EFFECT OF SOME NATURAL ESSENTIAL OILS ON CONTROLING SPROUTING OF STORED POTATOES

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Abstract

This investigation was carried out during the summer seasons 2004 and 2005 at Abou Awad Village, Aga, Dakahlia Governorate, to study the efficiency of some natural essential oils (caraway, cumin, celery, fennel, marjoram and peppermint oils), storage condition and their interaction on suppressing of sprouting growth parameters and quality characters of stored potato tubers.

The obtained results demonstrated the high efficiency of cold storage condition in reducing sprouting, sprout length, number of sprouts, weight loss, decay percentage, increasing of dry matter, starch, reducing sugar and non reducing sugar as well as vitamin C, total soluble solid (TSS), total phenols and total free amino acids in both storage seasons.

Sprouting parameters, i.e. sprouting, sprout length, number of sprouts, weight loss gave were greatly suppressed with the natural essential oils specially fennel followed by peppermint oils, while the lowest decay percentage was obtained with cumin oil, in both seasons.

On the other hand essential oils especially fennel and peppermint oils gave the highest values of dry matter, starch, vitamin C, TSS, total phenols and total free amino acids in tuber and the lowest values of reducing sugar and non reducing sugar compared with untreated tubers check in the two seasons.

The positive interaction treatments between storage conditions and natural essential oils were favorable for maintaining better storability, i.e., reduced on sprouting parameters, weight loss, decay percentage, and starch increased, sugars, vitamin C, TSS, total phenols and total free amino acids in both seasons.

Therefore, it could be concluded that the natural essential oils (caraway, cumin, celery, fennel, marjoram and peppermint oils) with cold storage gave the best storability (less sprouting, lest sprout length, lest number of sprout, less weight loss and decay percentage as well as best chemical quality characters compared with room conditions without oil treatment.

In other words, spraying potato tuber by essential oils three times , at the beginning of storage, 40 and 80 days after storage under cold conditions are safety treatments for storing potatoes for processing and fresh consumption.

INTRODUCTION

In general, potatoes are stored for a long time, for both consumption and processing. Sprout control is very important when potato tubers have to be stored for a long period. Sprouting represents a loss of material to the tubers and causes an

accelerated loss of water through the permeable surface of the sprout. Sprout control is in particular important when tubers are stored to be processed into crisps or French fries later in the storage season. Hartmans *et al.* (1995) indicated that essential oils and their major components (monoterpenes) from class of natural compounds which are produced in different parts of various medicinal and aromatic plants, i.e., thyme, caraway, eucalyptus, mint, dill, basal, proved to inhibit the potato sprouting. Bovwmeester *et al.* (1995) showed that the extracted monoterpenes (carvon, carveal, and limonene) from dill and caraway seeds act as sprouting inhibitors in potatoes. Sorce *et al.* (1997) found that treatment of carvone vapor fully inhibited bud growth of potato tubers cv. Monalisa stored at 23°C without affecting bud viability throughout 6 months period. Ali *et al.* (1997) revealed that applying essential oils (caraway, cumin and mustard) to potato tubers in liquid from 5, 10 or 100% emulsions) reduced sprout inhibition and growth. Singh *et al.* (1997) indicated that the essential oils of *Mentha piperata, Mentha spicata, Ocimum americ* and *Carum capticum* as well as s-carvone were effective as sprout suppressant of potatoes stored at relatively higher temperature. Nouri and Hassine (2001) found that there was high efficiency for caraway seed oil in reducing the number of sprouts per tuber of the treated cultivars. Coleman and Greg (2001) observed that neomenthol and for menthone, significantly inhibited sprouting of potatoes when applied alone or together. Chowdhury *et al.*(2002) reported that the applied essential oils on potato stored at room temperature induced significant sprout inhibition (40-60 % inhibition after 6 weeks). Edwards *et al.* (2002) revealed that stored potato tubers at different temperatures (3.3, 8.3 and 10 °C) for 84 days. As expected, low concentrations of sucrose, glucose and fructose were observed in tubers stored at 10°C compared to those stored at 3.3 and 8.3°C.

In principle, sprouting can be controlled by a good temperature regime. When, after the curing period, the temperature is lowered to 2 - 4°C, followed by storage at constant temperature, sprouting will be kept within acceptable limits for a long time. However, at this temperature range the so-called low temperature sweetening may develop, depending on cultivar and previous growth circumstances, leading to a high reducing sugar content which well in turn cause brownish, bitter products when processed. In order to prevent sweetening, storage at higher temperatures (7–8°C) in combination with the application of sprout suppressants is necessary. Kleninkopf *et al.* (2003) indicated that essential oils (caraway, peppermint, spearmint, clove) or their components (s-carvone and eugenol) physically damage the developing sprout and suppress sprout elongation. However, they reported that continuous application of these compounds may be necessary for efficacy.

Frazier*et al.* (2004) used some natural occurring volatiles, i.e., spearmint and peppermint oil (1 Ib oil/5 ton), as well as clove oil (0.52 Ib/5 ton) by fogging to suppress sprouting of potato tubers stored at 45°F for 9 months.

Elsadr and waterer (2005) noticed that natural products including ground dill, ground cloves, clove oil, garlic power, ground peppermint or peppermint oil were able to suppress sprouting of potato tubers.

Carla *et al.* (2006) indicated that carvone produced by both extraction and purification of essential oils from caraway, dill and spearmint seed acted as potato sprouting inhibitor. Tullis and Grove (2006) found that anise (licorice) and clove oils were most effective for inhibiting potato sprouting.

This work aimed to investigate the effect of some natural essential oils on controlling sprout growth of stored potatoes.

MATERIALS AND METHODS

The research was conducted during the two summer seasons 2004 and 2005 on potato (*Solanum tuberosum* L.) cv. Diamant at Abou Awad Village, Aga, Dakahilia Governorate, Egypt.

Seed pieces cv.Diamant were planted on 22th and 25th of January and were harvested on 24th and 27th of May (120 days after planting dates) in 2004 and 2005 seasons respectively. All agriculture practices were applied according to the Ministry of Agriculture recommendations.

Storability

The tubers were placed for curing for two weeks, then they were size graded and those of uniform size (35-55mm), potato tubers were placed in plastic boxes (40x30x25cm). Sixty randomly collected tubers were placed in each box and transported for storage treatments, the whole period of storage was120 days (four months).

The experimental design and treatments

The experimental design was factorial with three replicates. Ambient storage and cold storage (8-10^{0}C and RH 85%) conditions occupied main plots, whereas, the six natural essential oils were within the sub-plots. The experiments included 14 storage treatments. The temperatures and R.H. prevailing at room temperature conditions are shown in Table (1).

Table 1. Monthly room temperature and relative humidity during 2004 and 2005 seasons.

Months	Mean temperature (0C)		Relative humidity (%)	
	2004	2005	2004	2005
May	27.85	23.07	60.59	60.94
June	29.63	25.57	67.02	66.20
July	29.14	28.63	70.78	69.15
August	31.46	27.59	70.95	69.13
September	26.45	24.02	66.02	65.06

The natural essential oils treatments were

1- Caraway 3 ml/l.

2- Cumin 3 ml/l.

3- Celery 2 ml/l.

4- Marjoram 2 ml/l.

5- Mint (peppermint) 2 ml/l.

6- Fennel 3 ml/l.

7- Check.

The essential oils were emulsified by Tween 20 at dose 1 ml/l and sprayed three times regular intervals, i.,e., by using manual sprinkler at the beginning of storage, the second and the third were applied at 40 and 80 days after storage.

Essential oils extraction

The essential oils were collected from seeds of Caraway, Cumin, Celery and fennel while the essential oils of peppermint and marjoram plants collected from fresh herb on the first of May 2004 in the Laboratory of Medicinal and aromatic Plant Research Department, Horticulture Research Institute, A.R.E. Ministry of Agriculture. The essential oil was determined according to the method described in British pharmacopoeia (1963).

Gas liquid chromatography (GLC) method was used for the analyses of the essential oils. The main constitutes, are shown in Table (2).

Table 2. Main components of some natural essential oils.

Type of oil	Main components	%
Caraway	Carvone	32.48
	Limonene	27.02
	Y-Terpinene	12.24
	Dihydrocaveol	7.95
Cumin	Cumin aldehyde	25.01
	1,3-p-menthadien-7-al	20.15
	1,4-p-menthadien-7-al	9.91
	3-p-menthien-7-al	8.67
Celery	Limonene	72.24
	Selinene	11.17
	Phthalides	2.89
Fennel	Trans-Anethole	33.66
	Fenchone	24.34
	Limonene	15.63
	Estragole	8.07
	Eugenol	7.32
Marjoram	Terpinen-4-ol	28.49
	α-terpinene	20.17
	Y-terpinene	10.55
	Cineole	6.8
	Sabinene	5.84
Peppermint	Menthol	72.12
	Menthone	10.12
	Cineole	2.04

Data recorded

After 120 days sprouting(%),sprout length, number of sprouted eyes, weight loss (%) and decay (%) were determined. Ten tubers were marked and weighted at the beginning and the end of storage to recorded weight loss.

Dry matter (%), starch (%), reducing sugars, non reducing sugars, total soluble solids (TSS) by refractmeter, vitamin C, total phenols and total amino acids were estimated.

The data were statistically analyzed and means were compared by using L.S.D test described by Comez and Comez (1984).

RESULTS AND DISCUSSION

A. Sprouting, weight loss and decay

I. Effect of storage conditions

The results in Table (3) It is clear that, potato tubers which held at cold storage condition greatly controlled the incidence of sprouting, sprout length, number of sprouts, weight loss and decay percentage compared with room storage conditions in the two seasons. This result may be accounted to the respiration of the sprouts themselves, consequently heat output and moisture loss is much greater in potatoes that have sprouted. Hunter (1986) showed that the increase due to sprouting depended on the storage period and temperature.

II. Effect of natural essential oils

Data in Table (3) reveal that the tested natural essential oils (caraway, cumin, celery, marjoram, peppermint and fennel oils) were very effective for reducing sprouting, sprout length, number of sprouts, weight loss and decay percentage compared with the untreated (check treatment) in the two seasons.

Tubers treated by fennel and peppermint oils recorded the minimum values of sprouting percentage, sprout length, number of sprout and weight loss percentage compared to other oil treatments.

The highest decay percentage was obtained with untreated check treatment (8.41 and 8.88) while the lowest (1.52 and 1.49) was shown with cumin oil, in the two seasons, respectively.

The applied essential oils such as caraway, cumin, celery, marjoram, peppermint and fennel are rich in major monoterpens, i.e., carvone, limonene, Y-terpinene, cumin aldehyde, 1,3-p-menthadien-7-al, selinene, trans-Anethole, fenchone, terpinen-4-ol, α-terpinene, menthol and menthone, Table(2) beside their volatility nature, were found to have suppressive effect on sprouting and weight loss as reported by Coleman and Greg (2001), Kleninkopf *et al.* (2003) and Carla *et al.* (2006). They suppressed sprouting of tubers via their inhibitional role on mitochondrial respiration (Lorber and Muller, 1980), reducing carbohydrate degradation and sugars to provide energy and structural components for the rapidly developing sprout tissues. Thus, sprout act as a powerful sink to the mobilized sugars (Frazier *et al.* 2004). Besides, essential oils (caraway, cumin and peppermint) inhibited HMGR-enzyme system, this main key enzyme of mevalonate pathway in potato tuber at low concentration, known to be the main pathway of gibberellin biosynthesis which closely related with the sprouting and dormancy, (Ali *et al.* 1997 , Tullis and Grove, 2006). Chowdhury *et al.*(2002) showed that carvacrol containing essential oils were strong antimicrobial infection agents.

Table 3. Effect of natural essential oils and storage condition on sprouting percentage, sprout length, number of sprouts, weight loss and decay percentage of potato tuber during the two seasons 2004 and 2005.

Treatments		Sprouting (%)				Spout length (cm)				Number of sprouts				Weight loss(%)				Decay (%)			
		2004		2005		2004		2005		2004		2005		2004		2005		2004		2005	
Storage condition																					
		5.61	a	5.22	a	0.98	a	0.97	a	3.57	a	3.69	a	3.47	a	3.69	a	3.79	a	3.94	a
Cold storage		2.39	b	2.11	b	0.55	b	0.55	b	2.64	b	2.67	b	2.49	b	2.47	b	1.52	b	1.47	b
Essential oil																					
Caraway oils	(3ml/l)	2.50	cd	2.34	cd	0.68	c	0.67	c	2.80	bc	2.77	cd	2.21	bc	2.25	c	1.63	cd	1.56	b
Cumin oil	(3ml/l)	2.87	bc	2.73	c	0.64	c	0.63	c	2.74	bc	2.72	cd	2.36	bc	2.32	bc	1.52	d	1.49	b
Celery	(2ml/l)	3.42	b	3.43	b	0.79	b	0.83	b	3.02	b	3.06	b	2.59	b	2.64	b	1.73	bc	1.75	b
Majoram oil	(2ml/l)	2.78	bc	2.91	bc	0.64	c	0.63	c	2.77	bc	2.85	c	2.39	bc	2.36	bc	1.77	bc	1.72	b
Mint oil	(2ml/l)	1.99	de	1.91	de	0.50	d	0.50	d	2.79	bc	2.73	cd	2.15	bc	2.11	c	1.81	b	1.82	b
Fennel oil	(3ml/l)	1.69	e	1.50	e	0.30	e	0.28	e	2.50	c	2.63	d	1.96	d	2.02	c	1.71	bc	1.74	b
Check		12.77	a	10.84	a	1.79	a	1.80	a	5.10	a	5.49	a	7.21	a	7.86	a	4.81	a	8.88	a
Storage condition X Essential oils																					
Ambient storage temperature																					
Caraway oil	(3ml/l)	3.42		3.15		0.93		0.88		3.12		3.10		2.27		2.23		2.08		2.01	
Cumin oil	(3ml/l)	3.89		3.73		0.81		0.77		3.14		3.16		2.51		2.43		1.98		1.91	
Celery	(2ml/l)	4.88		4.84		1.02		1.08		3.53		3.53		2.95		2.96		2.09		2.11	
Majoram oil	(2ml/l)	3.97		4.08		0.76		0.77		3.10		3.18		2.71		2.70		2.05		1.96	
Mint oil	(2ml/l)	3.08		3.07		0.59		0.59		3.27		3.22		2.34		2.31		2.19		2.18	
Fennel oil	(3ml/l)	2.82		2.44		0.35		0.30		2.85		3.12		2.10		2.29		2.16		2.19	
Check		17.21		15.22		2.38		2.42		5.95		6.48		9.38		10.89		13.97		15.21	
Cold storage temperature (8-10^{0}C)																					
Caraway oil	(3ml/l)	1.58		1.52		0.43		0.46		2.47		2.44		2.15		2.26		1.18		1.12	
Cumin oil	(3ml/l)	1.84		1.72		0.47		0.49		2.34		2.27		2.20		2.20		1.06		1.06	
Celery	(2ml/l)	1.96		2.02		0.55		0.57		2.51		2.58		2.24		2.31		1.36		1.38	
Majoram oil	(2ml/l)	1.60		1.73		0.51		0.48		2.43		2.52		2.07		2.01		1.50		1.48	
Mint oil	(2ml/l)	0.90		0.74		0.40		0.40		2.31		2.23		1.96		1.90		1.43		1.45	
Fennel oil	(3ml/l)	0.57		0.57		0.25		0.25		2.15		2.14		1.81		1.76		1.26		1.29	
Check		8.32		6.47		1.20		1.17		4.24		4.51		5.03		4.83		2.84		2.54	
F Test		**		**		**		**		*		**		**		**		**		**	
LSD	5%	0.862		0.766		0.083		0.100		0.416		0.205		0.503		0.382		0.173		0.471	
	1%	1.168		1.038		0.112		0.135		0.564		0.278		0.682		0.517		0.235		0.639	

III. The interaction between storage conditions and essential oils

Data in Table (3) show that essential oils had a significant effect on sprouting percentage, sprout length, number of sprouts, weight loss and decay percentage in the two seasons. The same data illustrated tubers kept at cold storage conditions for 4 months with spraying essential oils were of lesser sprouting (>2%), sprouting incidence with sprout length (>0.58cm), number of sprouts, weight loss (>2%) and decay percentage (>2%) compared with those storage room temperature and sprayed with essential oils. The best result were obtained when used fennel oil flowed peppermint oil with cold storage temperature at (8-10°C) in combination with the application of suppressants is necessary. These results are agreement with those obtained by Singh *et al.* (1997), Sorce *et al.* (1997) and Chowdhury *et al.* (2002).

B. Chemical composition

A Dry matter and carbohydrates

I. Effect of storage temperature

Data presented in Table (4) reveal that potato tubers stored under cold storage had the maximum values of dry matter, starch, reducing sugar and non reducing sugar content compared with ambient room storage conditions in the two seasons. These results may be explained based on cold storage promotes cold increasing membrane permeability, inducing starch breakdown followed by sugars accumulation within tubers due to the inactivation of cold labiled glycolytic enzymes, phosphotrans ferase (Hartmans *et al.* 1995 and Edwards *et al.* 2002).

II. Effect of natural essential oils

Data illustrated in Table (4) show the there were significant increasing effects for the natural essential oils (caraway, cumin, celery, marjoram, peppermint and fennel) on dry matter and starch content in both seasons. The fennel oil showed the highest values of dry matter and starch contents, but there were no significant differences between fennel and peppermint oils expect for dry matter in the second seasons. The results indicated that the essential oils decreased both reducing sugar and non reducing sugars.

As for reducing and non reducing sugar compared with check untreated treatment in both seasons. This beneficial effect could be superior due to essential oils and/or major components (monoterpens), slow down the activity of carbohydrates, inhibit the activity of the internal biochemical reactions of potato tubers and respiration processing as well as energy metabolism enzymes. These results are in correspondence with those obtained by Bovwmeester *et al.* (1995), Frazier *et al.* (2004) and Tullis and Grove (2006).

III. The interaction between storage temperature and essential oils

Data in Table (4) clear, also, that starch and non reducing sugar were significantly influenced by the interaction in the second season and the reducing sugars in the first season, while dry matter was not significantly in affected both seasons.

b. Vitamin C, TSS, phenols and free amine acid contents

I. Effect of storage condition

Data recorded in Table (5) indicated that vitamin C, total soluble solid (TSS), total phenols and total free amino acids were significantly higher in tubers stored at cold storage compared with those stored at room conditions this might be explained that at cold storage the activity of respiration or degradable enzymes, are lower compared to room storage the internal bioconstituents and tuber quality (Hartmans *et al.*, 1995 and Edwards *et al.*, 2002).

II. Effect of natural essential oils

Data in Table (5) demonstrated clearly that vitamin C, TSS, total phenols and total free amino acids were significantly higher by the treatments essential oils (caraway, cumin, celery, marjoram, peppermint and fennel) in both seasons. The highest values of vitamin C, TSS, total phenols were observed when tubers were treated by fennel followed in decreasing order by mint oils respectively. The results might be attributed to that these essential oils specially fennel followed peppermint oil reduced sprouting, weight loss, (Table 3) beside the preservation of dry matter, starch and sugars in (Table 4). The obtained results are in harmony with those reported by Kleninkopf *et al.*, (2003) and Elsadr and Waterer, (2005).

Table 4. Effect of essential natural oils on stored potatoes and their interaction on dry matter %, starch %, reducing sugar and non reducing sugar during the two seasons 2004 and 2005.

Treatments		Dry matter %				Starch %				Reducing sugars				Non reducing sugar			
		2004		2005		2004		2005		2004		2005		2004		2005	
Storage temperature																	
Ambient storage temperature		17.79	b	17.84	b	12.72	b	12.71	b	0.47	b	0.47	b	0.88	b	0.86	b
Cold storage temperature (8-10°C)		20.12	a	20.05	a	14.62	a	14.63	a	0.93	a	0.92	a	1.34	a	1.33	a
Essential oil																	
Caraway oils	(3ml/l)	19.93	ab	19.66	b	14.14	bc	14.10	b	0.67	b	0.67	b	1.13	b	1.06	b
Cumin oil	(3ml/l)	19.43	b	19.52	b	14.15	bc	14.20	b	0.68	b	0.67	b	1.09	bc	1.09	b
Celery	(2ml/l)	19.25	b	19.53	b	13.76	c	13.64	c	0.64	bc	0.66	b	1.09	bc	1.08	b
Majoram oil	(2ml/l)	19.29	b	19.33	b	13.91	c	14.00	b	0.62	cd	0.63	bc	1.05	cd	1.05	b
Mint oil	(2ml/l)	19.93	ab	19.53	b	14.48	ab	14.56	a	0.62	cd	0.59	c	1.04	cd	1.05	b
Fennel oil	(3ml/l)	20.50	a	20.69	a	14.68	a	14.64	a	0.58	d	0.58	c	1.02	d	1.03	b
Control		14.34	c	14.37	c	10.57	d	10.56	b	1.11	a	1.05	a	1.38	a	1.33	a
Storage temperature X Essential oils																	
Ambient storage temperature																	
Caraway oil	(3ml/l)	18.58		18.13		13.42		13.43		0.39		0.42		0.88		0.81	
Cumin oil	(3ml/l)	18.34		18.25		13.23		13.27		0.43		0.44		0.86		0.81	
Celery	(2ml/l)	18.37		18.58		12.83		12.68		0.44		0.44		0.83		0.82	
Majoram oil	(2ml/l)	18.32		18.32		12.86		12.97		0.42		0.40		0.83		0.83	
Mint oil	(2ml/l)	18.50		18.42		13.58		13.69		0.39		0.36		0.81		0.83	
Fennel oil	(3ml/l)	19.10		19.47		13.63		13.65		0.37		0.37		0.80		0.83	
Control		13.30		13.73		9.48		9.28		0.83		0.83		1.15		1.10	
Cold storage temperature (8-10°C)		21.28		21.19		14.87		14.76		0.94		0.92		1.37		1.31	
Caraway oil	(3ml/l)	20.51		20.79		15.06		15.13		0.93		0.90		1.31		1.36	
Cumin oil	(3ml/l)	20.13		20.48		14.68		14.60		0.84		0.89		1.34		1.34	
Celery	(2ml/l)	20.27		20.33		14.96		15.02		0.82		0.85		1.28		1.26	
Majoram oil	(2ml/l)	21.37		20.63		15.38		15.43		0.84		0.82		1.26		1.26	
Mint oil	(2ml/l)	21.90		21.90		15.73		15.63		0.79		0.78		1.23		1.23	
Fennel oil	(3ml/l)	15.38		15.01		11.65		11.83		1.39		1.28		1.60		1.55	
Control		ns		ns		ns		**		**		ns		ns		*	
F Test																	
LSD	5%	--		--		--		0.376		0.051		--		--		0.060	
	1%	--		--		--		0.509		0.69		--		--		--	

Table 5 . Effect of essential natural oils on stored potatoes and their interaction on vitamin C, T.S.S, total phenols and total amino acids during the two seasons 2004 and 2005.

Treatments		Vitamin C (mg/100gFW)				T.S.S.				Total phenols (mg/100g)				Total free amino acids (mg/100g)			
		2004		2005		2004		2005		2004		2005		2004		2005	
Storage temperature																	
Ambient storage temperature		7.91	b	7.80	b	6.02	b	6.03	b	2.16	b	2.16	b	123.6	b	127.3	b
Cold storage temperature (8-10^{0}C)		10.47	a	10.53	a	7.73	a	7.77	a	2.61	a	2.57	a	138.7	a	142.8	a
Essential oil																	
Caraway oils	(3ml/l)	9.06	b	9.11	b	7.07	b	7.12	b	2.48	b	2.39	c	141.3	ab	148.7	a
Cumin oil	(3ml/l)	9.25	b	918	b	7.04	b	7.05	bc	2.35	c	2.29	d	138.5	ab	139.5	b
Celery	(2ml/l)	8.97	b	8.83	b	6.89	c	6.96	c	2.16	d	2.24	d	129.1	b	129.8	c
Majoram oil	(2ml/l)	8.94	b	9.08	b	6.89	c	6.93	c	2.32	c	2.33	cd	130.9	b	131.0	c
Mint oil	(2ml/l)	9.98	a	9.78	a	7.26	a	7.27	a	2.55	b	2.50	b	139.0	ab	141.6	b
Fennel oil	(3ml/l)	10.04	a	10.04	a	7.35	a	7.31	a	2.74	a	2.73	a	147.6	a	151.2	a
Control		8.10	c	8.11	c	5.63	d	5.67	d	2.09	d	2.09	e	91.8	c	103.7	d
Storage temperature X Essential oils																	
Ambient storage temperature																	
Caraway oil	(3ml/l)	7.93		7.99		6.31		6.35		2.32		2.29		133.2		141.8	
Cumin oil	(3ml/l)	8.02		7.92		6.31		6.28		2.24		2.25		140.1		135.3	
Celery	(2ml/l)	8.04		7.86		6.12		6.17		2.01		2.03		121.2		124.9	
Majoram oil	(2ml/l)	8.02		7.82		6.11		6.18		2.10		2.10		122.5		126.2	
Mint oil	(2ml/l)	8.17		7.93		6.51		6.55		2.25		2.20		131.2		131.5	
Fennel oil	(3ml/l)	8.24		8.18		6.59		6.50		2.36		2.36		139.9		138.7	
Control		6.91		6.87		4.18		4.20		1.85		1.88		77.1		92.5	
Cold storage temperature (8-10^{0}C)																	
Caraway oil	(3ml/l)	10.19		10.22		7.83		7.89		2.63		2.50		149.3		155.6	
Cumin oil	(3ml/l)	10.47		10.44		7.76		7.82		2.46		2.33		137.0		143.6	
Celery	(2ml/l)	9.91		9.80		7.67		7.75		2.31		2.44		137.0		134.6	
Majoram oil	(2ml/l)	9.85		10.33		7.67		7.67		2.54		2.57		139.2		135.7	
Mint oil	(2ml/l)	11.78		11.64		8.01		7.98		2.86		2.79		146.9		151.6	
Fennel oil	(3ml/l)	11.83		11.90		8.10		8.11		3.12		3.10		155.4		163.6	
Control		9.28		9.35		7.08		7.15		2.33		2.30		106.4		114.9	
F Test		**		**		**		**		**		**		ns		**	
LSD	5%	0.414		0.674		0.122		0.148		0.144		0.119		15.734		6.464	
	1%	0.561		0.913		0.165		0.201		0.195		0.162		21.322		8.760	

III. The interaction between storage conditions and essential oils

The effect of the interaction between storage condition and essential oils, as recorded in Table (5), was significant on vitamin C, TSS, total phenols and total free amino acids in the two seasons.

The lowest values of vitamin C, TSS, total phenols and total free amino acids were recorded in tubers stored under room storage conditions without any essential oil treatment.

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تأثير بعض الزيوت العطرية الطبيعية على التحكم فى تزريع البطاطس المخزنة

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أجرى هذا البحث خلال موسمين صيفيين ٢٠٠٤، ٢٠٠٥ فى قرية أبو عوض، مركز أجا، بمحافظة الدقهلية، لدراسة فعالية بعض الزيوت العطرية الطبيعية (الكراوية، الكمون، الكرفس، الشمر، البردقوش، النعناع الفلفلى) وظروف التخزين وتفاعلاتها على تثبيط التزريع وصفات جودة درنات البطاطس صنف دايمونت.

أوضحت النتائج المتحصل عليها أن التخزين المبرد فعال حيث نتج عنه انخفاض فى نسبة التزريع، وطول وعدد النبوت، والفقد فى الوزن ونسبة التالف مع زيادة نسبة المادة الجافة والنشا والسكريات المختزلة وغير المختزلة، بالإضافة إلى فيتامين C والمواد الصلبة الذائبة، المركبات الفينولية الكلية والأحماض الأمينية الكلية الحرة، مقارنة بالتخزين على درجة الحرارة العادية وذلك خلال موسمى التخزين.

أعطت قياسات التزريع (نسبة النبوت، طول النبت، عدد النبت)وكذا نسبة الفقد فى الوزن أعلى معدل لتثبيطها عند استخدام الزيوت الطبيعية (زيت الشمر، يليه زيت النعناع) بينما أقل نسبة ضرر حصل عليها من المعاملة بزيت الكمون فى كل من موسمى الدراسة. من ناحية أخرى الزيوت العطرية وخاصة الشمر والنعناع أعطت أعلى قيم من المادة الجافة والنشا وفيتامين C والمواد الصلبة الذائبة، والفينولات الكلية والأحماض الأمينية الكلية الحرة وأقل القيم السكريات المختزلة وغير المختزلة مقارنة بالكنترول خلال موسمي التخزين.

كان التفاعل بين ظروف التخزين (الغرفة العادية والثلاجة) والزيوت العطرية الطبيعية ذو تأثير معنوى موجب على قابلية الدرنات للتخزين (صفات النبت والفقد فى الوزن ونسبة الضرر والنشا والسكريات غير المختزلة فى الموسم الثانى والسكريات المختزلة فى الموسم الأول بالإضافة إلى محتوى فيتامين C والمواد الصلبة الذائبة والمركبات الفينولية الكلية والأحماض الأمينية الكلية الحرة فى كل من الموسمين).

وبذلك وجد أن استخدام الزيوت العطرية الطبيعية (الكراوية، الكمون، الكرفس، البردقوش، النعناع، والشمر) مع التخزين المبرد أعطت أحسن قابلية للتخزين مع أقل نسبة تزريع وطول وعدد النبوت وأقل فقد فى الوزن والضرر، بالإضافة إلى تحسين صفات الجودة للدرنات، مقارنة بالغير معاملة بالزيت.

فى النهاية نوصى برش درنات البطاطس المخزنة بالزيوت العطرية ثلاث مرات الأولى عند بدء التخزين ثم بعد ٤٠،٨٠ يوم من التخزين، مع التخزين فى مخازن مبردة. بالإضافة إلى أن هذه المعاملات آمنة لتخزين درنات بطاطس التصنيع والاستهلاك الطازج.