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USE of Some Essential Oils as Safe Alternatives to Conserve Peach Fruits Quality During Shelf Life

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THIS STUDY aimed to evaluate the potential application of essential oils of celery, cinnamon and coriander to determine the antifungal effects of the essential oils against grey mould disease of peach fruits and control postharvest decay under shelf conditions. Three concentrations (600, 800 and 1000 ppm) of the tested essential oils were applied. Chemical composition of the essential oils were identified by GC-MS. Results showed that all of these essential oils application significantly decreased weight loss and decay percentage and increased fruit shelf –life. Also, essential oils, positively, affected postharvest quality factors including total soluble solids, titratable acidity, total soluble sugars and total soluble pectin. It was observed that celery essential oil gave the best effect on the treated fruits followed in a descending order by cinnamon then coriander compared to control.

Peach (*Prunus persica* L.) is one of the most important fruits all over the World. Peaches are highly demanded by the Egyptian consumers. Total area cultivated of peach and nectarines in Egypt amounted to 333487 tons according to the statistics of FAO (2012).

Peaches are susceptible to postharvest decay caused by several pathogenic fungi such as *Botrytis cinerea*, which is one of the major disease of peach. *Botrytis cinerea* (grey mould rot) is a ubiquitous pathogen, causes severe damage in many fruits, vegetables and ornamental crops in pre- and postharvest (Mohammadi and Aminifard, 2012). In nature, essential oils play an important role in plant protection *i.e.* antibacterial, antiviral, antifungal, insecticides and also against herbivores by reducing their appetite for such plants (Bakkali *et al.*, 2008, Isman, 2000 and Burt, 2004). The plant essential oils antimicrobial mode of action' is vary and is still not fully understood (Burt, 2004). However, it could happen through several ways including cell wall deterioration, cytoplasmic membrane injury and leakage of cell contents, membrane protein damage, cytoplasm coagulation, depletion of proton motive force sites, inactivation of essential enzymes and disturbance of DNA and RNA (Burt, 2004 and Ayala-Zavala *et al*., 2008).The volatile oil in celery has been shown to have antifungal activity (Sipailiene *et al.,* 2005). The main constituents in the oil of *Apium graveolens* were limonene, carvone and 3-n-butylphthalide, phthalides, β-selinene, giaveobisides and fatty oil (Amin and Sleem, 2007). Gill and Holly (2004) proposed that cinnamic aldehyde could inhibit the energy metabolism by

depleting ATP in cells, without disturbing the cell membrane. On the other hand, Gupta *et al*. (2008) proposed that the high electronegative nature of cinnamic aldehyde could interfere the biological process by reacting with nucleic acid, proteins, impede the electron transfer and hence, inhibit the growth of microbes. The antifungal activity of the essential oil of *Coriandrum sativum* fruits may be attributed to its main constituents, linalool (58.22%) and geraniol (17.87%). Previous studies of the chemical composition of *C. sativum* fruit essential oil carried out by Pino *et al.* (1996) and Burt (2004) reported that linalool concentrations were 54.57% and 70%, respectively. Antimicrobial activity of linalool against several bacteria and fungi has also been reported (Pattnaik *et al.*, 1997 and Delaquis *et al.,* 2002). Essential oils mainly conjugated to phenolic compounds that accumulate in some plant cells and show useful effect for pathogen control (Plotto *et al.,* 2003). The oxidation products of phlorsidzin (an ortho-dihidroxyphenolic compound) inhibit growth the apple scab fungus *Venturia inaequalsi*. Fungal pectinases hydrolyze pectin, a cell wall compound that is abundant in the middle lamella and plays a role in cell adhesion. Thus, by inhibiting pectinases, the ability of the fungus to hydrolyze and invade the plant cell wall would be compromised (Vermerris and Nicholoson, 2006).

Due to the above mentioned information, this work aimed to control post harvest decay of peach fruits, elongating its market period by spraying fruits with essential oils of celery, cinnamon and coriander.

Materials and Methods

Mature peach fruits of 104 days age from full bloom were picked from a private farm located on Cairo Alex. Desert road in (2012-2013). The fruits were immediately transported to the laboratory, cleaned and packed in perforated carton boxes. Three replicates from each treatment were used for fruit physical and chemical properties determination, sprayed with three concentrations (600, 800 and 1000 ppm) of celery, cinnamon and coriander essential oils and left at ambient temperature (20-30ºC) for 12 days.

Separation of Essential Oils

Essential oils of celery oil (*Apium graveolens*), cinnamon oil (*Cinnamomum zeylanicum*) and coriander oil (*Coriandrum sativum*) were separated by hydro-distillation according to Guenther (1950). The pure volatile oil was injected in Gas Chromatograph Mass Spectrometer (GCMS) model Schimadzu QP-5000 equipped with DB-1 column (30m × 0.25mm × 0.250 Micron film thickness) according to Boniface *et al.* (2012).

Inhibition zone of grey mould

The fungi of *Botrytis cinerea* (grey mould) was grown in petri dishes on potato dextrose agar (pda) medium. The test were repeated on three replicates for two days per treatment [600, 800 and 1000 ppm] for each essential oil (Dhingra and Sinclair, 1985).

Fruit keeping quality under shelf conditions

In each treatment, different measurements were carried out starting from zero-time of shelf-life and continued at intervals of 4 days till the end of 12 days.

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.

Chemical characteristics

Determination of Acidity %

Total acidity as gm of anhydrous citric acid determined and estimated per 100 ml fruit juice, according to A.O.A.C. (1990).

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 dry weight according to the procedure of Aina *et al.* (2012).

Total soluble sugars

Colorimetric determination of total soluble sugars expressed as glucose was determined according to Dubois *et al.* (1956).

Statistical analyses

The obtained data were analyzed according to the method of Duncan (1955). Means were compared using L.S.D. values at 5% level. Means followed by the same letter are not statistically different.

Results and Discussion

Fractionation and identification of celery, cinnamon and coriander essential oils

Essential oil components of celery oil (*Apium graveolens*), cinnamon oil (*Cinnamomum zeylanicum*) and coriander oil (*Coriandrum sativum*) are presented in Table 1.

TABLE 1. Fractionation of celery, cinnamon and coriander essential oils by GCMS.

No	Compound name	Peak area (%)		
		Celery oil	Cinnamon oil	Coriander oil
1	α-pinene	7.4	5.14	6.21
2	β-pinene	9.75	4.99	2.17
3	Myrcene	4.24	3.65	4.54
4	α-terpinene	0.02	---	2.07
5	γ-Terpinene	---	---	6.3
6	δ- terpinene	---	0.9	---
7	p-cymene	4.54	2.65	2.38
8	Limonene	36.76	4.7	5.19
9	Camphor	---	1.43	7.22
10	1, 8 cineole	---	---	3.54
11	Linalool	3.2	---	48.43
12	Geraniol	0.74	0.09	---
13	Geranyl acetate	11.8	---	9.54
14	Apiol	6.45	---	---
15	Citronellol	0.96	---	---
16	β-Ocimene	6.7	---	---
17	Terpineol	4.24	5.23	---
18	β-Caryophyllene	5.4	---	---
19	α-phellandrene	---	4.11	---
20	Cinnamicaldehyde	---	54.65	---
21	Citronellal	---	---	2.41
22	Thymol	---	7.23	---
23	Caryophyllene	---	5.32	---

Data revealed that the main component of celery oil was limonene which recorded 36.76%. Moreover, the oil contained geranyl acetate, β-pinene, α-pinene, β-ocimene and apiol which recorded 11.8, 9.75, 7.4, 6.7 and 6.45%, respectively.

Moreover, data demonstrated that the main component of cinnamon oil was cinnamic aldehyde which recorded 54.65%. The oil, also, contained thymol (7.23%), caryophyllene (5.32%), terpineol (5.23%), α-pinene (5.14%), β-pinene (4.99%), limonene (4.7%), α-phellandrene (4.11%) and myrecene (3.65%).

Furthermore, data showed that the main component of coriander oil was linalool which recorded 48.43%. The oil contained geranyl acetate (9.54%), camphor (7.22%), γ-terpinene (6.3%), α-pinene (6.21%), limonene (5.19%), myrecene (4.54%) and 1,8 cineole (3.54%).

Results are in agreement with Dauksas *et al.* (2002) who stated that the limonene is the main component in celery oil.

Effect of celery, cinnamon and coriander essential oils on inhibition zone of grey mould disease (Botrytis cinerea):

The results presented in Table 2 show that celery, cinnamon and coriander oil in most cases inhibited fungi growth in the test cultures.

TABLE 2. Effect of celery, cinnamon and coriander essential oils on inhibition zone diameter of *Botrytis cinerea* (grey mould) after 2 days.

Plant	Concentration (ppm)	Diameter of inhibition zone (mm)
Control	----	0.0
Celery	600	17
	800	28
	1000	31
Cinnamon	600	20
	800	16
	1000	25
Coriander	600	10
	800	14
	1000	15

Diameter of inhibition zone (mm) resulted from the application by three concentrations of essential oils recorded that celery oil at the tested concentrations (800 and 1000 ppm) inhibited the growth of *Botrytis cinerea* (grey mould) more than any other applications.

The results of the present study are similar to that obtained by Sipailiene *et al.* (2005) who found that chemical composition of celery was active against many bacteria species. Also, Benbelaid *et al.* (2013) stated that *Apium graveolens* have an acceptable inhibitory effect on *Candida albicans*, *Bacillus subtilis* and *Staphylococcus aureus*.

Moreover, the antimicrobial activity of cinnamon is mainly due to the presence of cinnamic aldehyde (3-phenyl-2-propenal) (Zaika, 1988, Gill & Holley, 2004, Ooi *et al.,* 2006, Gupta *et al*., 2008 and Muthuswamy *et al*., 2008).

The essential oil of *Coriandrum sativum* has highest antibacterial activity against the *Staphylococcus aureus, Enterobacter aerogenes, Klebsiella pneumonia, Vibrio cholerae* and *Salmonella typhimerium* (Suganya *et al.,* 2012).

The mode of action of natural plant antimicrobials vary and are still not fully understood (Burt, 2004).

In this respect, Burt (2004) and Ayala-Zavala *et al*. (2009) suggested that natural antimicrobials have several mode of actions including cell wall deterioration, cytoplasmic membrane injury and leakage of cell contents, membrane protein damage, cytoplasm coagulation, depletion of proton motive force sites, inactivation of essential enzymes and disturbance of DNA and RNA.

Effect of celery, cinnamon and coriander essential oils on postharvest quality factors of peach fruits

Table 3 illustrated the effect of using celery, cinnamon and coriander essential oils on decay and weight loss of peach fruits under shelf life conditions.

Concerning the decay % in peach fruits under shelf conditions, the highest decay percentage was noticed in the control treatment after 12 days (100%), however, the lowest decay % is shown with the use of 600, 800 and 1000 ppm of celery essential oil after 12 days (10%) as shown in Table 3 and Fig. 1.

Considering weight loss%, it could be concluded that the highest weight loss % resulted from the control after 12 days (20.5%). On the contrary, the lowest weight loss % was recorded when using celery by 1000 ppm after 12 days (10%).

TABLE 3. Effect of using celery, cinnamon and coriander essential oils on decay and weight loss of peach fruits under shelf conditions.

Treatments	Concentration (ppm)	Decay %				Weight loss %			
		0	4	8	12	0	4	8	12
Control	------	0	24	70	100	0	5.70	12.35	20.5
Celery	600	0	0	4	10	0	1.8	5.8	12.4
	800	0	0	4	10	0	1.4	5.0	11.82
	1000	0	0	6	10	0	2.2	4.2	10.0
Cinnamon	600	0	0	8	24	0	3.4	6.7	12.64
	800	0	0	8	24	0	3.0	6.2	12.9
	1000	0	0	6	20	0	2.5	5.0	11.08
Coriander	600	0	8	28	80	0	4.8	11.09	15.2
	800	0	8	24	70	0	4.2	10.52	14.8
	1000	0	0	16	62	0	4.0	9.41	13.7

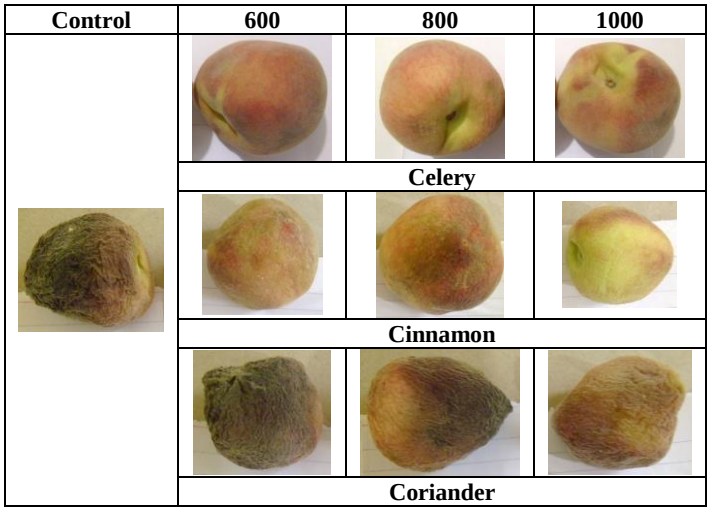

Fig. 1. Effect of celery, cinnamon and coriander essential oils (ppm) on keeping quality of peach fruits after 12 days under shelf conditions.

The effect of using celery, cinnamon and coriander, essential oils on acidity % and T.S.S % of peach fruits under shelf life conditions are presented in Table 4.

TABLE 4. Effect of using celery, cinnamon and coriander essential oils on acidity% and T.S.S% of peach fruits under shelf life conditions.

Treatments	Concentration (ppm)	Acidity% and T.S.S %									
		Acidity%					T.S.S%				
		0	4	8	12	Mean	0	4	8	12	Mean
Control	------	0.995	0.976	0.819	0.768	0.890i	10.07	10.39	10.62	10.78	10.465f
Celery	600	0.996	0.997	0.865	0.832	0.923d	10.10	10.675	10.84	10.97	10.645b
	800	0.998	0.999	0.943	0.803	0.936b	10.07	10.69	10.85	11.07	10.671ab
	1000	0.996	0.985	0.943	0.808	0.933c	10.07	10.70	10.81	11.12	10.675a
Cinnamon	600	0.996	0.980	0.843	0.800	0.905f	10.05	10.56	10.73	10.98	10.581c
	800	0.994	0.993	0.859	0.800	0.912e	10.08	10.52	10.72	10.85	10.542d
	1000	0.995	0.975	0.843	0.804	0.904f	10.07	10.53	10.73	10.85	10.546d
Coriander	600	0.994	0.973	0.821	0.780	0.892h	10.07	10.42	10.63	10.90	10.50be
	800	0.996	0.970	0.833	0.985	0.946a	10.09	10.40	10.60	10.89	10.495e
	1000	0.996	0.994	0.800	0.798	0.895g	10.08	10.47	10.69	10.93	10.543d
Mean		0.996a	0.984b	0.857c	0.817d		10.076d	10.535c	10.722b	10.934a	
L.S.D.at 5%		For interaction 0.004					For interaction 0.0527				

Concerning fruit juice acidity %, results revealed that it is significantly decreased during 12 days for all tested treatments while using coriander oil with concentration of 800ppm significantly resulted in the highest acidity % recording 0.946%. The lowest value is obtained with the control (0.890%) followed by the application of coriander oil at 600 ppm after 12 days (0.892 %).

Regarding T.S.S.%, the results showed significant increase during 12 days. Using celery oil by the concentration of 1000 ppm significantly led to the highest T.S.S. recording 10.675%, however, the control treatment significantly recorded the lowest T.S.S.% (10.465%).

The effect of using celery, coriander and cinnamon essential oils on pectin % and total sugars % of peach fruits under shelf life conditions are presented in Table 5.

TABLE 5. Effect of using celery, cinnamon and coriander essential oils on Total soluble Pectin% and Total soluble sugars% of peach fruits under shelf life conditions.

Treatments	Concentration (ppm)	Total soluble Pectin% and Total soluble sugars%									
		Total soluble Pectin %					Total soluble sugars %				
		0	4	8	12	Mean	0	4	8	12	Mean
Control	------	1.52	1.61	1.78	1.93	1.71a	6.96	6.89	6.91	6.94	6.923h
Celery	600	1.52	1.50	1.67	1.65	1.585f	6.94	7.26	7.33	7.30	7.193bc
	800	1.51	1.52	1.63	1.71	1.593f	6.94	7.30	7.32	7.33	7.202b
	1000	1.51	1.5	1.64	1.74	1.598f	6.93	7.3	7.40	7.37	7.25a
Cinnamon	600	1.51	1.50	1.63	1.82	1.615e	6.91	7.16	7.21	7.27	7.098e
	800	1.52	1.53	1.65	1.79	1.622de	6.95	7.22	7.25	7.26	7.148d
	1000	1.52	1.56	1.66	1.71	1.618e	6.94	7.24	7.29	7.28	7.178c
Coriander	600	1.51	1.47	1.66	1.92	1.645bc	6.95	6.90	6.94	6.98	6.951g
	800	1.51	1.48	1.63	1.91	1.633cd	6.95	6.90	6.96	6.99	6.963g
	1000	1.52	1.51	1.67	1.90	1.65b	6.93	6.89	7.00	7.06	6.983f
Mean		1.519c	1.518c	1.662b	1.808a		6.939d	7.078c	7.161b	7.178a	
L.S.D. at 5%		For interaction 0.0257					For interaction 0.0321				

The obtained data showed that total soluble pectin %, increased gradually during storage period up to 12 days. Results revealed that total soluble pectin% recorded the highest value for control (1.71%), while the lowest value was shown with celery oil at all concentrations.

The data, also, revealed that total soluble sugars % increased gradually up to 12 days. The highest total soluble sugars could be noticed using celery at1000 ppm after 12 days (7.25%), however the lowest total sugars% was recorded with the control treatment after 12 days of shelf life (6.923%).

In this regard, essential oils had positive effects on storage life by reducing fruit decay. Previous reports indicated that fruit decay was reduced during postharvest treatments with volatile compounds in raspberries (Wang, 2003 and Williamson *et al.,* 2007). Essential oils mainly conjugated to phenolic compounds that accumulate in some plant cells and show useful effect for pathogen control (Plotto *et al.,* 2003). It is known that those oxidations products of phlorsidzin (an orhto-dihidroxyphenolic compound) inhibit the growth of apple scab fungus *Venturia inaequalsi*. Fungal pectinases hydrolyze pectin (cell wall compound) is abundant in the middle lamella and plays a role in cell adhesion. Thus, by inhibiting pectinases, the ability of the fungus to hydrolyze and invade the plant cell wall would be compromised (Vermerris and Nicholoson, 2006). It seems that similar role was done by phenolic compound of essential oils. Thus, these findings reveal that essential oils may have a positive influence on shelf life and reducing the peach fruits decay. The effect of essential oils on microbial growth has been reported by Nazzaro *et al*. (2013), who thought it may be the result of phenolic compounds of essential oils that cause the altering of microbial cell permeability by interaction with membrane proteins. Treated fruits with essential oils had more total soluble solids, Total acidity, anthocyanin and carbohydrate content, this study showed that essential oils were effective to maintain fruit quality. Our results are in agreement with previous reports which showed that cinnamon and eucalyptus vapor had significant positive effect on fruit TSS of stored strawberry (Tzortzakis, 2007). Also, Marjanlo *et al.* (2009) reported that titratable acidity of strawberry infected with grey mould, increased with cumin essential oil application. In addation they indicated that essential oils application significantly decreased weight loss percentage. Previous experiments using natural antifungal compounds (eugenol, thymol and menthol vapors) revealed benefits due to reduced weight loss percentage in sweet cherry (Serrano *et al.,* 2005). Similar results were found with eucalyptus and cinnamon oil in strawberry and tomato on reducing weight loss percentage (Tzortzakis, 2007). In fact, there was a linear correlation between ethylene and damage, and, thus, the fungus were responsible for the majority of ethylene production, a part of the basal level typical of non-climacteric fruits. Accordingly, it has been reported that *B. cinerea* produced greater amounts of ethylene as the concentration of conidia inoculated *in vitro* or in the climacteric tomato fruit increased. The respiration rate was clearly affected by the dimension of infection (Cristescu *et al*., 2002).

Conclusion

Essential oils of celery, cinnamon and coriander play an important role in protecting peach fruits against grey mould and maintaining fruit quality during shelf-life thus decreased fruit weight loss and decay percentage.

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إستخدام بعض الزيوت العطرية كبدائل أمنة لحفظ ثمار الخوخ أثناء عمر الرف

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تهدف هذه الدراسة إلي تقييم تطبيق إستخدام الكرفس والقرفه والكسبرة لتقدير التأثير المضاد للفطريات والذي يرجع إلي هذه الزيوت الطيارة ضد مرض العفن الرمادي والذي يصيب ثمار الخوخ والتحكم في التلف الناتج عن معاملات مابعد الحصاد تحت ظروف تخزين الرف. تم إستخدام ثلاثة تركيزات (٦٠٠ و ٨٠٠ و ١٠٠٠ جزء في المليون) من الزيوت الطيارة المستخدمة. تم التعرف علي الزيوت الطيارة بواسطة جهاز التحليل الكروماتوجرافي بمطياف الكتلة. وقد أوضحت النتائج أن كل الزيوت الطيارة أدت إلي حدوث نقص معنوي في الفقد في الوزن ونسبة التالف كما ادت إلي زيادة في عمر الرف للثمار. بالإضافة إلي أن الزيوت الطيارة أثرت تأثيراً إيجابياً علي جودة معاملات ما بعد الحصاد بما يشمل المواد الصلبة الكلية ، الحموضة المعايرة ، السكريات الذائبة الكلية والبكتين الكلي الذائب. وقد لوحظ أن الثمار المعاملة بالزيت الطيار للكرفس أعطت أفضل تأثير علي الثمار المعاملة تلتها في ترتيب تنازلي الزيت الطيار للقرفه ثم زيت الكسبرة بالمقارنة بمعاملة الكنترول.