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Efficacy of Different Applications of Spearmint Oil on Storability and Processing Quality of two Potato Varieties

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ABSTRACT

The effect of spearmint oil on the storage period, processing and organoleptic qualities was investigated on Diamant and Sinora potato varieties. Different applications of spearmint oil were carried out to inhibit potato sprouting during the storage period, e.g., spraying of spearmint oil in the field, evaporation of spearmint oil in cold store and combination treatments of spraying spearmint oil in the field coupled with evaporation in cold store. Potato tubers were stored at 10±1°C (76-78% RH) for 6 months. The application of spearmint oil in the field exhibited early break of dormancy, fast sprout growth, high fresh weight loss and high sugar accumulation. The combination treatments of spraying spearmint oil in the field coupled with evaporation in cold store controlled the sprouts till the third month of storage. Application of spearmint vapor in cold store suppressed potato sprouting till the end of the storage period. The spearmint oil had no adverse effects on reducing sugars, dry matter and chips yield of potatoes. After storage for six months, both potato varieties were still suitable for making chips and French fries. Chips made from Sinora and Diamant tubers treated with spearmint oil in cold store were chosen by assessors as superior products

Keywords:. *Different Applications, Spearmint Oil, Storability, Processing Quality, Potato.*

INTRODUCTION

There is an increasing demand for potato (*Solanum tuberosum* L.) in Sudan as a result of urbanization, awareness on nutritional value, need for processing and as a highly rewarding crop for farmers (Khalfalla, 2004). Among the post-harvest problems that face potato cultivation in Sudan is the early sprouting varieties that suit the limited winter season. The problem faces both ware and processing varieties as sprouting leads to huge losses during storage season (Hironaka, 2001). It is more critical in the processing varieties which are stored at a relatively higher temperature compared with the ware potatoes (10 °C vs. 4 °C). Processing varieties are stored at a high temperature to slow down the accumulation of reducing sugars which are unacceptable for processing as they produce sweet taste and dark chips or French fries (Burton 1989; Verma 1991).
Lately, other environmentally friendly plants products are added as sprout inhibitors e.g. spearmint oil (Oosterhaven, 1995a and Sorce, 1997). Spearmint oil has been used successfully as a biological sprout inhibitor to prevent sprouting in potatoes for extended storage periods (Coleman, 2001). This oil, which is extracted from mint plants, is effective in maintaining a sprout-free condition in stored potatoes.

Therefore, the bio-efficacy of spearmint oil on storage behavior of various commercial varieties of potato grown under climatic conditions of Sudan needs to be explored.

This study handles the problem of sprouting inhibition using spearmint oil in different applications on early sprouting varieties, Diamant and Sinora (NIVAA, 2003). In addition, the effect of spearmint use on the processing quality and consumer acceptability was also studied.

MATERIALS AND METHODS

Materials

Planting was carried out at Elshek Eltayb (75 kilometers North Omdurman) in the western bank of the Nile. Diamant and Sinora varieties were grown in a farmer's field. Agronomic practices including regular weeding, earthing up, fertilization, irrigation and regular spraying against white flies, jassids and aphids were done as needed (Khalfalla, 2004).

Prior to harvest (70 days from planting) about 160 ridges from each variety were sprayed as follows; 80 ridges with spearmint oil concentration of, 0.1 ml /L, and the other 80 ridges with water using the manual sprayer. Yield from ridges sprayed with water was used for spearmint treatment in the cold store and control treatment. Yield from ridges sprayed with spearmint oil was used for field treated and double application in field and store. The trial was harvested 100 days after planting and all tubers were cured for 10 days in the field in shallow pits " Boata" covered with potato vines.

Potatoes for different treatments were packed in jute sacks and kept in cold store (10 ± 1 °C) at Food Research Center with relative humidity (RH) maintained at 76-78 %.

Methods

Treatments

The extraction of Spearmint oil was done according to Guenther (1948). The stored potatoes were divided into four groups; group (1) tubers treated with spearmint oil in field; group (2) tubers treated with spearmint oil in cold store; group (3) tubers treated with spearmint oil both in field and cold store group (4) tubers treated with water in the field (control treatment). The spearmint oil was applied to Diamant and Sinora varieties at the beginning of the storage period. Store treatments of spearmint oil were carried out as follows; Disease-free tubers uniform-sized (medium size equatorial diameter) were selected. The tested tubers were placed equally in 36 plastic containers volume of 18L. The spearmint oil was applied to a 10 cm filter paper disk which was attached to the lid of the container to prevent the spearmint oil from coming into direct contact with the potatoes. The lids of all containers were sealed immediately after application of the treatments. The lids were then removed for ten minutes every 2-3 days to allow gas exchange with the respiring potatoes. The application of the spearmint oil was repeated every 45 days for 6 months.

Physiochemical testing:

Tubers physiological testing was done during the cold storage period for sprout emergence (%), sprout length (cm/tuber), fresh weight loss (%) , dry matter content which was measured in all tested tubers using the potato Hydrometer (APH Group,Holand) method (Smith, 1975). The reducing sugars were determined in the tuber extract according to the technique described by Nelson (1944) as modified by Somogyi (1952).

Processing quality of tuber chips yield (%) was recorded during the storage.

Organoleptic quality of potato products

As a standard procedure, about 300 g slices of potato stored for 6 months were fired in sunflower seed oil at 170ºC in a deep fryer till the bubbling stopped (about 6 min). The fried chips were drained off to remove excess oil and then weighed to determine the tubers yield (%) Sandhu (2002). Twelve semi- trained assessors were provided chips and asked to evaluate the general appearance, flavor (odor & taste), texture, after taste and overall quality by the ranking method of Ihekoronye and Ngoddy (1985).

Statistical analysis

Data generated was subjected to statistical Analysis System (SAS**[2010]**). Two-factors Analysis of Variance (CRD*)* was performed; where factor A (treatments) and factor B (storage period - months). Means were separated using Duncan's Multiple Range Test (DMRT) at 5% level of significance.

RESULTS AND DISCUSSION

Emergence of sprouts

Table 1. shows the effect of different applications of spearmint oil on sprout emergence (%) in Diamant and Sinora potato varieties stored for six months (76-78% RH). Differences in emergence of sprouts (%) or dormancy length were observed among these tubers. The untreated tubers of Diamant variety showed excessive sprouting in the first month of the storage compared to

the untreated tubers of Sinora which commenced in the third month of the storage period. This would indicate that the dormancy period in potatoes differs with variety (Hironaka, 2001).

Tubers treated with spearmint oil in field showed emergence of sprouts in the first month of the storage, with maximum emergence of sprouts (100 %) recorded in Diamant against 13.03 % recorded in Sinora (Table .1). It seems that the method of application is critical in inducing the positive effect of spearmint oil (Frazier, 2004).

The combination treatment of spraying spearmint oil in field and - then evaporation in cold store seemed to have controlled the emergence of sprout up to the third month of storage in both varieties. No emergence of sprouts was observed on tubers treated with spearmint oil in cold store throughout the storage period. This application was very effective in controlling the emergence of sprouts in both Sinora and Diamant potato varieties (Table .1). The evaporation of spearmint oil in cold store was reported earlier to suppress completely the emergence of sprouts in all treated tubers (Beveride et al. 1981a; 1983).

Sprout length

Table .2 shows the effect of different applications of spearmint oil on sprout length (cm/tuber) in Diamant and Sinora potato varieties during six months storage (76-78% RH). The sprout length increased with progress in storage period, irrespective of the applications. No significant difference ($P \leq 0.05$) was observed in the sprout length of untreated tubers and tubers treated with spearmint oil in field in Diamant and Sinora tubers. They followed identical trend throughout the storage period, showing significant ($P \leq 0.05$) sprout length in the sixth month compared to other applications (plates 1,2,5and 6).

The double application of spraying spearmint oil in field and evaporation in store performed well in both potato varieties, giving negligible sprout length over the storage period (plates 3 and 7).

Spearmint oil evaporated in cold store controlled the sprouts throughout the storage in all tubers treated irrespective of potato variety (Plates 4 and 8). Spearmint oil was reported earlier to suppress completely potato sprouts (Fraizer, 2000), and also has been used successfully to prevent sprouting in potatoes for extended storage periods (Coleman, 2001).

Fresh weight loss

Table 3 shows the effect of different application of spearmint oil on weight loss (%) in Diamant and Sinora potato variety during six months storage (76-78% RH). The fresh weight loss gradually increased with time of storage in all tubers. In the sixth months of storage, significant ($P \leq 0.05$) fresh weight loss was observed on untreated tubers and tubers treated with spearmint oil in field in both potato varieties. The application of spearmint oil in cold store demonstrated a significantly ($P \leq 0.05$) lower fresh weight loss than all other applications.

Dry matter content

No significant differences ($P \leq 0.05$) were observed in dry matter content ($P \leq 0.05$) among the treated tubers in Diamant variety all over the storage period (Table .4). Also, no significant changes ($P \leq 0.05$) were observed in dry matter content of Sinora tubers treated with spearmint oil in cold store up to the end of the storage period. The dry matter content of treated tubers remained within the suitable range of processing (20-24%) as recommended by Hesen, (1979).

Reducing sugar content

Table .6 shows the effect of different applications of spearmint oil on changes in reducing sugars content (mg/100g) in Diamant and Sinora potato varieties during six months storage at 10 °C (76-78 % RH). There were significant ($P \leq 0.05$) differences among the treatments with respect to the changes in reducing sugars level with time. In all tubers tested, and irrespective of the treatment, a rise in reducing sugars level was observed clearly at sixth month of the storage period which also confirmed previous reports on the subject (Brown, 1990; Pritchard, 1992; McSay, 2003).

Among the applications, the control tubers exhibited significantly ($P \leq 0.05$) higher reducing sugars accumulation tendency in both potato varieties. Mahmoud (1973) found that reducing sugars content increased in treatments that had a high percentage of infected and sprouted tubers.

Tubers treated with spearmint oil in cold store comparatively had lower reducing sugars accumulation tendency throughout storage and were found suitable for making potato chips.

The treatments of spearmint oil; evaporated in store or the combined one, did not cause any processing quality changes such as altering tuber sugar profile. The sugars content of them were 0.226% and 0.218%, respectively, in Diamant and 0.237% and 0.286%, respectively, in Sinora. Mint oil evaporated in cold store generally did not impact reducing sugars or fry color (Frazier, 2000). The upper tolerable limit for reducing sugars should not exceed 0.25% for making chips and 0.5% for making French fries (Smith 1956; Burton 1990) Potato tubers treated with spearmint oil in cold store were found quite suitable for preparing both potato chips and French fries.

Chips yield

The potato chips yield (%) increased with progress in storage period of tubers, irrespective of the spearmint application (Table 7). Insignificant differences ($P \leq 0.05$) were observed in chips yield in Diamant tubers treated with spearmint in field and the control ones in the last month of storage. Also, insignificant differences ($P \leq 0.05$) were observed in chips yield in Diamant tubers treated with spearmint in cold store and in field plus store.

Organoleptic quality

Table 9 shows the sensory evaluation (acceptability) of potato chips prepared from tubers stored for 6 months using the ranking method of Ihekoronye and Ngoddy (1985). Sinora potato tubers treated with spearmint oil in cold store was significantly ($P \leq 0.05$) superior in flavor and overall quality followed by Diamant tubers treated with spearmint oil in cold store which was significantly ($P \leq 0.05$) superior in texture. Insignificant differences ($P \leq 0.05$) were also observed in general appearance and after taste of chips material. Frazier (2000) reported objectionable flavor in potatoes treated with spearmint oil, yet, such phenomenon was not detected by Sudanese assessors.

Plate. 1, 2, 3, 4 Effect of different applications of spearmint oil on sprouting in Diamant potato tubers during six months storage at 10 °C (76-78% RH)

Plate .1 Untreated potato tubers

Plate .2 Potato tubers treated in field

Plate .3 Potato tubers treated in field and cold store

Plate .4 Absence of sprouting in potato tubers treated in cold store

Plate. 5, 6, 7, 8 Effect of different applications of spearmint oil on sprouting in Sinora potato tubers during six months storage at 10 °C (76-78% RH)

Plate .5 Untreated potato tubers

Plate .6 Potato tubers treated in field

Plate .7 Absence of sprouting in potato tubers treated in field and cold store

Plate .8 Absence of sprouting in potato tubers treated in cold store

Table . 1 Effect of different applications of spearmint oil on sprout emergence (%) in Diamant and Sinora potato varieties during six months storage at 10 °C (76-78% RH)

Treatment	Varieties							
	Diamant				Sinora			
	Storage period (month)							
	1	3	5	6	1	3	5	6
Control	42.20^{bc} ±2.69	100.0^{a} ±0.00	100.0^{a} ±0.00	100.0^{a} ±0.00	0.00^{b} ±0.00	45.10^{b} ±47.94	100.0^{a} ±0.00	100.0^{a} ±0.00
Mint/field	100.0^{a} ±0.00	100.0^{a} ±0.00	100.0^{a} ±0.00	100.0^{a} ±0.00	13.03^{b} ±4.5	47.05^{b} ±2.62	100.0^{a} ±0.00	100.0^{a} ±0.00
Mint/store	0.00^{c} ±0.00	0.00^{c} ±0.00	0.00^{c} ±0.00	0.00^{c} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00	0.00^{b} ±0.00
Mint/field/store	0.00^{c} ±0.00	33.33^{bc} ±57.3	33.33^{bc} ±57.3	67.00^{ab} ±57.3	0.00^{b} ±0.00	33.33^{bc} ±57.3	33.33^{bc} ±57.3	33.33^{bc} ±57.3
$Lsd_{0.05}$	41.46**				46.16**			
SE±	14.39				16.02			

Mean ±SD values having different superscript letters in columns and rows are significantly different (P≤0.05). different as assessed by Duncan Multiple Range Test. * = Significant at P≤0.05 /** = Significant at P≤0.01 /n.s = not significant

Legend;
Control: The untreated tubers.
Mint/field: Tubers treated with spearmint oil in field.
Mint/store: Tubers treated with spearmint oil in cold store.
Mint/field/store: Tubers sprayed with spearmint oil in field and cold store.

Table .2 Effect of different applications of spearmint oil on sprout length (cm/tuber) in Diamant and Sinora potato varieties during six months storage at 10 °C (76-78% RH)

Treatment	Variety Diamant Storage period (month)			Variety Sinora		
	2nd	4th	6th	2nd	4th	6th
Control	2.95^{c} ±0.25	5.43^{b} ±0.60	13.13^{a} ±2.30	1.39^{cd} ±0.50	4.66^{bc} ±0.72	17.00^{a} ±5.01
Mint/field	1.97^{cd} ±0.11	5.63^{b} ±1.53	13.13^{a} ±2.30	2.45^{cd} ±0.33	8.23^{b} ±3.22	21.80^{a} ±3.02
Mint/store	0.00^{d} ±0.00	0.00^{d} ±0.00	0.00^{d} ±0.00	0.00^{d} ±0.00	0.00^{d} ±0.00	0.00^{d} ±0.00
Mint/field/store	0.24^{d} ±0.26	0.73^{cd} ±1.27	0.73^{cd} ±1.27	0.74^{cd} ±1.28	0.84^{cd} ±1.45	1.10^{cd} ±0.05
$Lsd_{0.05}$	2.355*			3.815		
SE	0.6804			1.102		

Mean ±SD values having different superscript letters in columns and rows are significantly different (P≤0.05). different as assessed by Duncan Multiple Range Test. * = Significant at P≤0.05 /** = Significant at P≤0.01 /n.s = not significant
Legend;
Control: The untreated tubers.
Mint/field: Tubers treated with spearmint oil in field.
Mint/store: Tubers treated with spearmint oil in cold store.
Mint/field/store: Tubers sprayed with spearmint oil in field and cold store.

Table 3. Effect of different applications of spearmint oil on weight loss (%)in Diamant and Sinora potato varieties during six months storage at 10 °C (76-78% RH)

Treatment	Variety Diamant Storage period (months)			Variety Sinora		
	2nd	4th	6th	2nd	4th	6th
Control	8.15^{cd} ±0.85	14.08^{b} ±2.50	21.94^{a} ±3.89	6.58^{def} ±2.08	9.35^{cd} ±1.63	21.01^{a} ±3.11
Mint/field	5.42^{ef} ±1.25	9.73^{cd} ±0.55	19.36^{a} ±0.57	7.13^{de} ±2.25	13.74^{b} ±2.93	19.03^{a} ±0.14
Mint/store	2.78^{f} ±0.00	5.56^{ef} ±0.01	7.21^{de} ±0.54	2.76^{g} ±0.28	3.57^{fg} ±0.20	4.48^{efg} ±0.00
Mint/field/store	3.71^{f} ±0.80	7.16^{de} ±0.52	10.52^{c} ±1.08	3.48^{fg} ±0.69	6.84^{def} ±0.48	10.70^{bc} ±0.41
$Lsd_{0.05}$	2.979**			3.266**		
SE	0.8610			0.9439		

Mean ±SD values having different superscript letters in columns and rows are significantly different (P≤0.05). different as assessed by Duncan Multiple Range Test. * = Significant at P≤0.05 /** = Significant at P≤0.01 /n.s = not significant
Legend;
Control: The untreated tubers.
Mint/field: Tubers treated with spearmint oil in field.
Mint/store: Tubers treated with spearmint oil in cold store.
Mint/field/store: Tubers sprayed with spearmint oil in field and cold store.

Table 4. Effect of different applications of spearmint oil on dry matter content (%) in Diamant and Sinora potato varieties during six months storage at 10 °C (76-78% RH)

Treatment	Variety Diamant		Variety Sinora	
	Storage period (months)			
	1st	6th	1st	6th
Control	21.98^{bcd} ±0.61	22.68^{ab} ±0.61	21.27^{c} ±0.00	22.33^{c} ±0.00
Mint/field	21.27^{d} ±0.00	23.03^{a} ±1.61	22.33^{c} ±0.00	25.49^{a} ±1.83
Mint/store	21.62^{cd} ±0.61	22.68^{ab} ±0.61	21.98^{c} ±2.53	22.33^{c} ±0.00
Mint/field/store	21.27^{d} ±0.61	22.33^{abc} ±0.00	21.27^{c} ±0.00	23.73^{b} ±1.06
$Lsd_{0.05}$	0.8319*		1.239*	
SE	0.2775		0.4131	

Mean ±SD values having different superscript letters in columns and rows are significantly different (P≤0.05). different as assessed by Duncan Multiple Range Test. * = Significant at P≤0.05 /** = Significant at P≤0.01 /n.s = not significant
Legend;
Control: The untreated tubers.
Mint/field: Tubers treated with spearmint oil in field.
Mint/store: Tubers treated with spearmint oil in cold store.
Mint/field/store: Tubers sprayed with spearmint oil in field and cold store.

Table 5. Effect of different applications of spearmint oil on reducing sugar content (mg/100g) in Diamant and Sinora potato varieties during six months storage at 10 °C (76-78% RH)

Treatment	Variety Diamant		Variety Sinora	
	Storage period (months)			
	1st	6th	1st	6th
Control	0.2200^{d} ±0.52	0.2943^{a} ±0.52	0.2420^{e} ±0.52	0.3830^{a} ±0.52
Mint/field	0.2150^{f} ±0.52	0.2600^{b} ±0.52	0.2223^{h} ±0.52	0.2440^{d} ±0.52
Mint/store	0.2200^{d} ±0.52	0.2263^{c} ±0.52	0.2317^{g} ±0.52	0.2377^{f} ±0.52
Mint/field/store	0.2037^{g} ±0.52	0.2187^{e} ±0.52	0.2573^{c} ±0.52	0.2867^{b} ±0.52
$Lsd_{0.05}$	0.0005474*		0.0005474*	
SE	0.0001826		0.0001826	

Mean ±SD values having different superscript letters in columns and rows are significantly different (P≤0.05). different as assessed by Duncan Multiple Range Test. * = Significant at P≤0.05 /** = Significant at P≤0.01 /n.s = not significant
Legend;
Control: The untreated tubers.
Mint/field: Tubers treated with spearmint oil in field.
Mint/store: Tubers treated with spearmint oil in cold store.
Mint/field/store: Tubers sprayed with spearmint oil in field and cold store.

Table 6. Effect of different applications of spearmint oil on chips yield (%) in Diamant and Sinora potato varieties during six months storage at 10 °C (76-78% RH)

Treatment	Variety Diamant		Variety Sinora	
	Storage period (months)			
	1st	6th	1st	6th
Control	33.60^{cd} ±0.002	34.12^{bcd} ±0.01	33.36^{bc} ±0.001	36.02^{ab} ±0.01
Mint/field	30.83^{e} ±0.01	34.93^{bc} ±0.01	32.39^{c} ±0.01	37.47^{a} ±0.004
Mint/store	32.93^{d} ±0.01	36.57^{a} ±0.01	31.67^{c} ±0.002	34.07^{bc} ±0.003
Mint/field/store	34.82^{bc} ±0.002	35.37^{ab} ±0.003	33.44^{bc} ±0.002	34.23^{bc} ±0.05
$Lsd_{0.05}$	1.38*		3.008*	
SE	0.4604		1.003	

Mean ±SD values having different superscript letters in columns and rows are significantly different (P≤0.05). different as assessed by Duncan Multiple Range Test. * = Significant at P≤0.05 /** = Significant at P≤0.01 /n.s = not significant
Legend;
Control: The untreated tubers.
Mint/field: Tubers treated with spearmint oil in field.
Mint/store: Tubers treated with spearmint oil in cold store.
Mint/field/store: Tubers sprayed with spearmint oil in field and cold store

Table 7. Acceptability of potato chips prepared from potato tubers exposed to different treatments and stored for 6 months

Treatment	Sum of ranks				
	General appearance	Flavor (odor + taste)	Texture	After taste	Overall quality
SMF	31 a	31 a	32 a	34 a	32 a
SMFS	35 a	37 a	39 a	39 a	37 a
SMS	32 a	25 b	25 b	31 a	26 b
DMF	33 a	40 a	31 a	31 a	37 a
DMFS	33 a	36 a	39 a	32 a	39 a
DMS	31 a	31 a	23 b	32 a	31 a

- Any two sum of ranks having similar superscript letter (s) in each column have no significant difference (P<= 0.5).
- 12 reps, 6 treatments rank total (28 -56).
- Range from Ihekoronye and Ngoddy (1985) Table was 28-56.
- Legend;

SMF: Sinora variety sprayed with spearmint oil in field.
SMFS: Sinora variety treated with spearmint oil in field and cold store.
SMS: Sinora tubers treated with spearmint oil in cold store.
DMF: Diamant variety sprayed with spearmint oil in field.
DMFS: Diamant tubers treated with Spearmint oil in field and cold store.
DMS: Diamant tubers treated with spearmint oil in cold store.

CONCLUSSION

It seems that the method of application is critical in inducing the positive effect of spearmint oil on Diamant and Sinora potato varieties. The application of spearmint vapor in cold store had no adverse effect on processing or sensory evaluation qualities and it is environmentally friendly techniques.

Spearmint oil is effective in maintaining a sprout-free condition in stored potatoes as long as the material is available in sufficient quantities in the headspace of the potato store**.**

RECOMMENDATION

The following recommendation was based on the results obtained:
-To control potato sprouting for replanting or direct consumption spearmint vapor could be used on potato pallet in cold store with repeated application every 45 days (5 times during 6 months). This method has the advantage of being reversible to allow for replanting of potato tubers as well as being environmentally friendly

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