-Knoot test at 5% probability.

The values of titratable acidity were also submitted to regression analysis where it was observed that in the control treatment the percentage of citric acid was around 0.5%, and when submitted to the concentration of 50ppm there was an increase, reaching values of 0.56% (Figure 1). This increase is due to the release of organic acids due to the increase of the metabolic activity and the conversion of sugars to acid (DIAS et al., 2017).

In the treatments submitted to the concentration de 100ppm there was a reduction in titratable acidity values, with values of 0.46% that continued to drop at 150ppm, going to 0.44% (Figure 1). This reduction in the values of titratable acidity was due to the metabolic activities of the tubers, which led to the use of organic acids in the tubers' respiration process and consequently their reduction (YAMASHITA et al., 2006).

Figure 1. Titratable acidity values (% Citric Acid) as in function of doses of Hydrogen Peroxide.



The soluble solids values were in contrast with the values of titratable acidity, where the control treatment had values of 4.18 °Brix and for the tubers submitted to 50ppm and 100ppm there was an increase in the values of soluble solids to 4.52 and 4.64 °Brix respectively. This increase in soluble solids is a result of the conversion of starch to glucose and sucrose resulting from the breathing processes. The tubers submitted to 150ppm had lower values than those submitted to 100ppm. This reduction is due to the exhaustion of sugars as a substrate for respiration (CHITARRA; CHITARRA, 2005).

Despite variations in acid values, pH values did not differ significantly. (Table 2), the results corroborate with those observed by Fernandes et al. 2016, working with different potato cultivars observed that pH values did not show significant variation within the same group of cultivars. Small pH variations are common, however a large number of vegetables maintains stable pH values even when there is variation in titratable acidity values (ALVARENGA et al., 2014).

CONCLUSION

The application of hydrogen peroxide at a concentration of 50ppm was effective in the control of soft rot, while its application at the concentration of 100ppm was effective in the control of shoots. Hydrogen peroxide increased the metabolic activity of the tubers leading to an increase in the soluble solids index.

REFERENCES

ALVARENGA, C.A.; PASSAGLIA, K.A.; CIABOTTI, S.; JESUS, E.J.; PERINI, T.F. Avaliação da fruta de *Eugenia uvalha* Cambes sob estádios de desenvolvimento. **Global Science and Technology,** v.7 n.1, p.67-75, 2014. https://doi.org/10.14688/1984-3801/gst.v7n1p67-75

AOAC - Association Official Analytical Chemistis. **Official Methods of Analysis of AOAC International**. 18. ed. Gaithersburg: AOAC, 2010.

ASSOCIAÇÃO BRASILEIRA DA BATATA. **Batata**. 2005. Disponível em: <http://www.abbabatatabrasileira.com.br>.

CALBO, AG; NERY, AA. Medida de firmeza em hortaliças pela técnica de aplanação. **Horticultura Brasileira,** v.3, p.14-18, 1995.

CHITARRA M.I.F.; CHITARRA, A.B. **Pós-colheita de frutos e hortaliças: fisiologia e manuseio.** 2. ed. UFLA, 2005. 785p.

DEIGHTON, N.; MUCKENSCHNABEL, I.; GOODMAN, B.A.; WILLIAMSON, B. Lipid peroxidation and the oxidative burst associated with infection of *Capsicum annum* by *Botrytis cinerea*. **The Plant Journal** v.20, p.485-492, 1999. https://doi.org/10.1046/j.1365-313x.1999.00622.x

DIAS, T.G.; BOAS, A.C.V.; JUNQUEIRA, M.B.A.; LIMA, L.C.O. Physicochemical characterization, antioxidant activity and total phenolic content in 'Gala' apples subjected to different UV-C radiation doses. **Acta Scientiarum,** v.39, n.1, p.67-73, 2017. https://doi.org/10.4025/actasciagron.v39i1.30979

DUBOIS, M.; GILLES, K.A.; HAMILTON, J.K.; REBERS, P.A.; SMITH, F. Colorimetric method for determination of sugar and related substances. **Analytical Chemistry,** v.28, n.1, p.350-356, 1956. https://doi.org/10.1021/ac60111a017

EVANGELISTA, R.M.; NARDIN, I.; FERNANDES, A.M.; SORATTO, R.P. Qualidade nutricional e esverdeamento pós-colheita de tubérculos de cultivares de batata. **Pesquisa Agropecuária Brasileira,** v.46, n.8, p.953-960, 2011. https://doi.org/10.1590/S0100-204X2011000800023

FAO - FOOD AND AGRICULTURE ORGANIZATION. **Preliminary data now available for selected countries and products**. 2011. Disponível em: <http://fao.org>.

FERNANDES, A.M.; SORATTO, R.P.; EVANGELISTA, R.M.; JOB, A.L.G. Influência do fósforo na qualidade e produtividade de tubérculos de cultivares de batata de duplo propósito. **Horticultura Brasileira,** v.34, n.1 p.346-355, 2016. https://doi.org/10.1590/S0102-05362016003007

INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA. **Levantamento sistemático da produção agrícola: Confronto das Safras de 2015 e 2016**. 2016.

MORKUNAS, I.; BEDNARSKI, W.; KOZŁOWSKA, M. Response of embryo axes of germinating seedsof yellow lupine to Fusarium oxysporum. **Plant Physiology And Biochemistry,** v.42 n.16, p.891-902, 2004.

SOUSA, F.A.; ROCHA, R.H.C.; MOREIRA, I.S.; FURTUNATO, T.C.S.; LIMA, J.F. Impact injury diagnosis in mango through starch degradation index. **Revista Caatinga,** v.30, n.1, p.263-270, 2017. https://doi.org/10.1590/1983-21252017v30n130rc

USALL J; IPPOLITO A; SISQUELLA M; NERI F. Physical treatments to control postharvest diseases of fresh fruits and vegetables. **Postharvest Biology and Technology,** v.122, n.1 p.30-40, 2016. https://doi.org/10.1016/j.postharvbio.2016.05.002

WALERON, M.; WALERON, K.; LOJKOWSKA, E. Occurrence of Pectobacterium wasabiae in potato field samples. **European. Journal of Plant Pathology,** v.137 p.149–158, 2013. https://doi.org/10.1007/s10658-013-0227-2

YAMASHITA, F.; VEIGA, G.F.; BENASSI, M.T.; ROBERTO, S.R. Morangos embalados com filme de Ppolicloreto de vinila (PVC). **Semina: Ciências Agrárias,** v.27, n.3, p.429-436, 2006. https://doi.org/10.5433/1679-0359.2006v27n3p429

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