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Response of Jerusalem Artichoke Storability and Disease Detection to Some Foliar Application Treatments

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Abstract: The present study was carried out at the experimental laboratory of Environmental Affairs of Environmental Studies and Research Institute, University of Sadat City during 2018 and 2019 seasons to examined the effects of some pre-harvest foliar spray with selenium (10ppm), SiO2 (200ppm), salicylic acid (30ppm), Gabrilic acid (50ppm), benzoyl adenine (5ppm), cycocil (100ppm) and garlic extract (2000ppm) compared with control (tab water on Jerusalem artichoke (JA) (Helianthus tuberosus L.) tuber quality during the cold storage at 5°C and RH 90%. The results indicated that tuber weight loss %, tuber decay%, tuber infection with *Rhizoctonia solani* and *Microphonina solani* gradually increased with the extended of cold storage period up to 21 days in addition to at shelf. All pre-harvest applications significant delayed the physical and chemical changes in the cold storage and room conditions. Garlic extract seemed to be excellent treatment to extended tuber shelf life where it showed the lowest tuber weight loss, tuber decay and tuber infections with *Rhizoctonia solani* and *Microphonina solani* under cold storage and shelf. In the same line, selenium application showed the highest tuber contents of total sugar and inulin in both cold storage and room conditions across the two seasons of this study.

Key words: Jerusalem artichoke · Selenium · Silicon · Salicylic acid · Growth regulators · Cold storage conditions

INTRODUCTION

Helianthus tuberosus L. (Jerusalem artichoke) is a perennial herb from *Asteraceae* family, originating from the United States where it was cultivated by the indigenous inhabitants. It has a 1.5-3 m tall stem, large leaves, fleshy tubers and yellow sunflower-like flowers [1]. The content of compounds contained in Jerusalem artichoke tubers depends strictly on the harvest conditions and topinambur clones. *Helianthus tuberosus* L. tubers are a rich source of carbohydrates [2]. It is one of the main sources of inulin in higher plants, its content reaches up to 85% of the dry matter of tubers [3]. The content of free sugars such as glucose, fructose and sucrose is much lower and rarely exceeds 6–8% of dry matter. Proteins present in topinambour tubers reaches up to 10% of dry matter. It contains almost all essentials amino acid such as tryptophan and threonine [4]. In cold stores tubers of Jerusalem artichoke can be kept at the temperature of 0 to 2°C and RH 90 to 95% for three months. Additionally, many fungi can grow at low temperatures and cause substantial damage, especially if the fruits are stored for extended periods of time [5]. The main factor which complicates the storage of tubers is the highly evaporation of tubers through thin peel and the browning of tubers peel [6]. There are many antioxidants compound that could be used to prolong the storage ability of different fruits and act the role of antioxidant agents. Growth regulators such as salycilic acid, gebbrilic acid, cytokines and cycocel as plant material play important roles in enzymes activities and antioxidant so it will reduce the changes due biotic and abiotic stresses. As for growth regulators Sultan *et al.* [7] showed that postharvest treatments with antioxidants specially SA decrease the respiration rate and weight losses, maintained higher levels of fruit firmness and delayed the incidence of fungal diseases.

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Silicon (Si) and selenium (Se) almost used to elevated plants the pad conditions such as drought and salinity. Se is closely related to enhancing antioxidant activity in plants, which helps protect plants from fungal diseases [8]. The improving effect of Si seemed to be due to increasing root hydraulic conductance of the plants. Also, Si can enhance antioxidant defense and then decrease oxidative substances subsequently oxidative stress in plants under bio and abiotic stresses [9].

This plant essential oils generally content of some components such as eugenol which had a strong inhibitors of enzyme processes and produce compounds as methyle- or actyl eugenol could change this property. These components had Antimicrobial activity so this oil can be attributed to the presence of an aromatic nucleus and a phenolic OH group that are known to be reactive and can form hydrogen bonds with-SH group in the active sites of target enzymes, resulting in deactivation of enzymes in fungi [10, 11].

The main objective of this were to evaluate some pre harvest foliar spray treatments to reduce changes occur tuber quality and fungal diseases of Jerusalem artichoke during cold storage and room conditions.

MATERIAL AND METHODS

Materials: To study the effects of foliar spray with selenium (10ppm), SiO2 (200ppm), salicylic acid (30ppm), Gabrilic acid (50ppm), benzoyl adenine (5ppm), cycocil (100ppm) and garlic extract (2000ppm) compared with control (tab water on Jerusalem artichoke (JA) (Helianthus tuberosus L.) tuber quality during the cold storage a field experiment designed in randomized complete block design (RCBD) with three replicates was conducted out at the experimental farm of Sadat city university, El-Menofya Governorate, Egypt during the two growing seasons of 2018 and 2019.

Methods: Whole, Jerusalem artichoke (JA) (Helianthus tuberosus L.) tubers were within a range of 20 to 25 g, was sown on April 1th and 4th in both seasons, respectively. All treatments were separated randomly in plots each plot was 6 meters long and 6 meters width each plot consists of 5 ridges with a total plot area of 36 m^2. Each ridge was 6 meters long and 120 cm apart. Tubers were being planted on the one side of the ridge at 50 cm hill spacing with one tuber per hill. All the other cultural practices were followed as recommended.

All treatments were applied as a foliar spry with the recommended dose three times: the first one after 75 days from sowing, the second one was 90 days after sowing and the third was 105 days after sowing.

Storage Experiment: After harvest representing tubers samples in the same size and full maturity from the previous treatment and control were transported immediately to the laboratory, washed and dried. The tubers were divided into 3 groups and each group was packed in one layer carton boxes (2Kg). All groups tubers were initially weighted and counted before storage.

All boxes were stored at 5°C and RH 90% for 21 days. Tubers Physical and chemical characteristics; weight losses, decay percentage, inulin content and total sugar content were measured every 7 days until the end of storage period.

Studied Characters Were:

Tuber Weight Loss: Fruit weight loss percentage was calculated by the following formula:

$$Tuber\ weight\ loss\ \% = \frac{Initial\ tuber\ weight\ before\ storage\ -\ tuber\ weight\ after\ each\ cold\ storage\ period}{Initial\ tuber\ weight\ before\ storage} x100$$

Tuber Decay Percentage: Tuber decay percentage was recorded every seven days of cold storage by counting the number of decayed tubers due to fungus or any microorganisms infection and calculated by the following formula:

$$Decay\ \% = \frac{Number\ of\ decayed\ tuber\ after\ each\ storage\ period}{Initial\ number\ of\ tuber\ before\ storage} x100$$

- Inulin content: was determined in tubers before storage and after each storage period according to the method of Winton and Winton [12].
- Total sugar content: tuber samples were taken representing each treatment before storage and at the end of each storage period to determent sugar content according to Winner [13].

Pathogenic Test: *Rhizoctonia solani* and *Microphonina solani* were assessed as disease incidence and reduction by aye vision as follow according to Tsror (Lahkim) *et al.* [14]:

$$Disease\ incidence\ \% = \frac{Number\ of\ \inf ected\ tubers\ in\ the\ treatment}{Total\ number\ of\ tuber\ in\ the\ same\ treatment} x100$$

$$Reduction\ \% = \frac{Disease\ severity\ in\ control\ -\ Disease\ severity\ in\ treatment}{Disease\ severity\ in\ control} x100$$

Tuber Shelf Life: At the end of storage experiment tubers of all treatments were lifted for one week at room temperature and relative humidity to determined tuber

shelf life by measuring the previous measurements tuber weight loss %, tuber decay%, inulin content and total sugar content once again.

Statistical Analysis: Results were expressed as mean. The data were analyzed by using two-way ANOVA followed by LSD test through SPSS 16 (version 4). The treatments means were compared using least significant difference (LSD) tested at significant levels of 5% as described by Gomez and Gomez [15].

RESULTS

Tuber Weight Loss %: The results in Table 1 showed that, tuber weight losses gradually increase with the extended storage periods from 1 day to 21 days. The extended of cold storage period to 21 days resulted in higher increase in tuber weight losses (11.66 and 11.89%) compared with the initial time (0.00 and 0.00 %) in both seasons, respectively.

The data also revealed that all pre-harvest treatments reduced tuber weight losses during cold storage compared to the control treatment in both seasons. Garlic extract at 2000 ppm resulted in the highest significantly reduce in tuber weight losses (6.95 and 7.25%) followed by Cycocel at 50 ppm (7.38 and 7.70%) then 5 ppm of benzyladenine acid (8.08 and 8.43%) and 50 ppm of gibberellic acid (8.29 and 8.65%) compared with control (11.55 and 12.04%) in both seasons, respectively (Table 1).

Garlic extract seemed to excellent treatment to extend tuber shelf life for one week at room condition after cold storage where it showed the lowest tuber weight losses at shelf life (7.99 and 8.34 %) followed by 50 ppm of Cycocel (8.49 and 8.86%) then 5 ppm of benzyladenine acid (9.29 and 9.69%) in the first and second seasons, respectively.

Tuber Decay %: The presented data in Table 2 confirmed that, tuber decay % increased with the extended storage periods from the initial time of cold storage to 21 days. The extended of cold storage period to 21 days resulted in a large increase in tuber decay % (11.66 and 11.89%) compared with the initial time, 7 and 14 days in both seasons, respectively.

The results showed that all pre-harvest treatments reduced tuber decay % during cold storage compared to the control treatment in both seasons. Garlic extract at 2000 ppm gave the lowest tuber decay % (4.03 and 4.19%) followed by Cycocel at 50 ppm (4.27 and 4.44%) then 5 ppm of benzyladenine acid (4.58 and 4.77%) compared with control (6.57 and 6.84%) in both seasons, respectively (Table 2).

The previous treatments seemed to excellent treatment to extend tuber shelf life for one week at room condition after cold storage where garlic extract showed the lowest tuber decay % at shelf life (4.51 and 4.69 %) followed by 50 ppm of Cycocel (4.78 and 4.98%) then 5 ppm of benzyladenine acid (5.13 and 5.34%) in the first and second seasons, respectively.

Visual Appearance (Score): The data are shown in Table 3 revealed that, tuber visual appearance gradually decreased with the extended storage periods from the initial time to 21 days. The extended of cold storage period to 21 days resulted in a large decrease in tuber Visual appearance (5.75 and 5.98) compared with the initial time (9.00 and 9.00) in both seasons, respectively.

The data in Table 3 also revealed that all pre-harvest treatments increase tuber Visual appearance during cold storage compared to the control treatment in both seasons. Garlic extract at 2000 ppm resulted in the highest significantly tuber Visual appearance (6.93 and 7.28) followed by cycocel at 50 ppm (6.71 and 7.05) then 30 ppm of salicylic acid (6.59 and 6.92) compared with control (5.48 and 5.75) in both seasons, respectively.

Garlic extract seemed to excellent treatment to extend tuber shelf life for one week at room condition after cold storage where it showed the highest tuber Visual appearance at shelf life (5.63 and 5.91) followed by 50 ppm of cycocel (5.45 and 5.72) then 30 ppm of salicylic acid (5.35 and 5.62) in the first and second seasons, respectively.

Tuber Content of Total Sugar: The presented data in Table 4 confirmed that, tuber content of total sugar gradually decreased with the extended storage periods from the initial time to 21 days of cold storage. The extended of cold storage period to 21 days resulted in a large decreased in tuber content of total sugar (2.86 and 2.78 mg/100g fw) compared with the initial time, 7 and 14 days in both seasons, respectively.

The results in Table 4 showed that all pre-harvest treatments delayed the change in tuber content of total sugar during cold storage compared to the control treatment in both seasons. Selenium at 10 ppm gave the highest tuber content of total sugar (4.63 and 4.89 mg/100g fw) compared with control (2.57 and 2.42 mg/100g fw) in both seasons, respectively.

Table 1: Effect of foliar spray with some pre-harvest treatments on Jerusalem artichoke tuber weight loss % under cold storage during 2018 and 2019 seasons

	Weight loss %					
	Storage period					
Treatments	0 day	7 days	14 days	21 days	Treatment mean	1 week at room condition
			1st season			
Control (tap water)	0.00	8.03 a	10.97 a	15.65 a	11.55 A	14.67 A
Foliar spray Se 10 ppm	0.00	6.91 b	10.21 ab	12.96 b	10.02 B	12.73 B
SiO2 2000 ppm	0.00	6.69 b	9.90 b	12.56 b	9.71 B	12.34 BC
Salicylic acid 30 ppm	0.00	5.54 cd	8.67 c	11.27 c	8.49 C	9.76 CD
GA3 50 ppm	0.00	5.40 cd	8.46 cd	11.00 c	8.29 CD	9.53 CD
BA 5 ppm	0.00	5.71 c	7.93 d	10.60 cd	8.08 CD	9.29 DE
CCC 50 ppm	0.00	4.77 d	7.54 de	9.83 d	7.38 DE	8.49 EF
Garlic extract 2000 ppm	0.00	4.63 d	6.80 e	9.43 d	6.95 E	7.99 F
Period mean	0.00 D	5.96 C	8.81 B	11.66 A		
			2nd season			
Control (tap water)	0.00	8.43 a	11.74 a	15.96 a	12.04 A	15.30 A
Foliar spray Se 10 ppm	0.00	7.25 b	10.93 ab	13.22 b	10.46 B	13.29 B
SiO2 2000 ppm	0.00	7.03 b	10.59 b	12.81 b	10.14 B	12.88 B
Salicylic acid 30 ppm	0.00	5.81 cd	9.27 c	11.49 c	8.86 C	10.19 C
GA3 50 ppm	0.00	5.67 cd	9.05 cd	11.22 c	8.65 CD	9.94 D
BA 5 ppm	0.00	6.00 c	8.48 cd	10.81cd	8.43 CD	9.69 DE
CCC 50 ppm	0.00	5.01 d	8.06 de	10.03 de	7.70 DE	8.86 EF
Garlic extract 2000 ppm	0.00	4.86 d	7.27 e	9.62 e	7.25 E	8.34 F
Period mean	0.00 D	6.26 C	9.42 B	11.89 A		

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Table 2: Effect of foliar spray with some pre-harvest treatments on Jerusalem artichoke tuber decay % under cold storage during 2018 and 2019 seasons

	Decay %					
	Storage period					
Treatments	0 day	7 days	14 days	21 days	Treatment mean	1 week at room condition
			1st season			
Control (tap water)	0.00	3.94 a	5.81 a	9.97 a	6.57 A	7.89 A
Foliar spray Se 10 ppm	0.00	3.39 b	5.40 ab	8.25 b	5.68 B	6.82 B
SiO2 2000 ppm	0.00	3.28 b	5.24 b	8.00 b	5.50 B	6.61 B
Salicylic acid 30 ppm	0.00	2.71 c	4.59 c	7.18 c	4.83 C	5.40 C
GA3 50 ppm	0.00	2.89 c	4.48 c	7.01 cd	4.79 C	5.36 C
BA 5 ppm	0.00	2.80 cd	4.19 cd	6.75 d	4.58 CD	5.13 CD
CCC 50 ppm	0.00	2.55 d	3.99 de	6.26 e	4.27 DE	4.78 DE
Garlic extract 2000 ppm	0.00	2.47 d	3.60 e	6.01 e	4.03 E	4.51 E
Period mean	0.00 D	3.00 C	4.66 B	7.43 A		
			2nd season			
Control (tap water)	0.00	4.13 a	6.21 a	10.17 a	6.84 A	8.21 A
Foliar spray Se 10 ppm	0.00	3.55 b	5.78 ab	8.42 b	5.92 B	7.11 B
SiO2 2000 ppm	0.00	3.44 b	5.60 b	8.16 b	5.73 B	6.89 B
Salicylic acid 30 ppm	0.00	2.85 d	4.91 c	7.32 c	5.03 C	6.04 C
GA3 50 ppm	0.00	2.78 d	4.79 cd	7.15 c	4.90 C	5.49 CD
BA 5 ppm	0.00	2.94 cd	4.49 cd	6.88 cd	4.77 CD	5.34 DE
CCC 50 ppm	0.00	2.68 d	4.27 de	6.39 de	4.44 CD	4.98 EF
Garlic extract 2000 ppm	0.00	2.60 d	3.85 e	6.13 e	4.19 D	4.69 F
Period mean	0.00 D	3.12 C	4.99 B	7.58 A		

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Table 3: Effect of foliar spray with some pre-harvest treatments on Jerusalem Artichoke tuber Visual appearance (score) under cold storage during 2018 and 2019 seasons

	Visual appearance (score)					
	Storage period					
Treatments	0 day	7 days	14 days	21 days	Treatment mean	1 week at room condition
			1st season			
Control (tap water)	9.00	6.02 e	5.48 e	4.93 e	5.48 E	4.45 e
Foliar spray Se 10 ppm	9.00	6.77 d	6.16 d	5.54 d	6.16 D	5.00 d
SiO2 2000 ppm	9.00	7.15 bc	6.51 bc	5.86 bc	6.51 BC	5.28 bc
Salicylic acid 30 ppm	9.00	7.25 bc	6.60 bc	5.94 b	6.59AB	5.35 bc
GA3 50 ppm	9.00	6.98 cd	6.36 cd	5.72 cd	6.35 CD	5.16 cd
BA 5 ppm	9.00	7.01 cd	6.38 cd	5.74 c	6.37 BC	5.18 cd
CCC 50 ppm	9.00	7.38 ab	6.71 ab	6.04 b	6.71 AB	5.45 ab
Garlic extract 2000 ppm	9.00	7.62 a	6.93 a	6.24 a	6.93 A	5.63 a
Period mean	9.00 A	7.02 B	6.39 C	5.75 D		
			2nd season			
Control (tap water)	9.00	6.33 e	5.76 e	5.18 e	5.75 G	4.67 f
Foliar spray Se 10 ppm	9.00	7.11d	6.47 d	5.82 d	6.47 E	5.25 d
SiO2 2000 ppm	9.00	7.51 cd	6.83 cd	6.15 cd	6.83 CD	5.55 bc
Salicylic acid 30 ppm	9.00	7.61 bc	6.92 bc	6.23 bc	6.92 BC	5.62 bc
GA3 50 ppm	9.00	6.72 bc	6.12 bc	5.51 bc	6.11 F	4.97 e
BA 5 ppm	9.00	7.36 d	6.70 d	6.03 d	6.69 D	5.44 cd
CCC 50 ppm	9.00	7.75 b	7.05 b	6.34 b	7.05 B	5.72 ab
Garlic extract 2000 ppm	9.00	8.00 a	7.28 a	6.55 a	7.28 A	5.91 a
Period mean	9.00 A	7.30 B	6.64 C	5.98 D		

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Table 4: Effect of foliar spray with some pre-harvest treatments on Jerusalem artichoke tuber content of total sugar (mg/100g) under cold storage during 2018 and 2019 seasons

	Total sugar content (mg/100g)					
	Storage period					
Treatments	0 day	7 days	14 days	21 days	Treatment mean	1 week at room condition
			1st season			
Control (tap water)	3.35 d	2.85 e	2.31 d	1.78 e	2.57 E	1.50 D
Foliar spray Se 10 ppm	6.03 a	5.13 a	4.15 a	3.20 a	4.63 A	2.20 A
SiO2 2000 ppm	5.84 ab	4.97 a	4.02 a	3.10 ab	4.48AB	2.14 AB
Salicylic acid 30 ppm	5.71 b	4.85 bc	3.93 ab	3.03 bc	4.38 BC	2.09 BC
GA3 50 ppm	5.59 b	4.75 c	3.85 b	2.96c	4.29 C	2.04 C
BA 5 ppm	5.86 ab	4.98 ab	4.04 a	3.11 ab	4.50 AB	2.14 AB
CCC 50 ppm	4.98 c	4.24 d	3.43 c	2.64 d	3.82 D	2.23 A
Garlic extract 2000 ppm	5.79 b	4.92 a	3.98 ab	3.07 b	4.44BC	2.11 B
Period mean	5.39 A	4.59 B	3.71 C	2.86 D		
			2nd season			
Control (tap water)	3.15 g	2.68 g	2.17 g	1.67 g	2.42 G	1.41 E
Foliar spray Se 10 ppm	6.38 a	5.42 a	4.39 a	3.38 a	4.89 A	2.33 A
SiO2 2000 ppm	5.61 cd	4.77 cd	3.86 cd	2.97 cd	4.30 CD	2.05 BC
Salicylic acid 30 ppm	5.39 de	4.58 de	3.71 de	2.86 de	4.13 DE	1.97 CD
GA3 50 ppm	5.16 e	4.38 e	3.55 e	2.73 e	3.96 E	1.88 D
BA 5 ppm	5.88 bc	5.00 bc	4.05 bc	3.12 bc	4.51 BC	2.15 B
CCC 50 ppm	4.35 f	3.70 f	3.00 f	2.31 f	3.34 F	1.95 CD
Garlic extract 2000 ppm	6.03 b	5.13 b	4.16 b	3.20 b	4.63 AB	2.21 AB
Period mean	5.25 A	4.46 B	3.61 C	2.78 D		

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Table 5: Effect of foliar spray with some pre-harvest treatments on Jerusalem artichoke tuber content of Inulin (g/100g) under cold storage during 2018 and 2019 seasons

	Inulin content (g/100g fw.)					
	Storage period					
Treatments	0 day	7 days	14 days	21 days	Treatment mean	1 week at room condition
			1st season			
Control (tap water)	6.70	5.70 f	4.61 e	3.55 d	5.14 E	3.24 D
Foliar spray Se 10 ppm	18.39 a	16.55 a	14.90 a	12.66 a	15.63 A	8.82 A
SiO2 2000 ppm	17.83 ab	16.04 ab	14.44 ab	12.27 ab	15.15 BC	8.55 A
Salicylic acid 30 ppm	17.41 bc	15.67 cd	14.10 bc	11.99 ab	14.79 C	8.35 AB
GA3 50 ppm	17.04 c	15.33 d	13.80 c	11.73 b	14.48 C	8.17 B
BA 5 ppm	17.88 ab	16.09 ab	14.48 ab	12.31 ab	15.19 BC	8.58 A
CCC 50 ppm	9.97 d	8.47 e	6.86 d	5.28 c	7.65 D	4.81 C
Garlic extract 2000 ppm	17.65 b	15.88 bc	14.30 abc	12.15 ab	14.99 AB	8.47 A
Period mean	15.36 A	13.72 B	12.19 C	10.24 D		
			2nd season			
Control (tap water)	6.31 g	5.36 g	4.34 g	3.35 g	4.84 G	3.05 E
Foliar spray Se 10 ppm	19.45 a	17.51 a	15.76 a	13.39 a	16.53 A	9.33 A
SiO2 2000 ppm	17.11 cd	15.40 cd	13.86 cd	11.78 cd	14.54 CD	8.21 BC
Salicylic acid 30 ppm	16.44 de	14.79 de	13.31 de	11.32 de	13.97 DE	7.89 C
GA3 50 ppm	15.73 e	14.16 e	12.74 e	10.83 e	13.36 E	7.54 C
BA 5 ppm	17.94 bc	16.14 bc	14.53 bc	12.35 bc	15.24 BC	8.60 AB
CCC 50 ppm	8.71 f	7.40 f	6.00 f	4.62 f	6.68 F	4.20 D
Garlic extract 2000 ppm	18.41 b	16.57 b	14.91 b	12.67 ab	15.64 B	8.83 AB
Period mean	15.01 A	13.42 B	11.93 C	10.04 D		

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Table 6: Effect of foliar spray with some pre-harvest treatments on *Rhizoctonia solani* Disease incidence % and reduction % during cold storage in 2018 and 2019 seasons

	Rhizoctonia solani											
	Storage period											
	0 day		7 days		14 days		21 days		Mean		1 week at room condition	
Treatments	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %
							1st season					
Control (tap water)	14.69 a		16.45 a		19.41 a		23.87 a		18.60 A		27.93A	
Foliar spray Se 10 ppm	7.60 b	48.27 f	8.28 b	49.65 f	9.19 b	52.64 f	10.66 b	55.33 f	8.93 B	51.98 E	12.69 B	54.57 E
SiO2 2000 ppm	7.11 bc	51.56 e	7.65 b	53.50 e	8.27 b	57.36 e	9.43 c	60.48 e	8.12 B	56.37 D	11.32 C	59.47 D
Salicylic acid 30 ppm	6.28 cd	57.25 d	6.69 c	59.32 d	7.13 c	63.28 d	7.91 d	66.86 d	7.00 C	62.36 C	9.57 D	65.73 C
GA3 50 ppm	6.14 d	58.19 cd	6.46 cd	60.73 cd	6.85 cd	64.69 cd	7.54 d	68.42 cd	6.75 CD	63.73 B	9.27 D	66.80 C
BA 5 ppm	5.86 d	60.12 c	6.14 cd	62.69 c	6.49 cd	66.58 c	7.11 de	70.22 bc	6.40 CD	65.61 B	8.25 E	70.47 B
CCC 50 ppm	5.41 de	63.16 b	5.63 de	65.76b	5.92 de	69.50 b	6.50 ef	72.77 ab	5.86 DE	68.47 A	7.99 EF	71.38 B
Garlic extract 2000 ppm	4.79 e	67.37 a	4.98 e	69.73a	5.22 e	73.11a	5.84 f	75.52a	5.21 E	72.00 A	7.01 F	74.89 A
Period mean	7.23 C	*57.99 D*	7.78 BC	*60.20C*	8.56 B	*63.88B*	9.86 A	*67.09 A*				
							2nd season					
Control (tap water)	13.84 a		15.50 a		18.29 a		22.49 a		17.53 A		26.32 A	
Foliar spray Se 10 ppm	7.92 b	42.78 f	8.63 b	44.31 f	9.58 b	47.62 e	11.11 b	50.60 f	9.31 B	46.89 F	13.22 B	49.75 F
SiO2 2000 ppm	7.41 bc	46.42 e	7.97 bc	48.58 e	8.62 b	52.85 d	9.83 c	56.30 e	8.46 B	51.74 E	11.80 C	55.18 E
Salicylic acid 30 ppm	6.54 cd	52.76 d	6.97 cd	55.03 d	7.42 c	59.42 c	8.24 d	63.38 d	7.29 C	58.40 D	9.97 D	62.12 D
GA3 50 ppm	6.28 d	54.59 cd	6.61 de	57.35 cd	7.01 cd	61.65 bc	7.71 de	65.71 cd	6.91 CD	60.61 CD	9.49 DE	63.95 CD
BA 5 ppm	6.09 d	55.98 c	6.38 de	58.81 c	6.75 cd	63.11 b	7.40de	67.13 bc	6.65 CD	62.04 BC	8.58 EF	67.41 BC
CCC 50 ppm	5.64 de	59.22 b	5.87 ef	62.09 b	6.17 de	66.24 b	6.78 e	69.86 b	6.12 DE	65.10 B	8.34 F	68.32 B
Garlic extract 2000 ppm	4.98 e	63.98 a	5.18 f	66.59 a	5.43 e	70.32 a	6.08 e	72.98 a	5.42 E	69.10 A	7.29 G	72.29 A
Period mean	7.34 C	*53.68 D*	7.89 C	*56.11 C*	8.66 B	*60.17 B*	9.96 A	*63.71 A*				

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Table 7: Effect of foliar spray with some pre-harvest treatments on *Microphonina solani* disease incidence % and reduction % during cold storage in 2018 and 2019 seasons.

	Microphonina solani											
	Storage period											
	0 day		7 days		14 days		21 days		Mean		1 week at room condition	
Treatments	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %	Disease incidence %	Reduction %
							1st season					
Control (tap water)	10.79 a		12.09 a		14.26 a		17.54 a		13.67 A		20.52 A	
Foliar spray Se 10 ppm	7.70 b	28.60 e	8.40 b	30.52 e	9.32 b	34.64 e	10.81 b	38.36 d	9.06 B	33.73 E	12.87 B	37.31 E
SiO2 2000 ppm	6.08 c	43.65 c	6.54 c	45.92 c	7.07 c	50.41 c	8.06 c	54.04 c	6.94 C	49.25 C	9.67 C	52.86 C
Salicylic acid 30 ppm	6.28 c	41.82 c	6.69 c	44.63 c	7.13 c	50.03 c	7.91 c	54.90 c	7.00 C	48.78 C	9.57 C	53.36 C
GA3 50 ppm	6.82 bc	36.83 d	7.17 c	40.67 d	7.61 c	46.65 d	8.37 c	52.29 c	7.49 C	45.20 D	10.29 C	49.84 D
BA 5 ppm	4.54 d	57.95 b	4.76 d	60.65 ab	5.03 d	64.75 b	5.51 d	68.59 b	4.96 D	63.74 B	6.39 D	68.86 B
CCC 50 ppm	4.61 d	57.29 b	4.80 d	60.31 b	5.04 d	64.65 b	5.54 d	68.44 b	5.00 D	63.46 B	6.81 D	66.82 B
Garlic extract 2000 ppm	3.25 e	69.92 a	3.37 e	72.10 a	3.53 e	75.22 a	3.96 e	77.44 a	3.53 E	74.20 A	4.75 E	76.86 A
Period mean	6.26 C	*48.01 D*	6.73 BC	*50.69 C*	7.37 B	*55.19 B*	8.46 A	*59.15 A*				
							2nd season					
Control (tap water)	8.92 a		9.99 a		11.79 a		14.50 a		11.30 A		16.97 A	
Foliar spray Se 10 ppm	7.35 b	17.60 g	8.01 b	19.81 g	8.89 b	24.56 f	10.32 b	28.86 E	8.64 B	23.52 G	12.28 B	27.64 F
SiO2 2000 ppm	6.96 b	22.00 f	7.48 c	25.13 f	8.09 bc	31.35 e	9.23 c	36.37 D	7.94 BC	29.74 F	11.07 C	34.74 E
Salicylic acid 30 ppm	6.54 bc	26.72 e	6.97 cd	30.25 e	7.42 c	37.05 d	8.24 d	43.19 C	7.29 C	35.48 E	9.97 D	41.25 D
GA3 50 ppm	5.43 d	39.10 c	5.71 e	42.80 c	6.06 d	48.57 c	6.67 e	54.01 B	5.97 D	47.17 C	8.20 E	51.65 C
BA 5 ppm	5.75 cd	35.50 d	6.03 de	39.65 d	6.37 d	45.94 c	6.99 e	51.83 B	6.29 D	44.38 D	8.10 E	52.24 C
CCC 50 ppm	4.34 e	51.30 b	4.52 f	54.74 b	4.75 e	59.69 b	5.22 f	64.01 B	4.71 E	58.33 B	6.42 F	62.17 B
Garlic extract 2000 ppm	2.86 f	67.93 a	2.97 g	70.25 a	3.12 f	73.58 a	3.49 g	75.94 A	3.11 F	72.48 A	4.19 G	75.32 A
Period mean	6.02 C	*37.16 D*	6.46 BC	*40.37 C*	7.06 B	*45.82 B*	8.08 A	*50.60 A*				

Means within each column followed by the same letter are not significantly different at normal probability level 0.05 (Duncan's range test)

Selenium seemed to excellent treatment to extend tuber shelf life for one week at room condition after cold storage where it showed the highest tuber content of total sugar at shelf life (2.20 and 2.33mg/100g fw) in the first and second seasons, respectively.

Tuber Content of Inulin: The presented data in Table 5 confirmed that, tuber content of inulin gradually decreased with the extended storage periods from the initial time to 21 days of cold storage. The extended of cold storage period to 21 days resulted in a large decreased in tuber content of inulin (10.24 and 10.04 g/100g fw) compared with the initial time (15.36 and 15.01g/100g fw) in both seasons, respectively.

The results in Table 5 showed that all pre-harvest treatments delayed the change in tuber content of inulin during cold storage compared to the control treatment in both seasons. Selenium at 10 ppm gave the highest tuber content of inulin (15.63 and 16.53 g/100g fw) followed by benzyladenine (15.19 and 15.24 g/100g fw) compared with control (5.14 and 4.84 g/100g fw) in both seasons, respectively.

Selenium and benzyladenine seemed to excellent treatments to extend tuber shelf life for one week at room condition after cold storage where it showed the highest tuber content of inulin in the first and second seasons.

Effect of Some Foliar Spray Treatments on *Rhizoctonia solani* And *Microphonina solani* Disease Incidence % and Reduction % Measured on Jerusalem Artichoke Tubers During Cold Storage.

***Rhizoctonia solani*:** The result in Table 6 indicated that tuber infesting with *Rhizoctonia solani* increased with the extended of cold storage period. The cold storage of tuber to 21 days showed the highest disease incidence (9.86 and 9.96%) compared to the initial time (7.23 and 7.34%) in both seasons respectively.

The results in Table 6 revealed that all pre-harvest treatments resulted in significantly reduce *Rhizoctonia solani* disease incidence during the two studied seasons compared with the control treatment. Jerusalem artichoke plants sprayed 2000 ppm of garlic extract showed the lowest disease incidence of *Rhizoctonia solani* (5.21 and 5.42%) with reduction percentages of 72.00 and 69.10% in both seasons, respectively. Also, sprayed 50 ppm of sycoccil resulted in a great reduce in the disease incidence of *Rhizoctonia solani* (5.86 and 6.12%) with reduction ratios of 68.47 and 65.10% in both seasons respectively.

Garlic extract also extended tuber shelf life where it showed the lowest disease incidence (7.01 and 7.29%) and the highest reduction percentages (74.89 and 72.29%) followed by cycocel with disease incidence of 7.99 and 8.34% and reduction ratios of 71.38 and 68.32 % at room condition in both seasons, respectively.

***Microphonina solani*:** The result in Table 7 indicated that tuber infesting with *Microphonina solani* increased with the extended of cold storage period. The cold storage of tuber to 21 days showed the highest disease incidence (8.46 and 8.08%) compared to the initial time (6.26 and 6.02%) in both seasons respectively.

The results in Table 7 revealed that all pre-harvest treatments resulted in significantly reduce *Microphonina solani* disease incidence during the two studied seasons compared with the control treatment. Jerusalem artichoke plants sprayed 2000 ppm of garlic extract showed the lowest disease incidence of *Microphonina solani* (3.53 and 3.11%) with reduction percentages of 74.20 and 72.48% in both seasons, respectively. Also, sprayed 50 ppm of sycoccil resulted in a great reduce in the disease incidence of *Microphonina solani* (5.00 and 4.71%) with reduction ratios of 63.46 and 58.33% in both seasons respectively.

Garlic extract also extended tuber shelf life where it showed the lowest disease incidence (4.75 and 4.19%) and the highest reduction percentages (76.86 and 75.32%) followed by cycocel with disease incidence of 6.81 and 6.42% and reduction ratios of 66.82 and 62.17 % at room condition in both seasons, respectively.

DISCUSSION

Cold Storage Period Effect in Jerusalem Artichoke Tubers Quality: Under the cold storage condition several chemical and physical changes will be appear in tuber with the extended of the storage period. In this study the extended of the storage period to 21 day resulted in significantly increase in tuber weight loss, tuber decay % and tuber infection with *R. solani* and *M. solani*. In the contrast of this large decrease in tuber visual appearance, tuber content of total sugar and inulin were shown with the extended of the cold storage period up to 21 days. Similar findings were obtained before by Danilèenko *et al.* [16], Attia and Alian [17] and Rashed *et al.* [18] who indicated that weight loss percentage of Jerusalem artichoke tubers increase with the extended of storage period. The decay of tubers during storage reaches their peak with the extended storage period up to 21 days and this may due the high respiration rate, microbiological load, the activity of different enzymes and biochemical changes in tubers during storage period. This increase in tuber decay make tuber very easy to penetrate by several fungi and Bactria [18]. El- Sharkawy *et al.* [19] Kader, [20] and Attia and Alian [17] who revealed that that the extended of the storage period of Jerusalem artichoke under 2ºC resulted in high reduce in visual appearance.

Saengthobpinit and Sajjaanantakul [6] revealed that most biochemical parameters reduced under low temperature. Also, the degradation rate of carbohydrates in Jerusalem artichoke tubers increase with the extended of storage period and associated with a large decrease in protein percentage of Jerusalem artichoke tubers [21]. In this study Inulin content gradually decreased with the extended of the storage and this may related to the continues metabolism in tuber under low temperature and led to the breakdown of inulin into short chain through the partial enzymatic hydrolysis that degrades it into lower DP frictions, sucrose, glucose and fructose period as the vision of Cabezas *et al.* [22]; Attia and Alian [17]; Rubel *et al.* [23]; Ghoneem *et al.* [21] and Rashed *et al.* [18].

Effect Pre-Harvest Treatments in Jerusalem Artichoke Tubers Quality During Cold Storage Period: The results in this study indicated that all pre-harvest treatments delayed chemical and physical changes on Jerusalem artichoke tubers during the cold storage period. Also the results revealed that garlic extract seemed to be excellent treatment to extend the marketable values and shelf life of Jerusalem artichoke under cold storage where it showed the highest reduce tuber weight loss, tuber decay percentage and delayed the change in tuber visual appearance as well as the same treatment gave the highest reduce of tuber infection by *R. solani and M. solani*. The essential plants such as clove and garlic generally content of some components such as eugenol which had a strong inhibitors of enzyme processes and produce compounds as methyle- or actyl eugenol could change this property. Eugenol components had antimicrobial activity so this oil can be attributed to the presence of an aromatic nucleus and a phenolic OH group that are known to be reactive and can form hydrogen bonds with-SH group in the active sites of target enzymes, resulting in deactivation of enzymes in fungi [10, 11]. Similar results were obtained before by El-Shayeb [24] who indicated that, garlic content a large amount of antioxidant phytochemicals that include organo sulfur compounds and flavonoids such as allixin, which release some free radicals which had a positive effect in yield and defense against diseases. Additionally, stimulation of the antioxidant enzymes such as superoxide dismutase (SOD) and peroxidase (POD) which are defense enzymes against many diseases. These enzymes also are antioxidant agents reduce the production of H2O2 and reduced the loss of weight and tuber decay.

In this study the pre-harvest application with selenium delayed the decrease in total sugar and inulin

contents in tuber and this almost due to Selenium (Se) is closely related to enhancing antioxidant activity, that protect plants from fungal diseases which destroy sugar and carbohydrate by feeding at them [8]. Kong *et al.* [25] indicated that Se is an antioxidant increase plants growth and strengthen the capacity of plants to resist the oxidative stress caused by reactive oxygen species produced by internal biochemical reactions and external factors. Turakainen *et al.* [26] reported Se increases the allocation of phytosimulates to grow tubers and enhance carbohydrates and selenium accumulation. They also attributed the positive effect of selenium on potatoes to the antioxidant effects of selenium on the plant's aging delay. They reported that selenium fertilization could improve the nutritional value of potato by increasing the level of organic compounds containing selenium in the tubers.

Our study also showed that all growth regulators and silicon delayed physical and chemical changes in tubers compared to control. These findings are in harmony with those obtained before by; Moussa and Shama [27] who revealed that, spraying potato plants with potassium silicate solution had significant positive effects on both tubers' quality characteristics (dry matter, total sugars and starch percentages) and estimated element concentrations (N, K and Si) in leaves and tubers.

As for growth regulators Sultan *et al.* [7] showed that postharvest treatments with antioxidants specially SA decrease the respiration rate and weight losses, maintained higher levels of fruit firmness and delayed the incidence of fungal diseases. Also, Ahmad *et al.* [28] found in sweet oranges that chilling injury was significantly reduced at 8mM and 9mM treatments. Maintained contents of SSC, TA, individual sugars and organic acids in treated fruit with higher doses after 93 confirmed preliminary findings such as SA has anti-senescent effect. Alexopoulos *et al.* [29] reported that the late application of GA3induced a high percentage of sprouted tubers prior to harvest and significantly extended the physiological age of the tubers, as reflected by an increased rate of respiration, sprouting and weight loss after harvest.

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