Laranja ‘Navelina’ submetida a indutores de resistência na pré-colheita

‘Navelina’ Orange submitted to pre-harvest resistance inducers

Resumo

Objetivou-se avaliar as características físico-químicas, o índice de podridões e os compostos bioativos dos frutos da laranjeira ‘Navelina’ na pós-colheita sob armazenamento refrigerado, após indução de resistência na pré-colheita, nas safras de 2015 e 2016.O delineamento experimental a campo foi em blocos completos casualizados. O fator de tratamento foi composto pelos indutores de resistência [sem indutor (testemunha), selênio (Se), silício (Si), acibenzolar-s-metil (ASM), metil jasmonato (MeJa), tiametoxam (TMT) e imidacloprido (IMI)]. No laboratório, o delineamento utilizado foi o mesmo estabelecido a campo, porém em esquema bifatorial, onde o fator A foi composto pelos mesmos indutores e o fator B, pelo período de armazenamento refrigerado (zero e 30 dias). As análises realizadas foram coloração, perda de massa fresca, índice de podridões, sólidos solúveis, pH, acidez titulável, razão SS/AT, ácido ascórbico, compostos fenólicos totais e capacidade antioxidante. A aplicação dos indutores de resistência na pré-colheita é eficiente na manutenção das características físico-químicas de laranja de umbigo ‘Navelina’ na pós-colheita, proporcionando aumento dos compostos bioativos, quando comparados a testemunha. Os indutores Se, Si, MeJa e IMI reduzem os índices de podridões, enquanto, o ASM e MeJa previnem a perda de massa fresca dos frutos.

Palavras chaves: *Citrus sinensis* (L.) Osbeck; laranja umbigo; elicitores; armazenamento refrigerado; podridões;

Abstract

The objective of this study was to evaluate the physical-chemical characteristics, the rot index and the bioactive compounds of 'Navelina' orange fruits during post-harvest under refrigerated storage, after pre-harvest resistance induction, in the 2015 and 2016 crops. The experimental design was in completely randomized blocks. The treatment factor was composed of the following resistance inducers [(without inducer, selenium (Se), silicon (Si), acibenzolar-s-methyl (ASM), methyl jasmonate (MeJa), Thiamethoxam (TMT) and Imidacloprid (IMI)]. In the laboratory, the design used was the same as that established in the field, but in a two-factor scheme, where factor A was composed of the same inducers and factor B, for the refrigerated storage period (zero and 30 days). The analyses were coloration, fresh mass loss, rot index, soluble solids, pH, titratable acidity, SS/TA ratio, ascorbic acid, total phenolic

compounds and antioxidant capacity. The application of pre-harvest resistance inducers is efficient in keeping the physical-chemical characteristics of 'Navelina' oranges in post-harvest, increasing the bioactive compounds when compared to the control. The inducers Se, Si, MeJa and IMI reduce rot rates, while ASM and MeJa prevent fresh fruits mass loss.
Keywords: *Citrus sinensis* (L.) Osbeck; navel orange; elicitors; refrigerated storage; rotting

Introduction

Brazil presents the largest orange production area; however, it is the 10th country in productivity. The sector is highly organized and competitive, accounting for 30% of the world production and comprises one of the largest centers of orange juice production, and over 19 million tons of orange are harvested per productive cycle (FAO, 2016).

Orange trees are susceptible to various diseases, mainly citrus canker, which cause economic damage to production, increasing costs. The most frequent procedure for diseasecontrolconsists of the use of agrochemicals, resistant cultivars, cultural practices and crop management.

The induction of systemic acquired resistance (SAR) is a promising alternative for diseasecontrol, as it is a natural defense mechanism of plants. After application, SAR can confer long protection against a broad spectrum of microorganisms (David et al., 2010). Sensitive plants can acquire greater ability to defend against pathogen attacks, from primary infection. This process involves a series of biochemical and physiological reactions, which trigger the production of several secondary metabolites (Hall et al., 2011).

Substances that promote SAR induction, mostly reported in the literature, are acibenzolar-s-methyl, methyl jasmonate, selenium, silicon and neonicotinoids. Acibenzolar-s-methyl (ASM) is a functional analog of salicylic acid and is able to activate plant defenses, such as pathogenesis-related proteins, largely used in apples (Quaglia et al., 2011) and citrus (Graham & Myers, 2011; Neto, Maraschin & Di Piero, 2015). Methyl jasmonate (MeJa) is the methyl ester of jasmonic acid phyto-hormone showing promising results in SARinduction, interfering in the physiological and/or biochemical processes, as a sign of endogenous molecule of loquat (Cao et al., 2012; Cai et al., 2011), pomegranate (Sayyari et al., 2011) and banana (Zhao et al, 2012). Silicon plays multiple roles in cell growth and development, combining physical and chemical barriers such as cell wall lignification and induction of defense proteins (French-Monar, 2010; Schultz, 2012), as observed in avocado (Tesfay, Bertling & Bower, 2011), cotton (Oliveira et al, 2012), coffee (Asmar et al., 2013) and tomato (Andrade et al., 2013). Selenium is absorbed and transported by plants in the form of selenite, presenting a high antioxidant capacity and induction of plant defense system (Becvort, 2011). Recently, substances such as Imidacloprid neonicotinoids (IMI) and Thiamethoxam (TMT) have been used with success in inducing SAR in Pomeranian (Graham & Myres, 2011; Bagio et al., 2016).

Therefore, the occurrence of diseases is one of the main factors for losses in orange production in all regions of the country, mainly in the southern region, where the amount and frequency of rainfall are high. Studies are necessary to investigate the application of resistance inducers in pre-harvest that respond to fruit conservation, reducing pesticide applications and increasing the levels of beneficial bioactive compounds to humans. This study aimed to evaluate the physical-chemical characteristics, rotindexes and bioactive compounds of ‘Navelina’ orange fruit in post-harvest under refrigerated storage, after inducing resistance in pre-harvest in the 2015 and 2016 crops.

Material and Methods

Resistance inducers were applied in a commercial orchard (31°25'58"S and 52°16'58" and 193 meters) of ‘Navelina’orange (*Citrus sinensis* (L.) Osbeck) in the 2015 and 2016 crops, in Santa Silvana, 6th district of the municipality of Pelotas, Rio Grande do Sul (RS) Brazil. The soil in the region is moderately deep, with medium texture in the A horizonand clayey in the B horizon, classified as Red-Yellow Argisoil (Embrapa, 2006). The climate features Cfa classification (Köppen and Geiger, 1928), i.e., temperate or humid subtropical with hot summers and average annual rainfall of 1582 mm, average annual temperature of 17.7° C and average annual relative humidity 78.8% (INMET, 2016).

The plants (4 years old) were installed under the trifoliate rootstock (*Poncirus trifoliata* (L.) Raf.) with 6 m spacing between rows and 4 m between plants. The experimental field was handled in accordance with the requirements of integrated production for citrus (Azevedo et al., 2010). To the orchard, the fungicide Nativo® (Trifloxystrobin and Tebuconazole) was applied in three events at the interval of 30 days with the first application in the phenological stage of newly formed fruitlets. In addition, Bordeaux mixture (copper sulfate and lime) was usedwith six applications spaced 45 days from the flowering and completion 60 days before harvest.

The experimental design the field for the application of resistance inducers was completely randomized blocks, with five repetitions, three plants per plot, by evaluating the central plant, in a unifactorial scheme. The treatment was composed of resistance inducers [no inducer (control, water), selenium (Se, 10 mg. L^{-1}), silicon (Si, 400 mg. L^{-1}), acibenzolar-s-methyl (ASM, 100 mg. L^{-1}), methyl jasmonate (MeJa, 10 mg. L^{-1}), Thiamethoxam (TMT, 2000 mg. L^{-1}) and Imidacloprid (IMI, 714mg. L^{-1})].

The resistance inducers were applied at a 15-day interval, totaling three applications in the orchard, with 45, 30 and 15 days before harvest using the total dosage. The products Si, ASM and MeJa were applied by spraying, with coastal spray (Guarani®), with flat fan nozzle and fine droplet size (101-200µ) in all plant canopy, avoiding run-off. It was added 0.1% of non-ionic adhesive spreader Silwet L-77®. For Se, TMT and IMI inducers, syrups were prepared with water for each product and applied in the soil around the plant canopy.

When they reached commercial maturation, the fruits were collected randomly in four quadrants of the tree canopy, placed in plastic boxes, cleaned and sanitized, and transported to the Agronomy Laboratory, Department of Plant Science at the Universidade Federal de Pelotas (UFPel), where they were pre-screened for standardization by removing the damaged fruits. The fruits were then submitted to pre-cooling (15 ± 2°C) for 24 hours.

In the lab, the design used was the same established in the field, but in a two-factorial scheme, where factor A was composed of the same resistance inducers described previously and factor B, by the storage period (zero and 30 days). Time zero corresponded to the fruits that were not subjected to storage and the 30-daystoragewas in refrigerate storage at 5±1°C, under 85-95% of relative humidity. After removing from the chamber, the fruits were submitted to simulation of commercialization time, 7 days at 20±1°C. For each treatment, three replicates were used with 20 fruits each, the same number of repetitions was used in refrigerated storage, totaling 840 fruits.

The coloring was measured with Minolta colorimeter CR-300, with reading system CIE L* a* b*, and the chromatic tone, represented by the hue angle (*hº*) through the arctangent formula b*/a*. The result of this equation, expressed in radians, was then converted to degrees (Minolta, 1994). The fresh fruit loss was obtained by the difference between the initial and final mass of fruits in cold storage period and the values expressed in percentage (%). The rotindex was established by the percentage of fruit attacked by pathogens through visual inspection of fruits, where fruits with lesion greater than or equal to 5 mm were considered rot. Both evaluations were conducted after 30 days of refrigerated storage.Soluble solids (SS) were quantified with a digital Refractometer (Atago®) model PAL-1, and the results were expressed in °Brix. The hydrogen potential (pH) was measured through digital pH meter (Digimed®). For titratable acidity (TA), 10 mL of orange juice were added to 90 mL of distilled water. The sample titration was made with the aid of digital burette (Brand®), containing sodium hydroxide solution (0.1 N) up to pH 8.1. The titratable acidity was expressed as percentage of citric acid. The SS/TA ratio of oranges was expressed by the relationship between the soluble solids and titratable acidity (SS/TA) (Instituto Adolfo Lutz, 2008). The ascorbic acid content was quantified through the official AOAC method (1997) by oxidative titration with 2.6-Dichlorophenol Indophenol (DCFI) in which the titration point is detected by the appearance of the pink coloration, and the result expressed in mg ascorbic acid per 100 $g^{-1}$of the sample (Jacobs, 1958; Leme & Malavolta, 1950).

To analyze the phenolic compounds and antioxidant capacity, the exocarp or epicarp (peel) was separated from the endocarp (pulp) and evaluated separately in order to monitor translocation in the fruit (Chitarra & Chitarra, 2005). Total phenolic compounds were quantified using the Folin-Ciocalteau reagent, as described by Swain and Hillis (1959), expressed in mg of chlorogenic acid equivalent (CAE) per 100 g^{-1}. The antioxidant capacity was determined by spectrophotometry, according to the method adapted from Brand-Williams et al. (1995), where the results were expressed as μg of Trolox equivalent antioxidant capacity (TEAC) g^{-1}.

The 2015 and 2016 crops were used as repetition. The data were analyzed for normality by the Shapiro-Wilk test, andhomoscedasticity by the Hartley test. Subsequently, the data were submitted to analysis of variance ($p\leq0.05$). In case of significance, the effects of resistance inducers were analyzed by the Tukey test ($p\leq0.05$) and the storage period by the t test ($p\leq0.05$). To compare the control with the resistance inducers, the Dunnett test ($p\leq0.05$)was carried out. The presence of correlations between the dependent variables of the study was analyzed through the Pearson correlation coefficient (r) ($p< 0.0001$).

Results and Discussion

For color variables (L* and b*), soluble solids (SS) and ascorbic acid, there were interactions between the treatment factors tested (Table 1). While the color expressed by a* and the hue angle, the pH, titratable acidity (TA) and ratio SS/TA showed significance only for the main effect of the storage period (Table 4). The applications of resistance inducers has not changed the luminosity coloration of ‘Navelina’ oranges expressed by L* coordinate in both periods; however, it decreased over the storage period for degradative processes, except for the TMT inducer. Compared to control, all inducers kept the luminosity levels (L*), except for MeJa at day zero, which was higher (Table 1). As observed in this study, the storage effect also reduced the luminosity parameters of ‘ValenciaDelta’fruits submitted to resistance inducers (Pereira, Machado & Costa, 2014). Investigation on the effectiveness of MeJa inducer applied in pre-harvest in mangoes (*Mangifera indica* L.) shows uniform development of the red color in the peel after harvesting, with an increase in L* and a* values (Muengkaew, Chaiprasart & Warrington, 2016). This increase is possibly due to MeJa inducer performance in accumulating certain proteins related to pathogenesis, promoting metabolic changes that keep color strength in oranges (Brinceño et al., 2012).

Regarding coloring of the b* coordinate, the highest values determined the intensity of yellow-orange in oranges for inducersSe, MeJa and IMI at day zero, with no significant effect of inducers at 30 days of refrigerated storage (Table 1). For storage purposes, ASM and TMT inducers increased b* intensity in the fruits. When compared to control, differences were foundfor ASM, TMT and IMI only at the end of the storage period. Regarding soluble solids (SS) of 'Navelina' orange fruits, there was no difference of the resistance inducers in both periods. However, the ASM inducer showed an increase in sugar contents along the storage period. In addition, there were no differences in relation to the control at both assessments (zero and 30 days), with no effects on sugar metabolism throughout the storage period.

The applied resistance inducers did not affect the ascorbic acid levels in each period. However, for ASM, the effect of refrigerated storage provided a reduction of these levels, caused by degradation during fruit ripening. Inducers Se and IMI showed higher levels of ascorbic acid in relation to the control for both assessment times. MeJa, in turn, was higher only at 30+7 days (Table 1). Storage of 'Pera Bianchi'oranges sowed increases in ascorbic acid levels from 48.89mg 100mL^{-1} at 15 days to 56.76 mg 100mL^{-1} at 45 days of storage (Rosa et al., 2016).

For coloring of the a* coordinate, orange fruits intensified the orange color to reddish throughout the storage period, and through the hue angle, the fruits lost the typical yellowish coloring. Similarly, the pH of oranges increased throughout the storage period (Table 4), typical feature of the cultivar studied (Koller, 2013). With ripening, oranges lose acidity rapidly increasing the pH, the inverse of the hydrogen ion concentration used in respiration and ripening. There was a reduction in levels of citric acid and ratio SS/TA with the storage time (Table 4), reducing fruit flavor. In studies conducted with 'Valencia Delta'orange during storage at room temperature, with the application of post-harvest coating, there was increased acidity (citric acid) and its ratio SS/TA in oranges, while the coloring tone (hue angle) decreased with the storage period (Pereira, Machado & Costa, 2014).

The ASM and MeJa inducers differed from control after 30 days of refrigerated storage with subsequent simulation of commercializationtime (7 days at 20±1°C) (Table 5). The application of salicylic acid activated the secondary metabolic synthesis, promoters of systemic resistance; however, it did not affect biomass loss of fresh fruits (Borsatti et al., 2015), corroborating with the results of this work.

Regarding rot rate after 30 days of refrigerated storage, the ASM and TMT inducers did not differ from control (Table 5). However, the other inducers were efficient in rot control in the studied period, signaling defense responses and biosynthesis induction of substance, generating physical and chemical barriers. In ‘Satsumas’ tangerines stored at 14±2°C, the application of resistance inducers in post-harvest reduced rot significantly during the first six days of storage (Zhu et al., 2015).

The total phenolic compounds and antioxidant capacity, in both peel and pulp, showed interactions between the treatment factors tested (Table 2). For the total content of phenolic compounds in the pulp, at day zero, the Si and ASM inducers showed higher levels compared to the others (Table 2). However, at 30 days, there was no significant difference between the inducers. When comparing the inducers with control, only IMI did not differ in both periods evaluated. Resistance inducers increase the demand of enzymes for the biosynthesis of phenolic compounds needed to fight the pathogen (Oliveira, Varanda & Félix, 2016).

As for the phenolic compounds in the pulp, there was no difference between the inducers, both at zeroand 30 days after cold storage. Similarly, there was no effect of storage period. However, when compared with control, the Se and Si inducers showed higher values in the two assessment periods. The application of these inducers in post-harvest raises levels of phenolic compounds in plant tissues, which usually have antioxidant properties that are highly beneficial to humans (Romanazzi et al., 2016). The Se and Siinducers confer tolerance to oxidative stress by strengthening the defense system in plants through increased antioxidant capacity (Hasanuzzaman, Nahar & Fujita, 2014).

The antioxidant capacity in the pulp was higher for the inducers Se, Si, MeJa and IMI, differing from the others at day zero. At 30 days, there were no differences between them (Table 2). The reduction in antioxidant capacity of oranges was observed at storagefor all inducers. However, all inducers differed from controlat day zero and at 30 days only for TMT and IMI. The neonicotinoidsinduced defense with increased bioactive compounds through increased biosynthesis of enzymes, mainly in young citrus plants, keeping this induction for a long period (Graham & Myres, 2013).

The antioxidant capacity in orange peels, at day zero, showed no difference between the inducers; however, at 30 days, there was a reduction with the application of the ASM inducer. Similar to the pulp, the antioxidant capacity in the peel decreased with storage time for all inducers. Higher levels than in the control were observed, mainly for the inducers Se, Si and IMI at day zero. Induced resistance raises the synthesis of phenolic compounds in planttissuesthrough stress caused by inducers that lead to changes in phenolic metabolism, as these compounds exhibit antioxidant properties (Wu et al., 2014; Orabi, Dawood & Salman, 2015).

Regarding correlations, significant results were found among total phenolics and antioxidant capacity, which showed the highest positive correlation coefficient (Table 3) for all inducers used, conferring an increase of receptors in the cell membrane mimicking the inevitable phenomenon of electron leakage of chloroplasts, mitochondria and plasma membrane (Bhattacharjee, 2012; Sharma et al., 2012). When there was an increase in the levels of total phenolics, there was also an increase in the antioxidant capacity of oranges. In this context, for the association between phenolic compounds and antioxidant capacity of orangepulp, the Si and ASM inducers showed correlation coefficients higher than in the control. The application of resistance inducers in ‘Fortune’tangerine in pre-harvest provided an increase in gene expression and synthesis of phenolic compounds (Llorens et al., 2015).

The Se and Si inducers obtained correlation coefficients between antioxidant capacity in the peel and pulp, higher than in the control, demonstrating that Se and Si promoted increased antioxidant capacity, which was transported from the peel to the pulp of oranges (Table 3). This behavior is due to the powerful antioxidant capacity of the phenolic compounds. In ‘Valencia’ and ‘Lanelate’ oranges, the application of resistance inducers in post-harvest as a curative activity showed positive effect of increasing bioactive compounds in citrus plants (Moscoso-Ramírez & Palou, 2013).

Table 1- Coloring (L* and b*), soluble solids (°Brix) and ascorbic acid (mg 100 g^{-1}) of 'Navelina' orange fruit due to resistance inducers applied in pre-harvest and periods of refrigerated storage with subsequent simulation of commercialization time(7 days at 20±1°C) in the 2015 and 2016 crops. Ufpel, Pelotas/RS.

Inducers	L*		b*		Soluble Solids (°Brix)		Ascorbic Acid (mg $100g^{-1}$)	
	Storage period							
	0	30	0	30	0	30	0	30
Control	69.32	64.51	66.60	66.72	10.15	11.23	44.69	43.49
Selenium	71.42 aA[1]ns	66.48 aB ns	68.74 aA ns	68.62 aB ns	10.91aA ns	11.58aA ns	51.78aA*	49.44aA*
Silicon	71.19 aA ns	66.88 aB ns	65.95 bA ns	69.43 aB ns	10.75aA ns	11.06aA ns	48.21aA ns	46.72aA ns
Acibenzolar-s-methyl	70.74 aA ns	67.17 aB ns	66.17 bB ns	72.20 aA*	10.16aA ns	10.48aA ns	48.36aA ns	45.72aB ns
Methyl Jasmonate	72.67 aA *	67.40 aB ns	68.48 abA ns	70.46 aA ns	10.41aA ns	10.46aA ns	49.10aA ns	47.69aA*
Thiamethoxam	70.30 aA ns	68.41 aA ns	66.17 bB ns	71.78 aA*	10.40aA ns	11.33aA ns	47.91aA ns	46.48aA ns
Imidacloprid	71.39 aA ns	67.62 aB ns	69.0 aA ns	70.72 aA*	10.73aA ns	11.18aA ns	52.23aA*	48.86aA*
C.V. (%)	3.0		3.0		5.5		6.0	

[1]Means followed by the same lowercase letter in the column do not differ by the Tukey test (p≤0.05) comparing the inducers in each storageperiod. Means followed by the same uppercase letter in the row do not differ by the t test (p≤0.05) comparing the storage of each inducer. *e ns, significant and not significant, respectively, in relation to the control (no inducer) by the Dunnett test (p≤0.05). C.V.: coefficient of variation.

Table 2- Total phenolics (mg CAE $100g^{-1}$) and antioxidant capacity (DPPH, µg TEAC g^{-1}) in the pulp and peel of Navelina'orange 'regarding resistance inducers applied in pre-harvest and periods of refrigerated storage with subsequent simulation of commercialization time (7 days at 20±1°C) in the 2015 and 2016 crops. Ufpel, Pelotas/RS.

Inducers	Total phenolics (mg CAE $100g^{-1}$) in pulp		Total phenolics (mg CAE $100g^{-1}$) in peel		DPPH (µg TEAC g^{-1}) in pulp		DPPH (µg TEAC g^{-1}) in peel	
	Storage period							
	0	30	0	30	0	30	0	30
Control	108.94	85.82	367.74	350.58	241.64	127.31	351.08	232.41
Selenium	129.02 dA[1] *	106.26 aB *	425.44 aA *	409.61 aA *	389.23abA *	153.00aB ns	455.54aA *	281.54abB *
Silicon	161.38 aA *	103.95 aB *	424.32 aA *	411.98 aA *	453.18aA *	150.08aB ns	472.54aA *	303.19aB *
Acibenzolar-s-methyl	147.22 abA *	104.37 aB *	403.28 aA ns	386.44 aA ns	363.39bA *	138.14aB ns	421.29aA ns	247.29bB ns
Methyl Jasmonate	134.18 bcA *	102.57 aB *	395.01 aA ns	380.34 aA ns	397.58abA*	159.06aB ns	440.82aA*	268.49abB ns
Thiamethoxam	135.59 bcA *	113.02 aB *	389.13 aA ns	371.29 aA ns	327.29bA *	173.64aB *	438.20aA *	272.69abB ns
Imidacloprid	117.89 dA ns	98.03 aB ns	375.56 aA ns	359.56 aA ns	410.65abA *	173.69aB *	441.85aA *	274.20abB *

C.V. (%)	7.2	7.4	13.8	11.1

[1]Means followed by the same lowercase letter in the column do not differ by the Tukey test (p≤0.05) comparing the inducers in each storage period. Means followed by the same uppercase letter in the row do not differ by the t test (p≤0.05) comparing the storage of each inducer. *e ns, significant and not significant, respectively, in relation to the control (no inducer) by the Dunnett test (p≤0.05). C.V.: coefficient of variation

Table 3-Pearson correlation coefficients (*r*, *p*< 0.0001) among total phenolics compounds (phenols) and antioxidant capacity (DPPH) in 'Navelina' orange in relation to resistance inducers selenium (Se), silicon (Si), acibenzolar-s-methyl (ASM), methyl jasmonate (MeJa), Thiamethoxam (TMT) and Imidacloprid (IMI) applied in the pre-harvest and submitted to refrigerated storage with subsequent simulation of commercialization time (7 days at 20±1°C) in the 2015 and 2016 crops.Ufpel, Pelotas/RS

	Control	Selenium	Silicon	ASM	MeJa	TMT	IMI
				DPPH in pulp			
Fhenols in pulp	0.91844	0.75758	0.98504	0.95590	0.85551	0.78681	0.81085
				Phenols in pulp			
DPPH in peel	0.91922	0.69533	0.92491	0.90886	0.72638	0.70688	0.86271
				DPPH in pulp			
	0.96059	0.97714	0.96091	0.90057	0.91894	0.89481	0.95486

Table 4- Coloring (a* and hue angle), pH, titratable acidity (% citric acid) and SS/TA ratio in'Navelina' orange under the effect of refrigerated storage with subsequent simulation of commercialization time (7 days at 20±1°C) in the 2015 and 2016 crops. Ufpel, Pelotas/RS.

Variables	Storage period		C.V. (%)
	0	30	
a*	13.85 b[1]	21.12 a	29,29
Hue angle	78.35 a	73.31 b	5,18
pH	3.46 b	3.60 a	3,90
Titratable acidity (%citric acid)	1.02 a	0.93 b	12,48
SS/TA ratio	11.40 a	10.86 b	10,43

[1]Means followed by the same lowercase letter in the row do not differ by the t test (p≤0.05) comparing the storage periods. C.V.: coefficient of variation

Table 5-Fresh mass loss (%) and rot index (%) of ‘Navelina’ orange treated in pre-harvest with resistance inducers in the 2015 and 2016 crops. Ufpel, Pelotas/RS.

Inducers	Fresh mass loss (%)	Rot index (%)
Control	8.43 ab[1]	6.66a
Selenium	9.75 a	1.66b
Silicon	8.45 ab	0.83b
Acibenzolar-s-methyl	6.71 b	5.03ab
Methyl Jasmonate	6.46 b	0.83b
Thiamethoxam	7.91 ab	5.03ab
Imidacloprid	7.01 ab	0.83b
C.V. (%)	30.2	124.7

[1]Means followed by the same lowercase letter in the column do not differ by the Tukey test ($p \leq 0.05$). C.V.: coefficient of variation.

Conclusions

The application of resistance inducers in pre-harvest is efficient to keep the physical-chemical properties of ‘Navelina’ orange in post-harvest,providing increasedbioactive compounds, both in peel and pulp, when compared to control. The inducers Se, Si, MeJa and IMI reduce the rot index, while ASM and MeJa prevent loss of fruit fresh mass.

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