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The efficiency of using some medicinal and aromatic plant extracts on keeping quality and resists postharvest diseases of apple

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Abstract : The use of natural products in horticultural practices instead of synthetic chemical products for improving growth, nutritional status and productivity of fruit crops is becoming as a main target for many fruit crop producers. Blue mold is a very common postharvest fungal disease of pome fruits that may cause more than 70% of decay in stored apples. Accordingly, the present experiment was carried out during two successive seasons (2013/2014) to evaluate the efficiency of using garlic and onion extracts as natural products on improving storage ability and control the blue mold in apple fruits. Trees were sprayed twice at pink bud and 80% petal-fall stages using aqueous and ethanolic extracts of garlic and onion at concentrations of 0, 5, 10 and 15%. Different measurements were carried out starting from zero time of storage at ambient temperature (25-28°c) and continued for four weeks. Plant extracts specially garlic ethanolic extract at 15% had beneficial effects on keeping fruit quality as physical properties (decay, weight loss and firmness) and chemical properties in terms of increasing TSS and total sugars as will as decreasing total acidity. Both garlic extracts and onion ethanolic extract significantly decreased activity of enzymatic browning compared to control and different concentrations of onion aqueous extract. Both garlic and onion extracts were effective against *Penicillium expansum*, blue mold, where the best significant inhibition was shown by 15% garlic ethanolic extract.
Keywords : Apple- natural extracts- storage ability- blue mold- enzymatic browning- fruit quality.

Introduction

Apple (*Malus domestica*) is a deciduous tree belongs to family Rosaceae, it is cultivated worldwide and is the most widely grown species in the genus Malus[1]. World apple production in marketing year 2015/16 is forecast to increase slightly to 77.0 tons [2].

Increasing demand for organic foods which may grant high profits has motivated producers to convert to a sizeable amount of farmland from traditional agricultural practices to organic production[3].

Plant extracts were found by many authors to enhance growth, nutritional status, yield and fruit quality of fruit crops [4,5,6,7,8,9,10,11,12,13]. Moreover, using garlic or onion extract improved quality of grapevines berries by increasing total soluble solids and reducing sugars and decreasing total acidity [5].

The quality and maintenance of apple fruits are greatly affected by the attack of molding fungi. For instance, blue mold, the very common postharvest fungal disease of pome fruits, may cause more than 70% of decay in stored apples. This disease is caused mainly by *Penicillium expansum* [14], but more than 50 Penicillium species have been found to be involved in apple blue mold [15,16,17]. Due to the great antimicrobial activity of onion (*Allium cepa* L.) and garlic (*Allium sativum* L.), the most well-known species belonging to the allium family, could be used as natural preservatives to control the microbial growth [18].

This study aimed to use garlic and onion extracts as natural products to improve storage ability and control the blue mold in apple fruits.

Materials and methods

The present experiment was carried out in a private farm during two successive seasons (2013/2014) on 6-year-old trees of Anna apple cv budded on MM.106 rootstock and planted at 4×4m. in sandy soil. The experiment contained 12 treatments in addition to the control (using water) with three replicates. The statistical analysis design of the experiment was randomized complete block design. All treatments were sprayed two times at pink bud and 80% petal-fall.

Fresh mature garlic cloves and onion bulbs (500 g) were peeled and then chopped with 1 L distilled water or ethanol (99.5%) (w/v) by using a domestic blender for 1 min at average speed. The mixture were macerated during 24 h at 4°C. After that, resulting extracts of materials were filtered and sterilized by passing through a sterilized Millipore filter (45 μm). Ethanol was evaporated under reduced pressure using a rotatory evaporator and extracts were dried to obtain a constant weight. Dilutions were prepared at concentrations of 5, 10 and 15 %. Spraying solution was quite enough in quantity to cover all the vegetative growth.

Mature apple fruits [19] picked, taken immediately to the laboratory, washed, air dried, packed in carton boxes (three replicates each) and stored at ambient temperature (25-28°C). Different measurements were carried out starting from zero time of storage and continued at intervals of one week, until the percentage of fruit decay attained about 50%.

Physical characteristics:

Fruit decay (%):

Fruits which were decayed by different physiological and pathological factors were periodically counted and discarded, and then percentage of fruit decay was calculated in relation to the total number of fruits.

Loss in fruit weight (%):

Fruits were periodically weighed and loss in fruit weight was recorded for each replicate and then it was calculated as percentages in relation to the fruits weight at zero time of shelf-life.

Firmness:

Fruit firmness was determined for each replicate using Magness and Taylor-pressure tester with 5/16 inch plunger. Fruit firmness was recorded as $lb/inch^2$.

Chemical characteristics:

Determination of Acidity %:

Total acidity as gm of anhydrous malic acid determined and estimated per 100 ml fruit juice [20].

Total soluble solids percentages (T.S.S.):

It was measured in juice using the Hand Refractometer.

Total soluble pectin:

Pectic substances were determined as gm./100 gm. d.wt. [21].

Total soluble sugars (gm/100gm of dry weight):

Colorimetric determination of total soluble sugars expressed as glucose [22].

Peroxidase activity:

Peroxidase enzyme activity was determined [23] and the activity was expressed as units per g fresh weight.

Polyphenol Oxidase Activity:

Polyphenol oxidase (PPO) activity was determined [24] and the activity was expressed as units per g fresh weight.

Antifungal activity:

The fungi of *Penicillium expansum* (blue mould) was grown in petri dishes on potato dextrose agar (PDA) medium. For the solution contact method, 50 µL of extracts was impregnated on an individual paper disc of 8 mm diameter, the solvent was left to vaporize for minute, then discs were placed directly on the petri dishes. Three replicates were used per treatment and incubated at 24ºC in the dark [25]. For each plant extract and concentration, inhibition of radial growth compared with the untreated control was calculated.

Statistical analysis

Data for the physical and chemical characteristics were subjected to analysis of variance (ANOVA) and least significant difference (L.S.D. at 5% level) was also adopted [26].

Results and Discussion

Physical characteristics

Table (1) demonstrates decay (%), weight loss (%) and firmness (lb/inch^2) of fruits as affected by spraying garlic and onion ethanolic and aqueous extracts on the trees.

Generally, it can be noticed that storage caused increasing decay % and weight loss % and decreasing firmness (**Table 1**). Decay % increased gradually during storage to reach the maximum values (43.9 and 40.3 %, respectively) in both first and second seasons by the fourth week. Furthermore, the highest weight loss were concluded in the fourth week recording 7.05 and 7.64 %, respectively in both first and second seasons. Moreover, the highest values of firmness were recorded at zero time in both first and second seasons reaching 14.4 and 15.4 lb/inch^2, respectively whereas the lowest values (9.51 and 10.3 lb/inch^2, respectively) were obtained by the end of the storage period.

However, using plant extracts specially garlic ethanolic extract at 15% had beneficial effects on decreasing decay % and weight loss % as well as increasing firmness, while onion aqueous extract was the least. As for decay %, results illustrated in Table (1) showed the lowest values in average using 15% garlic ethanolic extract (11.7 and 9.67%, respectively) in both first and second seasons compared to control which recorded 23.0 and 22.0%, respectively. Concerning weight loss, results concluded that the worst treatment was control which recorded 3.66 and 4.31%, respectively for both first and second seasons, while, the best results revealed from 15% garlic ethanolic extract giving 1.6 and 2.13%, respectively. Results of firmness revealed that, 15% garlic ethanolic extract in both first and second seasons recorded the highest values (12.8 and 13.8 lb/inch^2, respectively) for both first and second seasons compared to control which gave 11.3 and 12.0 lb/inch^2, respectively .

Table (1): Effect of spraying natural plant extracts at different concentrations (%) on decay (%), weight loss (%) and firmness (lb/inch^2) of apple fruits stored at ambient temperature up to 4 weeks

Treatments		Decay						Weight loss						Firmness					
First season																			
Extracts	Period / Conc.	0	1	2	3	4	Mean	0	1	2	3	4	Mean	0	1	2	3	4	Mean
Control		0	8.33	16.7	31.7	58.3	23.0	0	1.22	2.53	5.20	9.34	3.66	13.5	12.9	11.3	9.60	8.93	11.3
Garlic Ethanolic extract	5	0	5.00	13.3	20.0	41.7	16.0	0	0.82	1.51	3.89	7.77	2.79	14.6	13.8	12.5	10.1	9.60	12.1
	10	0	3.33	8.33	20.0	36.7	13.7	0	0.63	1.34	3.78	6.98	2.54	14.9	14.4	12.6	10.5	9.90	12.5
	15	0	0.00	5.00	18.3	35.0	11.7	0	0.06	1.26	2.41	4.27	1.60	15.7	14.5	12.9	10.9	10.1	12.8
Garlic Aqueous extract	5	0	6.67	11.7	23.3	43.3	17.0	0	0.64	1.34	3.34	6.53	2.37	14.1	13.5	12.4	10.0	9.47	11.9
	10	0	5.00	10.0	21.7	43.3	16.0	0	0.57	1.44	3.23	5.80	2.21	14.3	13.8	12.2	10.3	9.57	12.0
	15	0	0.00	6.67	18.3	36.7	12.3	0	0.10	1,39	2.86	5.78	2.03	14.7	14.3	12.8	10.5	9.83	12.4
Onion Ethanolic extract	5	0	3.33	8.33	23.3	41.7	15.3	0	0.78	2.31	3.21	6.36	2.53	14.1	13.1	12.0	10.1	9.23	11.7
	10	0	5.00	6.67	25.0	40.0	15.3	0	0.87	1.93	3.48	7.16	2.69	14.4	13.3	12.2	10.2	9.33	11.9
	15	0	0.00	8.33	28.3	38.3	15.0	0	0.14	1.24	2.87	6.97	2.24	14.8	13.8	12.4	10.3	9.67	12.2
Onion Aqueous extract	5	0	8.33	10.0	23.3	55.0	19.3	0	1.14	2.21	3.90	7.86	3.02	13.8	13.1	12.4	10.2	9.10	11.7
	10	0	8.33	10.0	26.7	51.7	19.3	0	1.08	3.69	4.03	8.08	3.38	14.2	13.5	12.5	9.93	9.37	11.9
	15	0	8.33	11.7	30.0	50.0	20.0	0	1.16	2.72	4.15	8.79	3.36	14.6	13.9	12.6	10.3	9.50	12.2
Mean		0	4.74	9.74	23.8	43.9		0	0.71	1.92	3.57	7.05		14.4	13.7	12.4	10.2	9.51	
L.S.D. 5%								A=0.071		B=0.044		AXB=0.158		A=0.271		B=0.168		AXB=0.605	
Second season																			
Control		0	8.33	15.0	31.7	55.0	22.0	0	1.32	3.07	6.58	10.57	4.31	14.1	13.9	12.2	10.2	9.6	12.0
Garlic Ethanolic extract	5	0	3.33	8.33	20.0	36.7	13.7	0	0.98	1.82	3.72	8.65	3.03	15.7	14.7	13.5	10.9	10.4	13.0
	10	0	1.67	6.67	18.3	33.3	12.0	0	0.89	1.49	4.22	7.64	2.85	15.9	15.4	13.6	11.3	10.6	13.4
	15	0	0.00	3.33	15.0	30.0	9.67	0	0.50	1.56	2.82	5.78	2.13	16.8	15.6	13.9	11.8	10.9	13.8
Garlic Aqueous extract	5	0	5.00	10.0	21.7	43.3	16.0	0	0.86	1.81	3.78	7.59	2.81	15.1	14.5	13.3	10.8	10.3	12.8
	10	0	3.33	10.0	18.33	38.3	14.0	0	0.78	1.58	3.64	6.34	2.47	15.3	14.6	13.2	11.1	10.4	12.9
	15	0	1.67	5.00	16.7	31.7	11.0	0	0.25	1.82	3.88	6.49	2.49	15.8	15.4	13.8	11.4	10.8	13.4
Onion Ethanolic extract	5	0	3.33	6.67	23.3	38.3	14.3	0	0.95	2.56	4.12	7.03	2.93	14.9	14.1	12.9	10.7	10.1	12.6
	10	0	3.33	5.00	21.7	36.7	13.3	0	1.15	2.21	3.76	7.31	2.89	15.4	14.3	13.0	11.1	10.3	12.8
	15	0	1.67	5.00	25.0	35.0	13.3	0	0.35	1.75	3.16	6.58	2.37	15.7	14.9	13.3	11.1	10.6	13.1
Onion Aqueous extract	5	0	5.00	10.0	21.7	50.0	17.3	0	1.64	1.95	4.40	8.12	3.22	14.8	14.2	13.5	10.9	9.9	12.6
	10	0	6.67	8.33	25.0	48.3	17.7	0	2.04	2.36	4.47	8.15	3.40	15.1	14.4	13.4	10.7	10.2	12.8
	15	0	6.67	11.7	26.7	46.7	18.3	0	1.43	2.77	4.51	9.05	3.55	15.6	14.8	13.5	11.0	10.2	13.0
Mean		0	3.85	8.08	21.9	40.3		0	1.01	2.06	4.08	7.64		15.4	14.7	13.3	11.0	10.3	
L.S.D. 5%								A=0.125		B=0.077		AXB=0.279		A=0.204		B=0.127		AXB=0.457	

Chemical characteristics

Results tabulated in **Table (2)** illustrates acidity (%), TSS (%) and total sugars (%) in apple fruits as affected by spraying of garlic and onion ethanolic and aqueous extracts on apple trees.

Results revealed that acidity % gave the least values due to treatment with 15% garlic ethanolic extract recording 0.52 and 0.41%, respectively in both first and second seasons. However, acidity % recorded highest means (0.65 and 0.58%, respectively) at zero time and decreased by increasing storage period to reach the lowest means by the fourth week (0.49 and 0.39%, respectively) for both first and second seasons.

Concerning TSS %, treating with 15% garlic ethanolic extract resulted in the highest TSS % which gave 17.6 and 18.1%, respectively for the first and second seasons. On the other hand, the lowest TSS % (14.6 and 15.2%, respectively for the first and second seasons) were recorded at zero time.

As for total sugars %, it could be noticed that the highest percentage of total sugars recorded using 15% garlic ethanolic extract reaching 8.85 and 9.20%, respectively for both first and second seasons. In addition, the highest total sugars % (9.11 and 9.54%, respectively for the first and second seasons) were obtained during the fourth week of storage, while the least ones were recorded at zero time giving the values of 6.48 and 6.89%, respectively for the first and second seasons.

In this respect, garlic extract showed significant positive effects on improving fruit quality as physical properties (fruit weight and firmness) and chemical properties in terms of increasing TSS % and total sugars % and decreasing total acidity % in several fruit crops [4,27,6,7,12,28].

The obtained results are in agreement with those observed by [5] who recommended the use of garlic or onion extracts at the rate of 15% for improving "Flame Seedless" and "Superior" grapevines berries quality by increasing total soluble solids and reducing sugars and decreasing total acidity as compared to the control. In addition, it was revealed that, garlic extract was more effective on enhancing fruit quality of Thompson seedless grapevines and Keitte mango compared to onion extract [29,13].

Table (3) illustrates pectin (%), polyphenol oxidase and peroxidase activities in fruits as affected by spraying of garlic and onion ethanolic and aqueous extracts on apple trees.

Concerning pectin content (%), it increased gradually from zero time (0.51 and 0.47 for first and second seasons, respectively) till the end of storage period reached 0.82 and 0.80 for first and second seasons, respectively at the fourth week. Generally, spraying with garlic or onion ethanolic or aqueous extracts decreased pectin content of the fruits as compared to untreated trees. The highest value of pectin content was observed in control after 4 weeks of storage recording 0.89 and 0.90% for first and second seasons, respectively.

Table (2): Effect of spraying natural plant extracts at different concentrations (%) on acidity (%), TSS (%) and total sugars (%) of apple fruits stored at ambient temperature up to 4 weeks

Treatments		Acidity						TSS						Total sugars					
First season																			
Extracts	**Period / Conc.**	**0**	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**
Control		0.75	0.71	0.62	0.56	0.52	**0.63**	11.8	12.2	13.3	14.0	14.3	**13.1**	5.29	5.64	6.89	7.52	7.90	**6.65**
Garlic Ethanolic extract	**5**	0.66	0.61	0.57	0.57	0.49	**0.58**	14.7	15.0	16.7	16.9	16.9	**16.1**	6.47	7.07	8.39	8.53	9.24	**7.94**
	10	0.63	0.58	0.52	0.49	0.48	**0.54**	16.3	16.7	16.9	17.1	17.2	**16.8**	7.28	7.81	8.49	8.99	9.54	**8.42**
	15	0.58	0.55	0.55	0.45	0.45	**0.52**	17.2	17.7	17.3	17.4	18.2	**17.6**	7.66	8.29	8.84	9.41	10.05	**8.85**
Garlic Aqueous extract	**5**	0.68	0.65	0.62	0.57	0.50	**0.60**	13.7	15.9	16.2	15.3	16.7	**15.6**	6.10	7.40	8.08	8.44	9.23	**7.85**
	10	0.65	0.63	0.60	0.55	0.49	**0.58**	15.5	16.4	16.9	17.2	17.3	**16.7**	6.87	7.63	8.43	8.97	9.62	**8.30**
	15	0.61	0.57	0.53	0.51	0.45	**0.53**	16.0	17.4	17.6	17.8	17.8	**17.3**	7.13	8.13	8.81	9.58	9.92	**8.71**
Onion Ethanolic extract	**5**	0.68	0.65	0.57	0.52	0.51	**0.58**	13.1	13.9	14.7	14.7	16.1	**14.5**	5.80	6.53	7.29	8.43	8.93	**7.39**
	10	0.65	0.65	0.59	0.56	0.55	**0.59**	14.6	15.9	16.2	8.7	16.9	**14.4**	6.40	7.41	8.11	8.70	9.38	**8.00**
	15	0.62	0.59	0.56	0.54	0.49	**0.56**	15.3	16.9	17.4	17.5	17.6	**16.9**	6.78	8.15	8.73	9.06	9.38	**8.42**
Onion Aqueous extract	**5**	0.69	0.63	0.59	0.56	0.52	**0.59**	13.2	13.9	14.2	14.4	14.5	**14.0**	5.88	6.49	7.12	7.48	7.90	**6.97**
	10	0.66	0.61	0.54	0.52	0.50	**0.57**	13.9	14.4	14.5	14.7	15.2	**14.5**	6.16	6.73	7.26	7.77	8.45	**7.27**
	15	0.64	0.59	0.51	0.5	0.49	**0.55**	14.5	14.9	15.5	15.7	16.3	**15.4**	6.45	6.94	7.75	8.10	8.89	**7.63**
Mean		**0.65**	**0.62**	**0.57**	**0.53**	**0.49**		**14.6**	**15.5**	**16.0**	**15.5**	**16.5**		**6.48**	**7.25**	**8.02**	**8.54**	**9.11**	
L.S.D. 5%		**A=0.010**		**B=0.006**		**AXB=0.021**		**A=0.701**		**B=0.435**		**AXB=1.566**		**A=0.347**		**B=0.215**		**AXB=0.777**	
Second season																			
Control		0.65	0.64	0.57	0.51	0.48	**0.57**	12.8	13.1	14.1	14.5	14.6	**13.8**	5.76	5.87	7.14	7.78	8.44	**7.00**
Garlic Ethanolic extract	**5**	0.56	0.52	0.47	0.37	0.36	**0.45**	14.9	15.7	16.5	16.8	17.1	**16.2**	6.88	7.21	8.64	8.92	9.66	**8.26**
	10	0.54	0.54	0.50	0.36	0.34	**0.46**	16.9	17.2	17.2	17.4	17.7	**17.3**	7.99	8.00	8.88	9.45	9.92	**8.85**
	15	0.49	0.47	0.44	0.34	0.33	**0.41**	17.6	17.8	18.1	18.3	18.6	**18.1**	8.17	8.44	9.00	9.94	10.45	**9.20**
Garlic Aqueous extract	**5**	0.57	0.51	0.50	0.48	0.44	**0.50**	13.9	15.6	16.2	16.6	16.8	**15.8**	6.28	7.62	8.42	8.78	9.57	**8.13**
	10	0.57	0.53	0.53	0.45	0.42	**0.50**	16.3	16.9	17.2	17.3	17.4	**17.0**	7.27	7.98	8.60	9.28	9.97	**8.62**
	15	0.54	0.49	0.47	0.43	0.37	**0.46**	16.5	17.2	17.7	18.1	18.3	**17.6**	7.46	8.27	9.17	9.74	10.19	**8.97**
Onion Ethanolic extract	**5**	0.56	0.54	0.51	0.49	0.45	**0.51**	13.8	14.9	15.8	15.9	16.7	**15.5**	6.24	7.26	7.57	8.97	9.23	**7.86**
	10	0.67	0.61	0.46	0.44	0.41	**0.52**	15.3	16.5	16.8	16.9	17.1	**16.5**	6.77	7.80	8.35	9.08	9.83	**8.36**
	15	0.57	0.52	0.47	0.40	0.37	**0.47**	16.1	16.6	17.6	18.0	18.3	**17.3**	7.22	8.31	9.19	9.44	9.57	**8.75**
Onion Aqueous extract	**5**	0.57	0.56	0.53	0.43	0.42	**0.50**	14.1	14.4	14.8	15.0	15.3	**14.7**	6.32	6.77	7.26	8.10	8.67	**7.42**
	10	0.60	0.54	0.52	0.44	0.40	**0.49**	14.5	14.8	15.3	15.5	16.1	**15.3**	6.51	7.00	7.49	8.24	9.29	**7.70**
	15	0.60	0.58	0.50	0.41	0.37	**0.49**	14.9	15.6	15.8	16.2	16.3	**13.8**	6.70	7.29	8.00	8.52	9.31	**7.96**
Mean		**0.58**	**0.54**	**0.49**	**0.43**	**0.39**		**15.2**	**15.9**	**16.4**	**16.7**	**16.9**		**6.89**	**7.52**	**8.28**	**8.94**	**9.54**	
L.S.D. 5%		**A=0.011**		**B=0.007**		**AXB=0.025**		**A= 0.694**		**B= 0.430**		**AXB=1.551**		**A=0.285**		**B= 0.177**		**AXB=0.638**	

A= Treatments B= Storage period

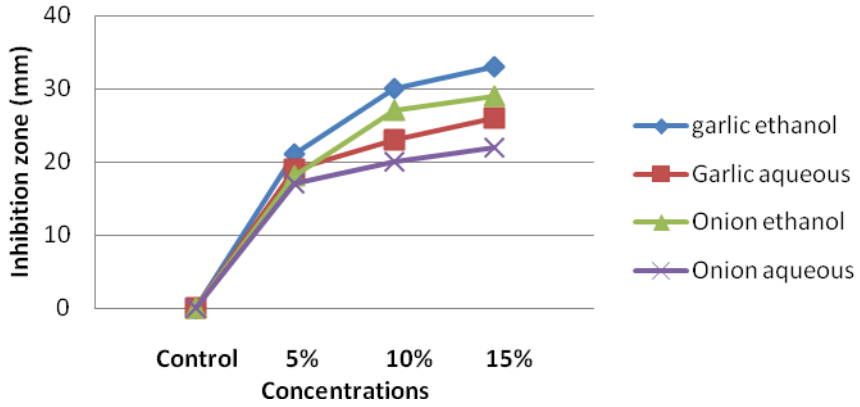
Regarding enzymes activity in apple fruits (**Table, 3**), activity of both determined enzymes increased gradually from zero time (0.11 and 0.17 U/gF.W.for polyphenol oxidase, 0.27 and 0.35U/gF.W. for peroxidase in first and second seasons, respectively) reaching maximum activities after four weeks of storage (0.42 and 0.47 U/gF.W.for polyphenol oxidase, 0.58 and 0.68 U/gF.W.for peroxidase in first and second seasons, respectively). Whereas, both garlic extracts as well as onion ethanolic extract significantly decreased enzymes activity compared to control and different concentrations of onion aqueous extract. The treatment of 15% garlic ethanolic extract gave the lowest values (0.15 and 0.21 U/gF.W.for polyphenol oxidase, 0.31 and 0.39 U/gF.W.for peroxidase in first and second seasons, respectively).

The beneficial effects of garlic extract on fruiting might be attributed to its higher own content of many antioxidants such as organosulfur compounds; sallylcysteine, allinin, diallydisulfide, diallytsulfide ajoene and allicin. Antioxidant action was determined by their ability to scavenge reactive oxygen species and inhibit the formation of lipid peroxidation [30,31,32]. Furthermore, peroxidase activity which involved in different aspects related to growth, such as auxin catabolism, ethylene biosynthesis and cell wall lignification could be altered or inhibited by excess of H_2O_2 [33].

Antifungal activity

Both garlic and onion extracts were effective against *Penicillium expansum* (Figure 1). Generally, garlic was effective more than onion against *Penicillium expansum*. On the other hand, the ethanolic extracts of garlic and onion showed significant better results as compared to the aqueous ones. The inhibition zone was significantly increased by increasing extract concentrations reached the maximum values with the highest concentration (15%). Accordingly, the best significant inhibition was shown by 15% garlic ethanolic extract forming the maximum inhibition zone of 33 mm.

The biological effects of garlic and onion are mainly due to their high content of organosulfur compounds, such as allin and allicin and their breakdown products [34]. In this concern, it was found that, garlic contains nearly three times more sulphur containing compounds as onion [35]. On the other hand, **it was** concluded that, garlic extracts have also been shown to decrease oxygen uptake of microbes, reduce the growth of pathogenic organisms, and to inhibit the synthesis of lipids, proteins and nucleic acids and damage to membranes of microorganisms [36].



L.S.D. 5%: Plant extracts= 0.51 Concentrations= 0.72 Interaction = 1.61

Figure 1. Antifungal activity (mm) of different concentrations (%) of garlic and onion extracts against *Penicillium expansum* (blue mould).

Table (3): Effect of spraying natural plant extracts at different concentrations (%) on pectin (%), polyphenol oxidase (U/gF.wt)and peroxidase activity (U/gF.wt) of apple fruits stored at ambient temperature up to 4 weeks

Treatments		Pectin						Polyphenol oxidase						Peroxidase					
First season																			
Extracts	**Period / Conc.**	**0**	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**	**0**	**1**	**2**	**3**	**4**	**Mean**
Control		0.58	0.66	0.74	0.82	0.89	**0.74**	0.17	0.22	0.28	0.41	0.57	**0.33**	0.32	0.37	0.43	0.57	0.73	**0.48**
Garlic Ethanolic extract	**5**	0.49	0.53	0.65	0.71	0.79	**0.64**	0.07	0.14	0.16	0.27	0.34	**0.19**	0.25	0.28	0.31	0.40	0.51	**0.35**
	10	0.49	0.56	0.66	0.74	0.81	**0.65**	0.05	0.13	0.14	0.25	0.33	**0.18**	0.23	0.27	0.29	0.38	0.49	**0.33**
	15	0.46	0.53	0.61	0.70	0.74	**0.61**	0.02	0.10	0.12	0.22	0.31	**0.15**	0.20	0.24	0.28	0.36	0.47	**0.31**
Garlic Aqueous extract	**5**	0.50	0.54	0.66	0.71	0.81	**0.65**	0.08	0.15	0.16	0.29	0.35	**0.21**	0.26	0.29	0.32	0.42	0.52	**0.36**
	10	0.47	0.54	0.62	0.71	0.78	**0.63**	0.06	0.10	0.14	0.26	0.36	**0.18**	0.24	0.24	0.29	0.39	0.53	**0.34**
	15	0.47	0.52	0.63	0.70	0.78	**0.62**	0.07	0.13	0.18	0.25	0.37	**0.19**	0.25	0.27	0.33	0.38	0.54	**0.35**
Onion Ethanolic extract	**5**	0.53	0.58	0.69	0.76	0.83	**0.68**	0.12	0.19	0.29	0.36	0.50	**0.29**	0.26	0.34	0.42	0.50	0.66	**0.44**
	10	0.52	0.56	0.68	0.74	0.82	**0.66**	0.12	0.13	0.29	0.34	0.35	**0.25**	0.26	0.28	0.42	0.51	0.51	**0.39**
	15	0.51	0.58	0.67	0.73	0.82	**0.66**	0.11	0.13	0.19	0.25	0.35	**0.21**	0.26	0.29	0.32	0.41	0.52	**0.35**
Onion Aqueous extract	**5**	0.55	0.61	0.71	0.79	0.86	**0.70**	0.17	0.20	0.28	0.39	0.55	**0.32**	0.32	0.35	0.41	0.55	0.71	**0.47**
	10	0.55	0.61	0.71	0.80	0.84	**0.70**	0.19	0.26	0.29	0.38	0.52	**0.33**	0.34	0.39	0.42	0.55	0.68	**0.48**
	15	0.54	0.61	0.69	0.78	0.83	**0.69**	0.18	0.27	0.29	0.37	0.50	**0.32**	0.32	0.39	0.43	0.54	0.67	**0.47**
Mean		**0.51**	**0.59**	**0.67**	**0.75**	**0.82**		**0.11**	**0.16**	**0.22**	**0.31**	**0.42**		**0.27**	**0.31**	**0.36**	**0.46**	**0.58**	
L.S.D. 5%		**A=0.014**		**B=0.009**		**AXB=0.032**		**A=0.020**		**B=0.012**		**AXB=0.044**		**A=0.024**		**B=0.015**		**AXB=0.054**	
Second season																			
Control		0.61	0.71	0.76	0.79	0.90	**0.76**	0.22	0.29	0.34	0.46	0.67	**0.39**	0.40	0.44	0.52	0.67	0.90	**0.59**
Garlic Ethanolic extract	**5**	0.43	0.48	0.63	0.72	0.78	**0.61**	0.13	0.21	0.22	0.32	0.39	**0.25**	0.34	0.37	0.40	0.48	0.60	**0.44**
	10	0.44	0.51	0.64	0.74	0.79	**0.62**	0.11	0.16	0.19	0.30	0.39	**0.23**	0.30	0.33	0.38	0.46	0.59	**0.41**
	15	0.40	0.48	0.59	0.70	0.73	**0.58**	0.08	0.18	0.18	0.28	0.35	**0.21**	0.27	0.34	0.36	0.44	0.55	**0.39**
Garlic Aqueous extract	**5**	0.46	0.51	0.65	0.71	0.80	**0.63**	0.14	0.22	0.22	0.34	0.41	**0.27**	0.34	0.39	0.41	0.50	0.61	**0.45**
	10	0.43	0.51	0.61	0.70	0.77	**0.60**	0.12	0.17	0.19	0.31	0.42	**0.24**	0.32	0.33	0.38	0.48	0.61	**0.42**
	15	0.42	0.49	0.61	0.71	0.76	**0.60**	0.12	0.18	0.24	0.30	0.40	**0.25**	0.32	0.33	0.41	0.47	0.61	**0.43**
Onion Ethanolic extract	**5**	0.47	0.51	0.66	0.78	0.82	**0.65**	0.18	0.27	0.35	0.41	0.56	**0.35**	0.34	0.42	0.52	0.58	0.77	**0.53**
	10	0.44	0.51	0.62	0.76	0.80	**0.63**	0.18	0.20	0.35	0.39	0.41	**0.31**	0.34	0.37	0.51	0.60	0.61	**0.49**
	15	0.43	0.49	0.62	0.75	0.80	**0.62**	0.17	0.19	0.25	0.30	0.41	**0.26**	0.34	0.36	0.40	0.50	0.61	**0.44**
Onion Aqueous extract	**5**	0.53	0.60	0.69	0.81	0.84	**0.69**	0.23	0.27	0.34	0.44	0.61	**0.38**	0.40	0.44	0.50	0.65	0.82	**0.56**
	10	0.53	0.59	0.67	0.80	0.83	**0.68**	0.26	0.32	0.35	0.44	0.57	**0.39**	0.43	0.50	0.50	0.64	0.79	**0.57**
	15	0.52	0.59	0.63	0.80	0.82	**0.67**	0.24	0.34	0.36	0.42	0.56	**0.38**	0.41	0.50	0.53	0.62	0.77	**0.57**
Mean		**0.47**	**0.54**	**0.64**	**0.75**	**0.80**		**0.17**	**0.23**	**0.28**	**0.36**	**0.47**		**0.35**	**0.39**	**0.45**	**0.55**	**0.68**	
L.S.D. 5%		**A=0.016**		**B=0.010**		**AXB=0.035**		**A=0.010**		**B=0.007**		**AXB=0.023**		**A=0.026**		**B=0.016**		**AXB=0.057**	

A= Treatments B= Storage period

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