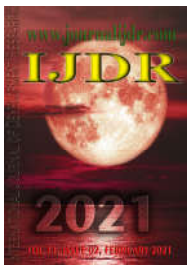
ISSN: 2230-9926

Available online at http://www.journalijdr.com

IJDR

International Journal of Development Research
Vol. 11, Issue, 02, pp. 44688-44691, February, 2021
https://doi.org/10.37118/ijdr.21161.02.2021



RESEARCH ARTICLE OPEN ACCESS

RESPONSES TO MENTHOL AND HYDROGEN PEROXIDE OVER PHYSIOLOGY OF POTATO SPROUTS

Luciana G. Soares*[1], Ariana M. Pereira[2], Maria Eduarda da S. Guimarães*[2], Dreice N. Gonçalves[2], Mirelle Nayana de S. Santos[1], Abelardo B. de Mendonça Neto[2], Renata R. Pedroza Cruz[2], Nicolas O. de Araújo[2], Mateus de P. Gomes[3], Daniela G. Soares[4], Paula Acácia S. Ramos[5] and Fernando L. Finger[2]

[1]Departamento de Biologia Vegetal, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brasil 36570-900
[2]Departamento de Agronomia, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brasil 36570-900
[3]Departamento de Solos, Universidade Federal de Viçosa, Viçosa, Minas Gerais, Brasil 36570-900
[4]Departamento de Biologia, Universidade Estadual da Paraíba, Campina Grande, Paraíba, Brasil 58.429-600
[5]Departamento de Agronomia, Universidade Estadual do Sudoeste da Bahia, Vitória da Conquista, Bahia, Brasil 45031-300

ARTICLE INFO

Article History:
Received 19th December, 2020
Received in revised form
28th December, 2020
Accepted 07th January, 2021
Published online 28th February, 2021

Key Words:
Quality, Darkening, Sugars, PPO.

Corresponding author:
Luciana G. Soares

ABSTRACT

Sprouting of potato tubers occurs over a prolonged storage, even at low temperatures, making tubers unsuitable for the processing industry. The application of sprouting inhibitors is an alternative; however, commercial compounds are toxic, making necessary the study of natural inhibitors, such as menthol and hydrogen peroxide (H_2O_2). The objective of this study was to evaluate the response menthol and hydrogen peroxide treatments on the physiology of sprouted tubers of 'Markies' potatoes in refrigerated storage for frying. The application of menthol and H_2O_2 + menthol reduced length of the sprouts and LFM besides the no effect on number of sprouts. The refrigerated storage of the sprouted tubers for 40 days resulted in a linear increase in TSS, RS and NRS contents up to 33.3 days; however, noenzymatic darkening was found. The POD increased from 8.1 days of storage. The PPO increased from 16.8 days which correlated with the reduction of the phenols until 32.5 days of storage and no enzymatic darkening was observed. It is concluded that the application of menthol reduces the length of sprouts and that the storage of sprouting tubers does not induce enzymatic or non-enzymatic darkening.

Citation: ***Luciana G. Soares, Ariana M. Pereira, Maria Eduarda da S. Guimarães, Dreice N. Gonçalves, Mirelle Nayana de S. Santos, Abelardo Barreto de M. Neto, Renata R. Pedroza, Nicolas O. de Araújo, Mateus de P. Gomes, Daniela G. Soares, Paula Acácia S. Ramos and Fernando L. Finger,*** **2021.** "Responses to menthol and hydrogen peroxide over physiology of potato sprouts", *International Journal of Development Research*, 11, (02), 44688-44691.

INTRODUCTION

Potato (*Solanum tuberosum* L.) is the third most consumed food in the world (Wang *et al*., 2015). The quality of tubers destined to the processing industry is determined by the sprouting, enzymatic darkening by peroxidase and polyphenoloxidase and non-enzymatic darkening due to the metabolism of the carbohydrates. Refrigerated storage is usually carried out at a temperature of 8°C (Voss *et al*., 2004) because lower temperatures may cause darkening. Tubers are stored for continuous periods to allow constant supply of the product to the industry and reduce summer production, which has a higher production cost in subtropical and tropical regions. However, sprouting of the tubers in the storage chambers is common.

Sprouting causes an increase in respiratory rate, water loss through transpiration, accumulation of reducing sugars (Singh and Kaur, 2016) and obstruct the air movement in the chambers, favoring the appearance of pathogens, resulting in tubers unsuitable for the processing industry. Compounds that suppress growth such as chloroprofen (CIPC) can be found. This compound is widely used in potatoes (Blenkinsop *et al*., 2002). However, they are toxic to human beings and the environment. An alternative is the use of essential oils, which are natural and non-residual compounds with low toxicity (Romero *et al*., 2009). Menthol is a crystalline cyclic monoterpene alcohol extracted from species of the genus Mentha (Mint) (Kamatou *et al*., 2013). Hydrogen peroxide (H_2O_2) is a strong oxidizing agent commonly used in medicine, farming and the food industry (Swieca, 2015; Buchanan *et al*., 2016). In addition, the application of these compounds in a combined way can potentiate their effect by making

them more efficient. Therefore, the objective of this study was to evaluate the response of the application of menthol and hydrogen peroxide on the physiology of sprouted tubers of 'Markies' potatoes in refrigerated storage for frying.

MATERIAL AND METHODS

Tubers of Markies potato cultivar were planted in July 2017 in Perdizes, state of Minas Gerais, Brazil (19°35'34" S and 46°56'27"W), with a cycle of 120 days. Cure was performed in an air-conditioned room for 10 days at 14 ºC (RH ± 95%). The tubers were selected for mass (150-200 g) and stored in a cold room at 8°C (RH 85-90%). When the sprouts were about 2 mm long, the tubers were submitted to the following treatments: T1- Hydrogen Peroxide 1:10 (27% H_2O_2); T2-Menthol (50%); T3 - Control (Water) and; T4- H_2O_2 (1:10) + Menthol. For the application of the treatments, 65-L buckets were used and a heater was placed over the potatoes (MA 085 - MARCONI) and petri dish containing filter paper, where the treatments were poured. The menthol treatment received 0.2 ml (100 ppm) for each 1 kg of potato and for treatment with H_2O_2, 2.3 ml per potato were applied for menthol treatment. After application, the buckets were hermetically sealed, until complete release of the applied compounds. The tubers were stored a second time at 8 °C (90% RH) in the absence of light and the evaluations occurred at 0, 10, 20, 30 and 40 days of storage. The evaluations were, as follow: length and number of sprouts, loss of fresh mass (LFM), total soluble sugars (TSS), reducing sugars (RS), non-reducing sugar (NRS), coloring of French fries after frying, activity of polyphenoloxidase enzymes (PPO) and peroxidase (POD) and phenolic compounds. Regarding length of the sprouts, the Stainless Hardened caliper was used expressed in mm. The number of sprouts was determined by manual counting them. The LFM was determined by the weight difference of the tubers at day 0 and in each evaluation period, expressed as a percentage. Total soluble sugars (TSS) were determined according to the methodology of (Dubois *et al*., 1956). This experiment followed the methodology of Gonçalves *et al*. (2010) with adaptations, using fructose as the standard to quantify the reducing sugars (RS). Non-reducing sugars (NRS) were obtained by the difference between TSS and RS. The coloring of the sticks after the frying was visually determined based on the 'United States Standards for Grades of Frozen French Fried Potatoes' color scale (USDA, 1967) and fast food industry with a scale from 1 to 5. The enzymatic activity of POD, PPO were determined by the methodologies described by Marques *et al*. (2011) and Kavrayan and Aydemir (2001), respectively. The results were obtained in UA min^{-1} mg^{-1} protein. The protein is quantified according to the method of Bradford (1976) using bovine serum albumin (BSA) as standard. The phenolic compounds followed the protocol of Fu *et al*. (2010). The experiment was conducted in a completely randomized design in split-plot design, with the treatments in the plots and in the subplots, the storage periods, with three replicates with two tubers per repetition. The data obtained in this study were analyzed through analysis of variance and regression using the System of Statistical Analysis and Genetics (SAEG-UFV). For the analysis of number of sprouts, the test of Tukey ($p < 0.05$) was used.

RESULTS AND DISCUSSION

The length of the sprouts increased throughout the storage. The menthol and H_2O_2 + menthol treatments result in smaller sprouts (Figure 1). The isolated application of H_2O_2 stimulated sprout growth (Figure 1). Menthol was also effective in reducing sprout length and sprouting rate in Asterix potato cultivar (Santos, 2017). Stimulus to the growth of sprouts with the use of H_2O_2 may be due to inhibition of catalase caused by the low storage temperature. For potato tubers, inhibition of catalase accelerates the release of dormancy and the growth of sprouting (Bajji *et al*., 2007; Liu *et al*., 2017). The number of sprouts increased over the storage period, from 1.00 to 5.00 sprouts per tuber on average (Figure 2).

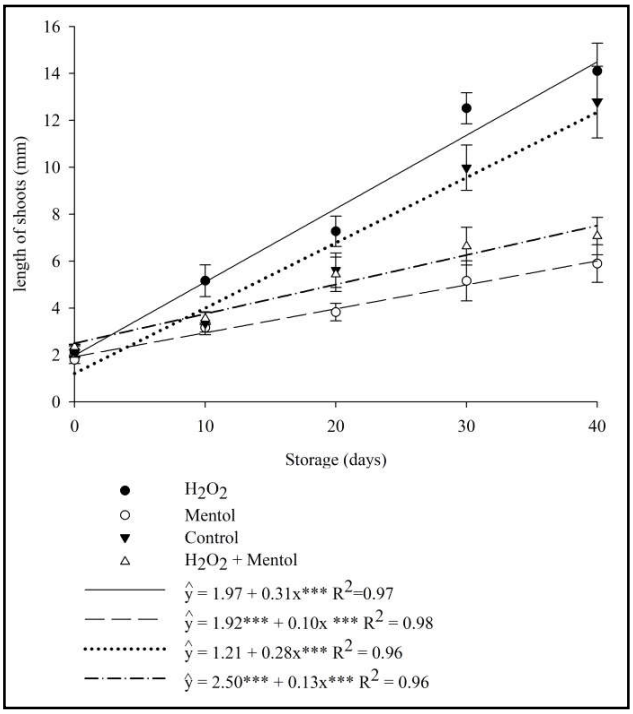


Figure 1. Length sprouts of Markies potato tubers submitted to H_2O_2, Menthol, Control and H_2O_2 + Menthol application during 40 days of storage at 8 °C

No reduction was observed in the number of sprouts as the treatments were applied in relation to the control (Figure 2). Loss of fresh mass increased over storage period. The lower rates were found in menthol and H_2O_2 + menthol treatments (Figure 3). In the tubers in which menthol were applied, the LFM was 0.91% and in the H_2O_2 + menthol treatment, it was 0.74%, while in the control it was 1.33% after 40 days of storage (Figure 3).

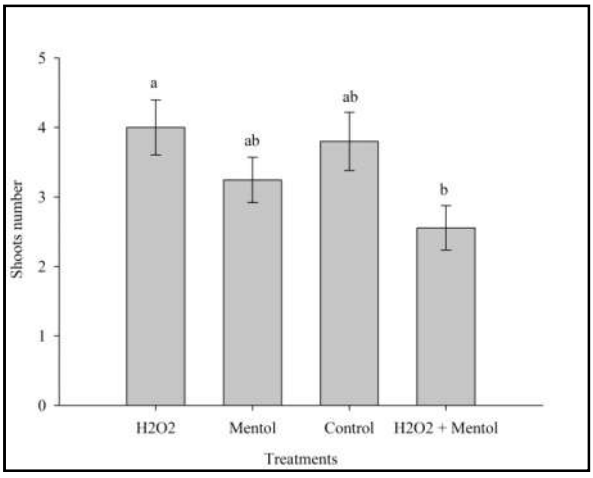


Figure 2. Number of sprouts in potato tubers of Markies cultivar submitted to H_2O_2, Menthol, Control and H_2O_2 + Menthol application during 40 days of storage at 8 °C. The bars followed by the same letter do not differ from each other by the 5% Tukey test

The increment in LFM is related to the increase in the sprout, which is consistent with sprout growth data. In the menthol and H_2O_2 + menthol treatments, the size of the sprouts and LFM were smaller (Figure 1 and 3). Sprouting increases, the respiratory activity, resulting in the consumption of tuber reserves (Singh and Kaun, 2016), therefore, increasing the mass loss. The reduction in the mass loss with the application of spearmint was also observed in 'Diamant' and 'Sinora' potato cultivars (Elbashir *et al*., 2014).

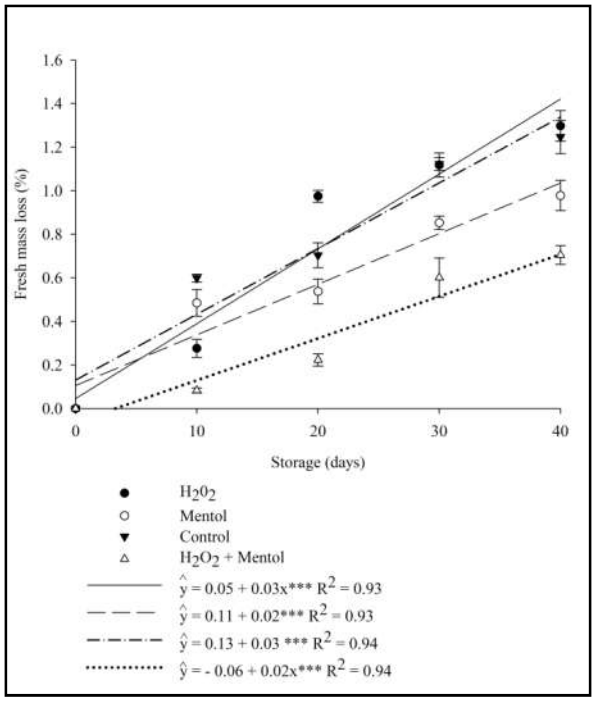


Figure 3. Loss of fresh potato mass of Markies potato submitted to H_2O_2, Menthol, Control and H_2O_2 + Menthol application during 40 days of storage at 8 °C.

Table 1. Variation in TSS, RS, NRS, POD, PPO and phenol contents in Markies potato tubers during 40 days of storage at 8 ° C

TSS	$\hat{Y} = 0.14 + 0.0024^{*}$ $R^2 = 0.82$
RS	$\hat{Y} = 0.0006 + 0.0154\ x^{*}$ $R^2 = 0.92$
NRS	$\hat{Y} = 0.1174 + 0.004x - 0.00006\ x^2$ $R^2 = 0.89$
POD	$\hat{Y} = 0.4929 - 0.0227x^{*} + 0.0014\ x^{2**}$ $R^2 = 0.99$
PPO	$\hat{Y} = 2.3580 - 0.0972x^{*} + 0.0029\ x^{2*}$ $R^2 = 0.99$
Phenol	$\hat{Y} = 2.0303 - 0.013x^{*} + 0.0002\ x^{2*}$ $R^2 = 0.86$

Spearmint belongs to the same genus as Mint. An increase was found in TSS and RS over storage, and in NRS, it was up to 33.3 days (Table 1). The increase in sugars was the result of the tubers sprouting. During sprouting, starch is broken in TSS, which is transported for sprout growth (Buchanan *et al*., 2016). Available NRSs can be cleaved by apoplastic or cytosolic invertase or by sucrose synthase (Susy) resulting in RS (Buchanan, 2016). The predominant form of NRS cleavage depends on the development stage of the tuber (Vreugdenhil *et al*., 2007). The application of menthol and H_2O_2 + menthol did not reduce the concentrations of TSS, NRS and RS, which may be due to the fact that the number of sprouts was not reduced. Tubers at 10 days of storage were classified in category 1 and category 2 at 40 days of storage. Categories 1 and 2 were suitable for the processing industry, indicating that the increase in sugar contents with sprout length did not cause non-enzymatic darkening. The RS carbonyl grouping reacts with the amino group of amino acids, resulting in an enzymatic reaction denominated Maillard, causing the formation of melanoidines, which are brownish pigments formed during frying (Amy *et al*., 2016). Darkening results in low consumer acceptability (Singh and Kaun, 2016). Also, another reaction takes place leading to the formation of acrylamide which is carcinogenic (Amy *et al*., 2016). The enzymatic activity of POD increased from 8.1 days of storage (Table 1). Under stress conditions, such as refrigerated storage, reactive oxygen species are produced, activating the plant defense system to avoid cellular damage. The POD is found among the enzymes of the defense system. The PPO increased from 16.8 days of storage (Table 1). The increase in PPO activity correlates with the reduction of the concentration of phenolic compounds that occurred up to 32.5 days of storage (Table 1). The PPO oxidizes phenolic compounds, producing rapidly condensed quinones, forming insoluble and dark pigments (Carneiro *et al*., 2003). These pigments are visible before frying the toothpicks, making them unsuitable for the industry. The application of menthol and H_2O_2 did not affect the enzymatic activity of POD and PPO nor the production of phenolic compounds.

CONCLUSION

The application of menthol reduces the length of sprouts and that the storage of sprouting tubers does not induce enzymatic or non-enzymatic darkening.

REFERENCES

Amy E, Bradforda W, Busseb JS, Bethkea PC (2016). Temperature-dependent regulation of sugar metabolism in wild-type and low-invertase transgenic chipping potatoes during and after cooling for low-temperature storage. Postharvest Biol. Technol. 115:60-71.

Bajji M, Hamdi MM, Gastiny F, Rojas-Beltran GA, Du Jardin D (2007). Catalase inhibition accelerates dormancy release and sprouting in potato (*Solanum tuberosum* L.) tubers. Biotechnol. Agron. Soc. Environ. 11:121-131.

Blenkinsop RW, Copp LJ, Yada RY, Marangoni AG (2002). Effect of chlorpropham (CIPC) on carbohydrate metabolism of potato tubers during storage. Food Res. Int. 35:651-655.

Bradford MM (1976). A rapid and sensitive method for thw quantitation of microgram quantities of protein utilizing the principle of protein-dye binding. Anal. Biochem. 72:248-254.

Buchanan BB, Gruissem W, Jones RL (2016). Biochemistry & molecular biology of plants. USA: Wiley Blackwell, ed. 2, 1283 p.

Carneiro CEA, Rolim HMR, Fernandes KF (2003). Estudo das atividades de peroxidades e polifenoloxidase de guariroba (Syagrus oleracea Becc) sob a ação de diferentes inibidores, Acta Sci. 25:189-193.

Dubois M, Gilles KA, Hamilton JK, Rebers PT, Smith F (1956). Colorimetric method form determination of sugars and related substaceas. Anal. Chem. 28:350-356.

Elbashir HA, Ahmed AHR, Yousif KS (2014). Efficacy of Different Applications of Spearmint Oil on Storability and Processing Quality of two Potato Varieties. J. agri-food appl. sci. 2:124-133.

Fu L, Xu BT, Xu XR, Qin XS, Gan RY, Li H-B (2010). Antioxidant capacities and total phenolic contents of 56 wild fruits from South China. Molecules 15:8602-8617.

Gonçalves C, Rodrigues-Jasso MR, Gomes N, Teixeira JÁ, BELO I (2010). Adaptation of dinitrosalicylic acid method to microtiter plates. Anal. Methods 2:2046-2048.

Kamatou GPP, Vermaak I, Viljoen AM, Lawrence BM (2013). Menthol: a sample monoterpene with remarkable biological properties. Phytochemistry 96:15-25.

Kavrayan D, Aydemir T (2001). Partial purification and characterization of polyphenoloxidase from peppermint (Mentha piperita). Food Chem. 74:146-154.

Liu B, Zhao S, Tan F, Zhao H, Wang D, Si H, Chen Q (2017). Changes in ROS prodution and antioxidant capacity during tuber sprouting in potato. Food Chem. 237:205-213, 2017.

Marques AE, Silva F, Barbosa JB, Finger FL (2011). Ação de inibidores de enzimas oxidativas e crescimento bacteriano sobre a longevidade das flores de Ave-do-Paraíso (*Strelitzia reginae* Aiton). Ver. Bras. Hort. Orn. 17:75-86.

Romero AL, Specian V, Oliveira RC, Diniz SPSS (2009). Atividade do óleo essencial de tomilho (Thymus vulgaris L.) contra fungos fitopatogênicos. Ciênc. Biol. Saúde 11:15-18.

Santos MNS (2017). Ação do eugenol e mentol na supressão da brotação de tubérculos de batata (S*olanum tuberosum* L.). Dissertação de mestrado, Universidade Federal de Viçosa, Viçosa, Brasil.

Singh J, Kaur L (2016). (Ed.). Advances in potato chemistry and technology. Academic press, 725 p.

Swieca M (2015). Production of ready-to-eat lentil sprouts with improved antioxidant capacity: optimization of elicitation conditions with hydrogen peroxide. Food chem. 180:219-226.

UNITED STATES DEPARTMENT OF AGRICULTURE – USDA (1967). United States Standands for Grades of Frozen French Fried Potato, Baltimore 16 p.

Voss RE, Baghott KG, Timm H (2004). Proper Environment For Potato Storage. Communication by the Vegetable Research and Information Center 1:1-3.

Vreugdenhil D, STRUIK PC (1989). An integrated view of the hormonal regulation of tuber formation in potato (Solanum tuberosum). Physiol. Plant. 75:525-531.

Wang Q, Cao Y, Jiang CZ, Feng Y, Wei S (2015). Effects of postharvest curing treatment on flesh colour and phenolic metabolism in fresh-cut potato products. Food Chem. 169:246-254.

****