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Effect of Hydrogen Peroxide and Fumaric Acid Treatments on Quality of Jerusalem Artichoke (*Helianthus tuberosus* L.) Tubers during Cold Storage

[1]Abdullah, M. A. A., A. M. Mounir [2] and Huda A. Ibrahim [3]

[1]Vegetable Handling Dept., Horticulture Research Institute, Agriculture Research Center, Giza, Egypt.
[2]Natural Products Dept., National Center for Radiation Research and Technology, Nasr City, Cairo, Egypt.
[3]Vegetable Research Dept., Agricultural and Biological Research Division, National Research Center, Dokki, Giza, Egypt.

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ABSTRACT

This study was carried out at private farm, El-Sharkia Governorate, Egypt on Jerusalem artichoke cv. Fuseau during 2015 and 2016 seasons to study the effect of hydrogen peroxide (H_2O_2) at 5 % or 10% and fumaric acid at 5 % or 10% on maintaining tuber quality during cold storage at 5˚C and relative humidity 90-95% for 100 days. Results showed that dipping tubers in 5% hydrogen peroxide reduced tubers decay and maintained tubers total sugars, carbohydrates and inulin content. Furthermore, this treatment led to a significant decrease in polyphenol oxidase activity and gave tubers with good appearance without decay till 80 days of storage at 5˚C followed by dipping in 5% fumaric acid which gave good appearance after 60 days of storage, while, untreated tubers (control) had the poorest appearance at the end of storage period (100 days).

Key words: Jerusalem artichoke, hydrogen peroxide, fumaric acid

Introduction

Jerusalem artichoke or Girasol (*Helianthus tuberosus* L.) is one of the non-traditional crops of the family Asteraceae, originates from North America but did not specify exactly its home land (Ben Chekroun *et al.,* 1994). Its tubers are considered one of the richest vegetable crop in sugars especially inulin which makes it useful in pharmaceuticals industry (Ben Chekroun *et al*., 1994), tubers also contain dietary fibers, cellulose and lignin, pectin and hemicelluloses (Cieslik *et al*., 2005). Jerusalem artichoke face some problems during storage such as tubers shriveling, whereas its tubers have a thin layer of peel which increases water loss through transpiration (Saengthobpinit and Sajjaanantakul, 2005). Also during storage several pathogens led to tubers rotting which differ in their effect (Kays and Nottingham 2008). Sometimes the infection started in field after harvesting, when plant defense is going down which increase the economic loss during storage (Jin *et al*. 2013).

Controlling tubers storage disease may be started at harvesting time, through decreasing mechanical damage which diminish the probability of fungus infection, another method is keeping tubers under the soil provided that this area is under the cold climate region, but even so some pathogen may attack the tubers and increase the chance of infestation. Although the cold storage is the appropriate method to increase tuber storability although some fungi can still grow under low temperature and infect tubers (Tesio *et al*. 2011). One of the effective method in controlling rot disease and decay of tubers during cold storage is safe chemical compounds for human health i.e. hydrogen peroxide and fumaric acid.

Fumaric acid is one of the organic acids which was used as a food additive to preserve human nourishment against bacterial pathogens (Comes and Beelman, 2002; Liao *et al*. 2008; Chun and Song 2014), and used as antibacterial in fresh cut lettuce and apple cider (Chikthimmah *et al*. 2005), furthermore, Kim *et al*., (2007) found that the total count of yeast and mold was diminished when broccoli sprouts were treated with fumaric acid.

Hydrogen peroxide is an environmental safe compound whose activity is based on oxidation of fungi and bacteria, and it was successfully used to control vegetable pathogens during storage (Afek *et al.* 2000) and (Simmons *et al.,* 1997). Also, H_2O_2 acts as signaling molecule in plant, it is a

Corresponding Author: Abdullah, M. A. A., Vegetable Handling Dept., Horticulture Research Institute, Agriculture Research Center, Giza, Egypt. E-mail: mohmedabdalla80@yahoo.com

form of reactive oxygen species (ROS) generated as a result of oxidative stress tolerance. Oxidative stress arises from an imbalance in the generation and metabolism of ROS (such as H_2O_2) being produced than are metabolized. H_2O_2 is generated via super oxide, presumably in non-controlled manner, during electron transport processes such as photosynthesis and mitochondrial respiration (Neill *et al*., 2002 and Mermelstein, 2001). Therefore, using H_2O_2 as an alternative to chemical materials for disinfecting fresh-cut or whole fruits and vegetables appeared to reduce microbial populations on fresh products and extend the shelf life without leaving significant residues or causing loss of quality (Sapers *et al*., 2001; Sapers and Simmons 1998). In this concern, (Ukuku *et al*., 2005 and Ukuku *et al*., 2004) found that H_2O_2 treatments of whole and fresh-cut cantaloupe and honeydew melons resulted in significant improving general appearance of fruits, extended fruit shelf life and highly reduction of *Salmonella spp*. population on surface of cantaloupe and melon fruits. Moreover, Bhagwat (2006) showed that, shelf life of melon fruits (fresh-cut) treated with H_2O_2 was extended by 4 to 5 days compared to that of chlorine-treated melons. On fresh cut-tomato, Kim *et al.* (2007) investigated the effect of H_2O_2 treatments on nutritional quality during storage in fridge. They found that vitamin C content was decreased after 1 day from H_2O_2 treatment; however it increased directly after 7 days especially with the rate of 0.2 and 0.4 mM H_2O_2 compared to control (untreated fruits).

Thus the aim of this study was to investigate the effect of hydrogen peroxide and fumaric acid on the physical and chemical characteristics of Jerusalem artichoke tubers during cold storage.

Materials and Methods

This study was carried out at private farm, El-Sharkia Governorate, Egypt on Jerusalem artichoke cv. Fuseau during 2015 and 2016 seasons. Tubers were harvested on January 3rd and 15th in the first and second season respectively, then transported immediately to the Vegetable Handling Department and kept overnight at 5˚C with 90-95% relative humidity. The following morning, tubers were carefully selected, free of visual damage or defects, washed initially with water, then air dried. Tubers were divided into five groups for the following treatments

dipping for 5 minutes in a 5% or 10% solution of hydrogen peroxide (H_2O_2), solution of 5% and 10 of % fumaric acid plus dipping in tap water as control (untreated tubers).

Jerusalem artichoke tubers were placed in boxes for each treatment and arranged in a complete randomized design and stored at 5˚C and 90-95% relative humidity for 100 days. Samples were collected immediately after the dipping treatment and every twenty days intervals.

Measured Parameters:-

General appearance: it was determined as score system of excellent > 9, good > 7 to 8.9, fair > 5 to 6.9, poor > 3 to 4.9, and unassailable > 2.9. The scale depends on morphological defects such as shriveling, fresh appearance, color change of tubers and decay. Tubers rating (5) or below considered unmarketable (Watada and Morris, 1996; Jimenez *et al*., 1998).
Decay: it was determined as score system of 1= none, 2= slight, 3= moderate, 4= moderately severe, 5= severe. This depends on decay percentage on fruits (Watada and Morris, 1996; Jimenez *et al*., 1998).
Total sugars: was determined via the method mentioned by A.O.A.C., (1990).
Total Carbohydrates content: was determined via the method mentioned by A.O.A.C., (1990).
Inulin content: was determined via the method mentioned by A.O.A.C., (1990).
Polyphenol oxidase (PPO): was extracted by homogenizing fruit samples with 5 fold of their weight sodium phosphate buffer (0.1 m, pH 6.5) containing 30 mM sodium ascorbate and 0.4 mM sucrose at 25°C. The homogenated tuber was then centrifuged at 10000 ×g for 15 min. Supernatant was collected and stored at 4°C. Catechol was dissolved in the phosphate buffer (10 mM) then a volume of 3 mL was mixed with 1.0 enzyme extract. The increment of absorption of 495 nm was spectrophotometrically recorded. The increase in absorbance of 0.01 per minute at 495 nm at the specified condition was defined as one unit of PPO activity. The results were expressed as IU per mg protein (Dogan *et al.*, 2002).

Statistical analysis

All data were subjected to statistical analysis according to the procedures reported by Snedecor and Cochran (1980) and means were compared by Duncan's multiple range tests.

Results and Discussion

General appearance:

Data in table (1) show that general appearance (score) of Jerusalem artichoke tubers decreased significantly with prolonging storage period in the two successive seasons. These results are in agreement with El-Awady *et al.* (2015) and may be due to slight dryness of the tuber surface, shriveling, color change and decay as reported by Attia and Alian (2011).

Concerning the effect of postharvest treatments, data show that there were significant differences among different postharvest treatments and untreated tubers. All treatments were better than control during storage period. Tubers dipped in solution of 5 % hydrogen peroxide and fumaric acid scored the best general appearance with no significant differences between them during the two successive seasons of storage. In another word, these treatments gave the highest score of appearance, while untreated tubers obtained the lowest one in this concern. Dipping Tubers in solution of 10 % H_2O_2 and 10% of fumaric was less effective in this concern. These results are in agreement with (Abdullah, 2013) for H_2O_2 and (Chun and Song, 2014) for fumaric acid.

The keeping quality of general appearance that was improved using H_2O_2 may be attributed to the effect of H_2O_2 on the reduction of weight loss and rot rate of fruits (Bayoumi, 2008). H_2O_2 treatments have beneficial effect on fruits physiology such as delaying ripening of fruits by increasing antioxidants content in fruits (Saltveit and Sharaf, 1992). In the same time, ethylene production by fruits could be reduced via H_2O_2 and this reduction keeps the appearance of fruits in the best condition.

As for the interaction between postharvest treatments and storage period, data revealed that tubers dipped in solution of H_2O_2 at 5% did not exhibit any changes in their appearance till 60 days, of storage and showed good appearance after 80 days, and then dropped to fair appearance after 100 days, of storage, meanwhile tubers dipped in fumaric acid at 5% showed good appearance after 60 days of storage. On the other hand, untreated tubers had the poorest appearance at the end of storage period (100 days). These results were true in both seasons.

Decay:

Data presented in Table (1) showed that there was a remarkable increase in decay of tubers which associated with the increase in storage period in both seasons, especially at the end of storage period in both seasons. These results agree with those obtained by (Ghoneem *et al*., 2016) who found that the increase in storage period was accompanied by an increase in decay of Jerusalem artichoke tubers. This result might be attributed to the acceleration in transpiration rate of tubers which rise during storage period (Bowler *et al.*, 1992).

Concerning the effect of postharvest treatments, data revealed that there were significant differences among postharvest treatments and decay score during storage. All treatments were much better in reducing decay score and so longer storage period than control. However, Jerusalem artichoke tubers treated with H_2O_2 at 5% or fumaric acid at 5% were the most effective treatments in minimizing decay incidence during storage period with significant differences between them in the two successive seasons followed by 10 % of H_2O_2 and 10% of fumaric acid with no significant differences between them in both seasons. These results are in agreement with Abd El-Monem *et al*., (2013) who found that H_2O_2 has a positive effect in decreasing mango fruit decay % during storage. The reduction of decay using H_2O_2 treatment may be attributed to its role as a reactive oxygen species (ROS) which play an important and manifold role in plant disease resistance to infection with pathogens (Bayoumi, 2008).

For the interaction among postharvest treatments and storage period, data show that, for the untreated tubers, the decay of untreated tubers started to be shown after 40 days of storage and several

symptoms of decay at the end of storage period were observed, while no decay was noticed in tubers treated with 5 % of H_2O_2 or 5 % of fumaric acid till 80 or 60 days of storage respectively and gave slight score or moderate score at the end of storage period (100 days) respectively. H_2O_2 at the rate 10% or fumaric acid at the same rate was effective up to 40 days of storage; however, its efficacy was reduced afterwards.

Table 1: Effect of hydrogen peroxide and fumaric acid dipping treatments on general appearance and decay score of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers during cold storage.

Treatments	Storage period in days	First season				Second season			
		General appearance score		Decay score		General appearance score		Decay score	
H_2O_2 5 %	0	9.00	a	1.00	f	9.00	a	1.00	g
	20	9.00	a	1.00	f	9.00	a	1.00	g
	40	9.00	a	1.00	f	9.00	a	1.00	g
	60	9.00	a	1.00	f	8.33	ab	1.00	g
	80	7.67	abc	1.00	f	7.00	abc	1.00	g
	100	5.00	def	2.00	cdef	6.33	bcd	2.33	cdef
H_2O_2 10 %	0	9.00	a	1.00	f	9.00	a	1.00	g
	20	9.00	a	1.00	f	9.00	a	1.00	g
	40	9.00	a	1.00	f	7.67	ab	1.33	fg
	60	6.33	bcde	1.67	def	5.00	cde	2.00	defg
	80	5.00	def	2.33	bcde	4.33	def	2.67	bcde
	100	5.00	def	3.00	abc	4.33	def	3.33	abc
Fumaric acid 5%	0	9.00	a	1.00	f	9.00	a	1.00	g
	20	9.00	a	1.00	f	9.00	a	1.00	g
	40	9.00	a	1.00	f	8.33	ab	1.00	g
	60	7.00	abcd	1.33	ef	7.67	ab	1.67	efg
	80	6.33	bcde	2.00	cdef	6.33	bcd	2.33	cdef
	100	5.67	cde	2.67	bcd	5.00	cde	3.00	bcd
Fumaric acid 10%	0	9.00	a	1.00	f	9.00	a	1.00	g
	20	9.00	a	1.00	f	9.00	a	1.00	g
	40	8.33	ab	1.00	f	7.67	ab	1.00	g
	60	6.33	bcde	2.00	cdef	6.33	bcd	2.33	cdef
	80	5.67	cde	2.67	bcd	5.00	cde	3.00	bcd
	100	4.33	ef	3.33	ab	3.67	ef	3.67	ab
Control	0	9.00	a	1.00	f	9.00	a	1.00	g
	20	9.00	a	1.00	f	9.00	a	1.00	g
	40	7.67	abc	1.67	def	7.00	abc	2.00	defg
	60	5.67	cde	2.67	bcd	5.00	cde	3.00	bcd
	80	4.33	ef	3.33	ab	3.67	ef	3.67	ab
	100	3.00	f	4.00	a	2.33	f	4.33	a
H_2O_2 5%		8.11	A	1.17	D	8.11	A	1.22	D
H_2O_2 10%		7.22	B	1.67	BC	6.56	BC	1.89	BC
Fumaric acid 5%		7.67	AB	1.50	C	7.56	AB	1.67	C
Fumaric acid 10%		7.11	B	1.83	B	6.78	B	2.00	B
Control		6.44	C	2.28	A	6.00	C	2.50	A
	0	9.00	A	1.00	D	9.00	A	1.00	D
	20	9.00	A	1.00	D	9.00	A	1.00	D
	40	8.60	A	1.13	D	7.93	B	1.27	D
	60	6.87	B	1.73	C	6.47	C	2.00	C
	80	5.80	C	2.27	B	5.27	D	2.53	B
	100	4.60	D	3.00	A	4.33	E	3.33	A

Values followed by the same letter (s) in each group are not significantly different at 5 %

Total sugars content:

Regarding storage period and its impact on total sugars content of Jerusalem artichoke tubers, data showed in Table (2) indicated that there was a decrease in total sugars integrated with the elongation of storage period till 60 days after storage, then it was noticed a gradual elevation on total sugars during the last twenty days of cold storage in both seasons. Same finding was obtained by Saengthobpinit and Sajjaanantakul (2005), they noticed that fructose and sucrose % increased with increasing storage period of Jerusalem artichoke tubers under cold storage.

Table 2: Effect of hydrogen peroxide and fumaric acid dipping treatments on total sugars and carbohydrates content of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers during cold storage.

Treatments	Storage period in days	First season				Second season			
		Total sugars		Carbohydrates content		Total sugars		Carbohydrates content	
H_2O_2 5 %	0	6.95	a	61.21	a	6.84	a	60.53	a
	20	6.89	a	59.02	b	6.68	b	59.41	b
	40	5.84	g	53.80	g	5.59	g	53.32	g
	60	4.88	m	48.95	l	4.71	n	48.93	l
	80	5.88	g	44.21	q	5.39	h	44.03	q
	100	6.33	e	37.33	v	6.19	e	36.06	v
H_2O_2 10 %	0	6.95	a	61.21	a	6.84	a	60.53	a
	20	6.51	c	57.80	d	6.30	d	57.73	d
	40	5.26	j	52.51	i	5.02	k	52.05	i
	60	4.26	q	47.81	n	4.03	r	46.92	n
	80	5.10	k	43.17	s	4.67	n	42.33	s
	100	5.38	i	35.94	x	5.11	j	34.91	x
Fumaric acid 5%	0	6.95	a	61.21	a	6.84	a	60.53	a
	20	6.70	b	58.32	c	6.50	c	58.55	c
	40	5.53	h	52.92	h	5.28	i	52.72	h
	60	4.45	p	48.13	m	4.21	p	47.41	m
	80	5.36	i	43.63	r	4.90	l	42.93	r
	100	5.87	g	36.42	w	5.60	g	35.71	w
Fumaric acid 10%	0	6.95	a	61.21	a	6.84	a	60.53	a
	20	6.40	d	57.62	e	6.20	e	57.33	e
	40	5.08	kl	52.23	j	4.90	l	51.72	j
	60	4.14	r	47.51	o	3.90	s	46.63	o
	80	4.83	mn	42.85	t	4.39	o	41.83	t
	100	5.01	l	35.41	y	4.81	m	34.63	y
Control	0	6.95	a	61.21	a	6.84	a	60.53	a
	20	6.14	f	56.44	f	6.03	f	56.06	f
	40	4.76	n	51.15	k	4.71	n	50.51	k
	60	3.76	s	46.34	p	3.63	t	45.81	p
	80	4.42	p	41.16	u	4.13	q	40.72	u
	100	4.54	o	34.07	z	4.18	pq	33.44	z
H_2O_2 5%		6.13	A	50.75	A	5.90	A	50.38	A
H_2O_2 10%		5.58	C	49.74	C	5.33	C	49.08	C
Fumaric acid 5%		5.81	B	50.10	B	5.56	B	49.64	B
Fumaric acid 10%		5.40	D	49.47	D	5.17	D	48.78	D
Control		5.10	E	48.39	E	4.92	E	47.85	E
	0	6.95	A	61.21	A	6.84	A	60.53	A
	20	6.53	B	57.84	B	6.34	B	57.82	B
	40	5.29	D	52.52	C	5.10	D	52.06	C
	60	4.30	F	47.75	D	4.10	F	47.14	D
	80	5.12	E	43.00	E	4.70	E	42.37	E
	100	5.43	C	35.83	F	5.18	C	34.95	F

Values followed by the same letter (s) in each group are not significantly different at 5 %

The increase in total sugars in the last period of storage might be attributed to the higher rate of moisture loss through transpiration than the rate of dry matter loss through respiration. Also, the reduction in total sugars during storage might be attributed to the higher rate of sugar loss through respiration than water loss through transpiration (Wills *et al*., 1981).

As for different treatments and its impact on total sugars content in tubers, it was observed that all treatments reduced the loss of total sugars as compared with untreated tubers. On the other side, dipping tubers in 5 % of H_2O_2 or 5% fumaric acid seems to be the most effective method in maintaining total sugars. While, H_2O_2 at the rate of 10% or fumaric acid at the same rate was less effective in this concern. The lowest values were resulted from untreated tubers; these results were true in both seasons.

The favorable effect of H_2O_2 in maintaining total sugars may be attributed to H_2O_2 treatment which reduces the respiration rates during storage period (Du *et al*., 2007) which led to reducing the consumption of sugars during respiration.

In general, the interaction among postharvest treatments and storage period was significant in the two seasons. After 100 days of storage, Jerusalem artichoke tubers treated with various treatments had the highest values of total sugars content as compared with control. Tubers treated with H_2O_2 at 5% or fumaric acid at 5% were the most effective treatments in maintaining total sugars content with significant differences between them at the same period in the two seasons.

Carbohydrates content:

Data presented in Table (2) indicated that the increase in storage period was accompanied by a decrease in carbohydrates content, this finding agrees with that obtained by (Rubel *et al*., 2014; El-Awady *et al*., 2015; Ghoneem *et al.,* 2016) who found that carbohydrates content in tubers of Jerusalem artichoke decrease gradually with the increase in storage period .

For the effect of different treatments and its impact on carbohydrates content of tubers, it was observed that there were significant differences among all treatments used and untreated tubers, however, 5% of hydrogen peroxide exhibited the highest carbohydrates content of Jerusalem artichoke tubers followed by 5% of fumaric acid with significant differences between them compared with other treatments in both seasons.

The interaction between postharvest treatments and storage period was significant in the two seasons. All various treatments had the highest values of total carbohydrates content during all storage period as compared with untreated control, However, Jerusalem artichoke tubers treated with H_2O_2 at 5% or fumaric acid at 5% were significant superior in maintaining total carbohydrate contents compared with the other treatments or untreated control during all storage period.

Inulin content:

As presented in Table (3) data showed that the increase in storage period was accompanied by a decrease in inulin content of Jerusalem artichoke tubers which riches its summit at the end of storage period, on the same line was the result of (Rubel et al., 2014; El-Awady et al., 2015; Ghoneem et al., 2016) who announced that inulin content in tubers of Jerusalem artichoke decrease through the elongation of storage period. Also, Saengthobpinit and Sajjaanantakul (2005), who found that long term storage of jerusalem artichoke tubers would inevitably affect Inulin composition, i. e degradation to shorter chains, they also revealed that tuber metabolism in tissues of Jerusalem artichoke tubers could continue at slow rate under cold storage conditions (2ºC). Thus the inulin content in tubers could be reserved for 20 days at 5ºC, and then an elevation in breakdown of inulin and utilization of monosaccharide obtained from this operation, which may be related to the highly transpiration rate or other metabolic activities (El –Awady et al., 2015).

Concerning the effect of different treatment on inulin content, data show that 5 % of hydrogen peroxide led to the highest content of inulin followed by 5% of fumaric acid compared with other treatments in both seasons.

Respecting the interaction among several treatments, storage period and its influence on Inulin content of tubers, results illustrate that tubers treated with 5% of hydrogen peroxide and stored for 20 days followed by tubers treated with 5 % of fumaric acid and stored for the same period had the

highest inulin content, then after a gradually decline in inulin content was observed with the elongation of storage period specially with untreated tubers.

Table 3: Effect of hydrogen peroxide and fumaric acid dipping treatments on inulin composition and polyphenol oxidase activity % of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers during cold storage.

Treatments	Storage period in days	First season				Second season			
		Inulin composition		polyphenol oxidase activity %		Inulin composition		polyphenol oxidase activity %	
H_2O_2 5 %	0	38.46	a	53.20	z	40.05	a	51.82	z
	20	35.92	b	55.56	x	36.05	ab	52.51	y
	40	31.04	f	62.16	t	31.91	abcd	60.35	t
	60	25.22	j	70.17	o	25.81	cdefg	69.84	o
	80	18.91	n	79.03	j	19.22	efgh	79.93	j
	100	10.14	r	90.61	e	11.32	hi	90.03	e
H_2O_2 10 %	0	38.46	a	53.20	z	40.05	a	51.82	z
	20	34.42	d	55.34	y	34.93	abc	54.14	w
	40	28.41	h	64.83	r	29.41	bcd	63.01	r
	60	22.04	l	73.82	m	23.52	defg	71.83	m
	80	16.71	p	81.84	h	18.03	ghi	82.13	h
	100	8.44	t	93.74	c	9.32	hi	92.71	c
Fumaric acid 5%	0	38.46	a	53.20	z	40.20	a	51.82	z
	20	34.92	c	56.94	v	35.33	abc	53.61	x
	40	29.05	g	64.13	s	30.53	abcd	62.23	s
	60	23.93	k	72.95	n	24.15	defg	71.14	n
	80	17.70	o	80.73	i	18.32	fghi	81.54	i
	100	8.95	s	92.94	d	10.13	hi	91.85	d
Fumaric acid 10%	0	38.46	a	53.20	z	40.20	a	51.82	z
	20	34.27	d	55.71	w	34.92	abc	55.14	v
	40	28.54	h	65.16	q	29.35	bcde	63.93	q
	60	22.18	l	74.22	l	23.43	defg	72.51	l
	80	16.83	p	82.71	g	17.83	ghi	82.82	g
	100	8.43	t	94.25	b	9.06	hi	93.02	b
Control	0	38.46	a	53.20	z	40.05	a	51.82	z
	20	31.80	e	58.44	u	23.41	defg	56.73	u
	40	27.20	i	67.32	p	28.32	bcdef	66.81	p
	60	20.81	m	76.45	k	22.03	defg	75.14	k
	80	14.16	q	85.35	f	16.33	ghi	84.61	f
	100	7.32	u	96.81	a	8.82	i	95.52	a
H_2O_2 5%		26.61	A	68.45	E	27.39	A	67.41	E
H_2O_2 10%		24.75	C	70.46	C	25.88	AB	69.27	C
Fumaric acid 5%		25.50	B	70.15	D	26.44	A	68.70	D
Fumaric acid 10%		24.78	C	70.88	B	25.80	AB	69.87	B
Control		23.29	D	72.93	A	23.16	B	71.77	A
	0	38.46	A	53.20	F	40.11	A	51.82	F
	20	34.27	B	56.40	E	32.93	B	54.43	E
	40	28.85	C	64.72	D	29.91	B	63.27	D
	60	22.84	D	73.52	C	23.79	C	72.09	C
	80	16.86	E	81.93	B	17.95	D	82.21	B
	100	8.66	F	93.67	A	9.73	E	92.63	A

Values followed by the same letter (s) in each group are not significantly different at 5 %

Polyphenol oxidase activity:

Data presented in Table (3) clear that polyphenol oxidase (PPO) activity of Jerusalem artichoke tubers, increases with increasing storage period and reach its top activity at the end of the trial in both seasons. These results are in agreement with El-Awady et al. (2015) on Jerusalem artichoke tubers.
Concerning the effect of different treatments on polyphenol oxidase activity, data show that there were significant differences among treatments and untreated tubers on PPO activity during storage. All treatments reduced the activity of PPO as compared with untreated tubers, however tubers treated with 5 % of H_2O_2 or 5% of fumaric acid were the most effective treatment in reducing the activity of PPO with significant differences between them in both seasons.

Respecting the interaction among several treatments, storage period and its influence on polyphenol oxidase activity, results indicate that treating tubers with 5% of hydrogen peroxide or 5 % of fumaric acid and stored for 20 days had an affirmative effectiveness on detracting the activity of polyphenol oxidase compared with untreated tubers. This result agrees with that obtained on fresh-cut apples, pears, and jicama (Buta and Abbott, 2000; Aquino- Bolanos and Mercado-Silva, 2004), who found that H_2O_2 decreases the activity of polyphenol oxidase. The direct effect of hydrogen peroxide on polyphenol oxidase might be related to the direct denaturation of its protein (Peng et al., 2008).

Conclusion

From the previous results, it could be concluded that Jerusalem artichoke tubers dipped in solution of 5% hydrogen peroxide for 5 minutes was the most effective treatment in maintaining quality (total sugars, total carbohydrates and inulin content), reduced PPO activity and gave tuber with good appearance without decay till 80 days of storage at 5˚C and 90-95% relative humidity.

References

A. O. A. C., 1990. Official Methods of Analysis of Association of Official Agricultural Chemists. 15th: 1045-1106.

Abd El-Monem, A. A. Eman, A. A. Zahran, A. E. Shaban, 2013. Role of some postharvest treatments in maintaining mango fruit quality during cold storage. Journal of Applied Sciences Research, 9(3): 2355-2366.

Abdullah, M. A. A., 2013. Pre and Postharvest Treatments to Enhance Sweet Pepper (*Capsicum annuum* L.) Productivity and Quality. Ph.D. Thesis, Arid Land Agricultural Dep., Fac. Agric., Ain Shams Univ.

Afek, U., J. Orenstein and E. Nuriel, 2000. Using HPP (Hydrogen peroxide Plus) to inhibit potato sprouting during storage. Amer. J. Potato Res., 77:63-65.

Aquino-Bolanos, E. N., E. Mercado-Silva, 2004. Effects of polyphenol oxidase and peroxidase activity, phenolics and lignin content on the browning of cut jicama. Postharvest Biol. Technol. 33, 275–283.

Attia, M. M. and F. S. Alian, 2011. Physiological studies on Jerusalem artichoke 2- Effects of harvesting dates, wrapping film and storage temperature on quality attributes of Jerusalem artichoke (local cultivar) during storage. Journal of Plant Production, 2(12): 1619-1631.

Bayoumi, Y. A., 2008. Improvement of postharvest keeping quality of white pepper fruits (*Capsicum annuum*, L.) by hydrogen peroxide treatment under storage conditions. Acta Biologica Szegediensis., 52(1):7-15.

Ben Chekroun M., J. Amzile, M. El Yachioui, 1994. Qualitative and quantitative development of carbohydrate reserves during the biological cycle of Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. New Zealand, J. of Crop and Hort. Sci. 22, 31-37.

Bhagwat, A. A., 2006. Microbiological safety of fresh-cut produce: where are we now? In Matthews KR, ed., Microbiology of fresh produce. Herndon, VA, ASM Press, pp. 121-166.

Bowler, C., M.V. Montogu, and D. Inze, 1992. Super oxide dismutase and stress tolerance. Ann. Rev. Plant Physiol. Plant Mol. Biol., 48, 233-250.

Buta, J.G. and J. A. Abbott, 2000. Browning inhibition of fresh-cut 'Anjou', 'Bartlett', and 'Bosc' pears. Hort Science 35, 1111–1113.

Chikthimmah, N., L. F. LaBorde and R. B. Beelman, 2005. Hydrogen peroxide and calcium chloride added to irrigation water as a strategy to reduce bacterial populations and improve quality of fresh mushrooms. J. Food Sci. 70, M273–M278.

Chun, H. H., and Song, K. B. 2014. Optimization of the combined treatments of aqueous chlorine dioxide, fumaric acid and ultraviolet-C for improving the microbial quality and maintaining sensory quality of common buckwheat sprout. International Journal of Food Science and Technology, 49(1), 121-127.

Cieslik, E., A. Kopec and W. Praznik, 2005. Healthy properties of Jerusalem artichoke flour (*Helianthus tuberosus* L.). EJPAU., 8 (2) #37.

Comes, J. E. and Beelman, R. B. 2002. Addition of fumaric acid and sodium benzoateas an alternative method to achieve a 5-log reduction of Escherichia coliO157:H7 populations in apple cider. Journal of Food Protection, 65, 476–483.

Dogan, M., O. Aslan and S. Dogan, 2002. Substrate specificity, heat inactivation and inhabitation of polyphenol oxidase from different aubergine cultivars. Int. J. Food Sci. Technol., 37:415-423.

Du. J. M. Fu; M. Li and W .Xia. 2007. Effects of chlorine dioxide gas on postharvest physiology and storage quality of green bell pepper (*Capsicum frutescens* L. var. Longrum). Agricultural Sciences in China. 6(2):214-219.

El-Awady, A. A., K. M. Ghoneem and Wesam I.A. Saber, 2015. Enhancement of Quality and Storability as Well as Rots Reduction of Jerusalem Artichoke Tuber by Co-application of Essential Oils and Temperature. Egypt. J. Hort. .42 (1). 491 - 508.

Ghoneem, K. M., W. I. A. Saber, A. A. El-Awady, Y. M. Rashad and A. A. Al-Askar 2106. Alternative preservation method against *Sclerotium* tuber rot of Jerusalem artichoke using natural essential oils. Phytoparasitica , 44: 341-352.

Jimenez, M., E. Trejo and M. Cantwell, 1998. Postvarvest quality changes in green beans. Research Report, UC Davis, cooperative extension service No. pp9.

Jin, S., L. Liu, Z. Liu, X .Long, H. Shao, and J. Chen, 2013. Characterization of marine Pseudomonas spp. Antagonist towards three tuber-rotting fungi from Jerusalem artichoke, a new industrial crop. Industrial Crops and Products, 43,556–561.

Kays, S. J. and S. F. Nottingham, 2008. Biology and chemistry of Jerusalem artichoke: *Helianthus tuberosus*L. - Boca Raton -Abingdon - Oxon - New York: CRC Press, Taylor and Francis Group.

Kim, H. J., J. M. Fonseca, C. Kubota and H. Choi, 2007. Effect of Hydrogen Peroxide on Quality of Fresh-Cut Tomato. J. Food Sci., 72(7):463-467.

Liao, W., Y. Liu, C. Frear and S. Chen, 2008. Co-production of fumaric acid and chitin from a nitrogen-rich lingo cellulosic material dairy manure using a pelletized filamentous fungus Rhizopus oryzae ATCC 20344.Bioresource Technology, 99(13), 5859–5866.

Mermelstein, N. H., 2001. Sanitizing meat. Food Technol. 5, 64–68.

Neill, S. J, R. Desikan, A. Clarke, R. D. Hurst and J. Hancock, 2002. Hydrogen peroxide and nitric oxides signaling molecules in plants. J. Exp. Bot., 53(372):1237-1247.

Peng, L., S. Yang, Q. Li, Y. Jiang and D. C. Joyce, 2008. Hydrogen peroxide treatments inhibit the browning of fresh-cut Chinese water chestnut. Postharvest Biology and Technology 47,260-266.

Rubel, I. A., E. E. Perez, D. B. Genovese and G. D. Manrique 2014. *In vitro* prebiotic acticity of inulin-rich carbohydrates extracted from Jerusalem artichoke (*Helianthus tuberosus* L.) as different storage times by *Lactobacillus paracasei*. Food Research International. 62: 59-65.

Saengthobpinit, W. and T. Sajjaanantakul, 2005. Influence of harvest time and storage temperature on charecteristics of inulin from Jerusalem artichoke (*Helianthus tuberosus* L.) tubers. Postharvest Biol. Technol. 37(1), 93-100.

Saltveit, M. E and A. R. Sharaf. 1992. Ethanol inhibitors ripening of tomato fruit harvested at various degrees of ripeness without affecting subsequent quality. J. Am. Soc. Hort Sci. 117:793-798.

Sapers, G. M., R. L. Miller, A. V. Pilizota and A. M. Mattrazo, 2001. Antimicrobial treatments for minimally processed cantaloupe melon. J. Food Sci. 66,345–349.

Sapers, G. M. and G. F. Simmons, 1998. Hydrogen peroxide disinfection of minimally processed fruits and vegetables. Food Technol. 52, 48–52.

Simmons, G. E., J. L. Semilanick, S. John and D. A. Margosan, 1997. Reduction of microbial populations on prunes by vapor phase hydrogen peroxide. J. Food Protect. 60, 188–191.

Snedecor, C. W. and W. G. Cochran, 1980. Statistical Methods. 7th Ed. Thelowa state Univ. Press.Ames. lowa, USA, PP: 325-330.

Tesio, F., L. A.Weston, and A. Ferrero, 2011. Allelochemicals identified from Jerusalem artichoke (*Helianthus tuberosus* L.) residues and their potential inhibitory activity in the field and laboratory. Scientia Horticulturae Amsterdam, 129, 361–368.

Ukuku, D.U., 2004. Effect of hydrogen peroxide treatment on microbial quality and appearance of whole and fresh-cut melons contaminated with Salmonella spp. Int. J. Food Micro., 95:137-146.

Ukuku, D.O., M. L. Bari, S. Kawamoto, K. Isshiki, 2005. Use of hydrogen peroxide in combination with nisin, sodium lactate and citric acid for reducing transfer of bacterial pathogens from whole melon surfaces to fresh-cut pieces. Int. J. Food Microbiol. 104, 225–233.

Watada, A. E. and L. L. Morris, 1996. Effect of chilling and non-chilling temperatures on snap beans fruits. Proc. Amer. Soc. Hort. Sci., 89: 368-374.

Wills, H. H. R.; T. H. Lee; D. Graham; W. B. Mc Glasson and E. G. Hall, 1981. An introduction in the physiology and handling of fruits and vegetables. New South Wales University Prees Limited, Australia. 123-126.