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Effect of Spearmint Oil on Sprouting and Processing Quality of Diamant and Sinora Potato Varieties

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Abstract: The effect of spearmint oil on the storage and processing qualities of two potato varieties Diamant and Sinora was investigated and compared with the sprout inhibitor, isopropyl - N 3-chlorophenyl carbamate (CIPC). Potatoes were stored at 10±1ºC and (73-78% RH) for 6 months. Results showed spearmint oil was as effective as CIPC in checking the break of dormancy, fast sprout growth, high fresh weight loss but unlike CIPC did not kill the eye buds; so can be used for seed tubers. The oil had no adverse effects on reducing sugars, dry matter, specific gravity and chips yield. After storage for six months both varieties were still suitable for making chips and French fries. Consumers preferred chips prepared from Sinora tubers and French fries prepared from Diamant tubers treated with spearmint oil.

Key words: CIPC, potato, processing, quality, spearmint, sprouting, storage

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 *et al*., 2001). It is more critical in the processing varieties which are stored at a relatively higher temperature compared with the ware potatoes (10ºC vs. 4ºC). 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 (Smith, 1987; Burton, 1989; Verma, 1991).

CIPC {isopropyl–N (3-chlorophenyl) carbamate} is widely used as a sprout inhibitor for ware and processing potatoes (Brandt *et al*., 2003). There are some concerns regarding consumer safety of CIPC residues (Kleinkopf *et al*., 2003). Lately, other environmentally friendly plants products are added as sprout inhibitors e.g., spearmint oil (Meigh, 1969; Beveridge *et al*., 1981, 1983; Vaughn and Spencer, 1991; Vokou *et al*., 1993; Oosterhaven *et al*., 1995; Sorce *et al*., 1997). The oil extracted from mint plants is effective in maintaining a sprout-free condition in stored potatoes as long as the material is available in sufficient quantity in the headspace of potato store.

This study investigated the use of spearmint oil as an alternative to CIPC for long term potato storage at high temperature (10ºC) of the 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

The study was conducted at Food Research Center, Khartoum North Sudan season 2007-2008. Disease-free and uniform-sized tubers of Diamant and Sinora potato varieties were selected and placed equally in 36 plastic containers (18L).

Spearmint oil was extracted according to (Guenther, 1948) and applied to a 10 cm filter paper disk attached to the lid of the container to prevent the essential oil from coming into direct contact with the potatoes. The lids of all containers were immediately sealed and this marks the start of the storage period (10ºC, 73-78 RH). The lids were removed for ten minutes every 2-3 days to allow gas exchange with the respiring potatoes and the application of the spearmint oil was repeated every 45 days for 6 months. CIPC was applied manually at the rate of 2 kg/ton for both potato varieties. Tubers emergence (%), sprout length (cm/tuber) and fresh weight loss (%) were recorded during storage. Dry matter content and specific gravity were measured in all tested tubers using the potato Hydrometer (APH Group, Holland) method of Smith (1975).

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Reducing sugars in the tuber extract was determined by Nelson (1944) method as modified by Somogyi (1952).

Potato chips and French fries prepared from treated tubers were tested for consumer acceptability testing according to the ranking method of Ihekoronye and Ngoddy (1985).

Data generated was assessed statistically analysis using (SAS) using two factors completely randomized design; where factor A is storage period and factor B is treatments. Then means were tested and separated using Duncan's Multiple Range Test (DMRT) at 0.05% probability referred to (Mead and Gurnow 1983). The samples were replicated three times.

RESULTS AND DISCUSSION

Physiological parameters: The data on emergence of sprouts (%) and sprout length (cm/tuber) revealed that the evolution of spearmint oil in cold store controlled the emergence of sprout and sprout length up to the end of the storage period in both varieties. The evolution of spearmint oil in cold store was reported earlier to suppress completely the emergence of sprouts in treated tubers (Beveridge *et al*., 1981, 1983; Fraizer, 2000; Coleman *et al*., 2001) as long as the material is available in sufficient quantities in the headspace of potato stores. On the other hand no sprout growth was observed on the

Table 1: Effect of spearmint oil and CIPC treatments on sprout emergence (%) in diamant and sinora potato varieties during six months storage at 10ºC (73-78% RH)

	Varieties [storage period (month)]							
	Diamant				Sinora			
Treatment	1	3	5	6	1	3	5	6
Control	42.20^{b}±2.69	100.0^{a}±0.00	100.0^{a}±0.00	100.0^{a}±0.00	0.00^{c}±0.00	45.10^{b}±47.94	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^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00
CIPC	0.00^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00	0.00^{c}±0.00
$Lsd_{0.05}$	1.309**				23.32*			
SE±	0.4483				7.990			

Means in columns and rows (for each variety) not sharing a common superscript letters are significantly ($p \leq 0.05$) different as assessed by Duncan Multiple Range Test; *: Significant at $p \leq 0.05$; **: Significant at $p \leq 0.01$; n.s: not significant; Control: The untreated tubers; Mint/store: Tubers treated with spearmint oil in cold store; CIPC: Tubers treated with CIPC

Table 2: Effect of spearmint oil and CIPC treatments on sprout length (cm/tuber) in diamant and sinora potato varieties during six months storage at 10ºC (73-78% RH)

	Varieties [storage period (month)]					
	Diamant			Sinora		
Treatment	2	4	6	2	4	6
Control	2.95^{c}±0.25	5.43^{b}±0.60	13.13^{a}±2.30	1.39^{bc}±0.01	4.66^{b} ±0.72	17.00^{a}±5.01
Mint/Store	0.00^{d}±0.00	0.00^{d}±0.00	0.00^{d}±0.00	0.00^{c}±0.00	0.00^{c} ±0.00	0.00^{c} ±0.00
CIPC	0.00^{d}±0.00	0.00^{d}±0.00	0.00^{d}±0.00	0.00^{c}±0.00	0.00^{c} ±0.00	0.00^{c} ±0.00
$Lsd_{0.05}$	1.368^{**}			2.910^{**}		
SE±	0.4604			0.9793		

Means in columns and rows (for each variety) not sharing a common superscript letters are significantly ($p \leq 0.05$) different as assessed by Duncan Multiple Range Test; *: Significant at $p \leq 0.05$; **: Significant at $p \leq 0.01$; n.s: not significant; Control: The untreated tubers; Mint/store: Tubers treated with spearmint oil in cold store; CIPC: Tubers treated with CIPC

Table 3: Effect of spearmint oil and CIPC treatments on weight loss (%) in diamant and sinora potato varieties during six months storage at 10ºC (73-78% RH)

	Varieties storage period (month)					
	Diamant			Sinora		
Treatment	2	4	6	2	4	6
Control	8.15^{c} ±0.85	14.08^{b} ±2.51	21.94^{a}±3.89	6.58^{c} ±2.08	9.35^{b} ±1.63	21.01^{a}±3.11
Mint/Store	2.78^{de} ±0.00	5.56^{cd} ±0.01	7.21^{c}±0.55	2.76^{de} ±0.28	3.57^{d} ±0.20	4.48^{cd}±0.81
CIPC	2.39^{e} ±0.59	4.10^{de} ±0.10	5.60^{cd}±0.10	0.88^{e} ±0.03	3.79^{d} ±0.52	5.27^{cd}±0.20
$Lsd_{0.05}$	2.729^{*}			2.411^{**}		
SE±	0.9183			0.8114		

Means in columns and rows (for each variety) not sharing a common superscript letters are significantly ($p \leq 0.05$) different as assessed by Duncan Multiple Range Test; *: Significant at $p \leq 0.05$; **: Significant at $p \leq 0.01$; n.s: not significantLegend; Control: The untreated tubers; Mint/store: Tubers treated with spearmint oil in cold store; CIPC: Tubers treated with CIPC

Table 4: Effect of spearmint oil and CIPC treatments on dry matter content (%) in diamant and sinora potato varieties during six months storage at 10ºC (73-78% RH)

	Varieties storage period (month)			
	Diamant		Sinora	
Treatment	1	6	1	6
Control	21.98^{ab}±0.61	22.68^{a} ±0.6	21.27^{c} ±0.00	22.33^{b} ±0.00
Mint/Store	21.62^{b} ±0.61	22.68^{a} ±0.03	21.98^{bc}±0.61	22.33^{b}±0.00
CIPC	22.33^{ab}±0.00	22.33^{ab}±0.00	21.98^{bc}±0.61	23.73^{a} ±0.61
$Lsd_{0.05}$	0.8864*	0.7418*		
SE±	0.2983	0.2497		

Means in columns and rows (for each variety) not sharing a common superscript letters are significantly ($p \leq 0.05$) different as assessed by Duncan Multiple Range Test; *: Significant at $p \leq 0.05$; **: Significant at $p \leq 0.01$; n.s: not significant; Control: The untreated tubers; Mint/store: Tubers treated with spearmint oil in cold store; CIPC: Tubers treated with CIPC

Table 5: Effect of spearmint oil and CIPC treatments on specific gravity (%) in diamant and sinora potato varieties during six months storage at 10 ºC (73-78% RH).

	Varieties storage period (month)			
	Diamant		Sinora	
Treatment	1	6	1	6
Control	1.088^{c} ±0.00	1.092^{a}±0.00	1.085^{e} ±0.00	1.090^{b}±0.00
Mint/Store	1.087^{d} ±0.00	1.092^{a}±0.00	1.088^{c} ±0.00	1.090^{b}±0.00
CIPC	1.090^{b} ±0.00	1.090^{b}±0.00	1.088^{c} ±0.00	1.098^{a}±0.00
$Lsd_{0.05}$	0.0005425*	0.0005425*		
SE±	0.0001826	0.0001826		

Means in columns and rows (for each variety) not sharing a common superscript letters are significantly ($p \leq 0.05$) different as assessed by Duncan Multiple Range Test; *: Significant at $p \leq 0.05$; **: Significant at $p \leq 0.01$; n.s: not significantLegend; Control: The untreated tubers; Mint/store: Tubers treated with spearmint oil in cold store; CIPC: Tubers treated with CIPC

Table 6: Effect of spearmint oil and CIPC treatments on reducing sugar content (mg/100g) in diamant and sinora potato varieties during six months storage at 10 ºC (73-78% RH)

	Varieties storage period (month)			
	Diamant		Sinora	
Treatment	1	6	1	6
Control	0.221^{d} ±0.00	0.294^{a}±0.00	0.242^{c}±0.00	0.383^{a}±0.01
Mint/Store	0.220^{e} ±0.00	0.226^{c}±0.00	0.232^{e}±0.00	0.238^{d}±0.01
CIPC	0.216^{f} ±0.01	0.245^{b}±0.00	0.227^{f}±0.00	0.253^{b}±0.01
$Lsd_{0.05}$	0.0005425*	0.0005425 *		
SE±	0.0001826	0.0001826		

Means in columns and rows (for each variety) not sharing a common superscript letters are significantly ($p \leq 0.05$) different as assessed by Duncan Multiple Range Test; *: Significant at $p \leq 0.05$; **: Significant at $p \leq 0.01$; n.s: not significantLegend; Control: The untreated tubers; Mint/store: Tubers treated with spearmint oil in cold store; CIPC: Tubers treated with CIPC

Table 7: Effect of spearmint oil and CIPC treatments on chips yield (%) in diamante and sinora potato varieties during six months storage at 10 ºC (73-78% RH)

	Varieties storage period (month)			
	Diamant		Sinora	
Treatment	1	6	1	6
Control	33.60^{b} ±1.75	34.12^{b}±2.85	33.36^{bcd}±0.91	36.02^{a} ±0.49
Mint/Store	32.93^{b} ±8.29	36.57^{a}±2.50	31.67^{cd} ±2.53	34.07^{abc}±1.59
CIPC	32.97^{b} ±2.07	33.72^{b}±1.57	31.28^{d} ±0.70	34.71^{ab} ±0.70
$Lsd_{0.05}$	5.767*	2.324*		
SE±	1.941	0.7823		

Means in columns and rows (for each variety) not sharing a common superscript letters are significantly ($p \leq 0.05$) different as assessed by Duncan Multiple Range Test; *: Significant at $p \leq 0.05$; **: Significant at $p \leq 0.01$; n.s: not significantLegend; Control: The untreated tubers; Mint/store: Tubers treated with spearmint oil in cold store; CIPC: Tubers treated with CIPC

Table 8: Acceptability of potato chips prepared from potato tubers treated with spearmint oil and CIPC and stored for 6 months

	Sum of ranks				
Treatment	General appearance	Flavor (Odor +Taste)	Texture	After taste	Overall quality
DC	31a	33a	23b	42a	31a
DMS		36a	28a	26b	28a29a
DP	20b	30a	26b	35a	29a
SC	45a	41a	40a	41a	44a
SMS	32a	25b	25b	31a	26b
SP	31a	32a	37a	35a	35a

Any two sum of ranks having similar superscript letter (s) in each column have no significant difference ($p \leq 0.5$); 12 reps, 6 treatments rank total (28 -56); Range from Ihekoronye and Ngoddy (1985) Table was 28-56; Legend; DC: Untreated tubers of Diamant variety; DMS: Diamant tubers treated with spearmint oil in cold store; DP: Diamant tubers treated CIPC; SC: Untreated tubers of Sinora variety; SMS: Sinora tubers treated with spearmint oil in cold store; SP: Sinora tuberstreated CIPC

Table 9: Acceptability of potato french fries prepared from potato tubers treated with spearmint oil and CIPC and stored for 6 months

	Sum of ranks				
Treatment	General appearance	Flavor (Odor +Taste)	Texture	After taste	Overall quality
DC	67c	59c	57c	62c	60c
DMS		23b	27b	31a	29a26b
DP	21b	25b	19b	30a	27b
SC	42a	40a	38a	44a	45a
SMS	35a	28a	28a	28a	32a
SP	31a	44a	48a	47a	50c

Any two sum of ranks having similar superscript letter (s) in each column have no significant difference ($p \leq 0.5$); 12 reps, 6 treatments rank total (28 -56); Range from Ihekoronye and Ngoddy (1985) Table was 28-56; Legend; DC: Untreated tubers of Diamant variety; DMS: Diamant tubers treated with spearmint oil in cold store; DP: Diamant tubers treated CIPC; SC: Untreated tubers of Sinora variety; SMS: Sinora tubers treated with spearmint oil in cold store; SP: Sinora tuberstreated CIPC

tubers treated with CIPC throughout the storage period (Table 1 and 2). The CIPC inhibits potato sprout development by interfering with spindle formation during cell division (Apelbaum, 1978; Mahajan *et al.*, 2008) that is why CIPC cannot be used on or in the vicinity of seed potatoes (Brandt *et al.*, 2003).

Table 3 shows the effect of spearmint oil and CIPC on weight loss (%) in Diamant and Sinora potato varieties during six months storage (73-78% RH). The fresh weight loss gradually increased with time of storage in all tubers. During sixth months of storage, significant ($p \leq 0.05$) fresh weight loss was observed on the untreated tubers.

Owing to their effectiveness in sprout inhibition, treatments of spearmint oil in cold store and CIPC demonstrated a significantly lower fresh weight loss.

The dry matter content in the untreated and treated tubers still remain within the recommended range for processing (20-24%) as reported by Hesen *et al*. (1979) (Table 4).

The effect of spearmint oil and CIPC on specific gravity (%) of Diamant and Sinora potato varieties during (six months storage (73-78% RH) is shown in Table 5. All tubers were tested and found to have specific gravity higher than 1.090 which is considered optimal for processing (Tony, 1995).

Technological parameters: Table 6 shows the effect of spearmint oil and CIPC on reducing sugar content (mg/100 g) in Diamant and Sinora potato varieties during six months storage (73-78% RH). The treatment of spearmint oil in store did not cause any processing quality changes such as altering tuber sugar profile. The sugars content was (0.218%). Mint oils generally did not impact reducing sugars or USDA fry color (Frazier *et al*., 2000). Potato tubers treated with spearmint oil in cold store and tubers treated with CIPC were found quite suitable for preparing both potato chips and French fries since the upper tolerable limit for reducing sugars should not exceed 0.25% for making chips and 0.5% for making French fries (Burton, 1990; Sandhu *et al*., 2002). The highest chips yield (%) was observed in Diamant tubers treated with spearmint oil in cold store in the last months of the storage. No significant differences ($p \leq 0.05$) were observed in chips yield among the tested tubers in Sinora variety especially in the last month of storage (Table 7).

Sensory evaluation: The superior tubers preferred by assessor in potato chips and French fries and got the highest overall quality were Sinora and Diamant tubers treated with spearmint oil in cold store respectively, they were good in general appearance, flavor, texture, after taste and got the highest overall quality (Table 8 and 9, respectively).

CONCLUSION

Spearmint (*Mentha Spicata*) oil can be a good alternative to CIPC for sprout suppression in long term potato storage, especially as it is environmently friendly; has zero residues compared to CIPC. Accordingly, potato tubers treated with spearmint oil could be used for planting as seed tubers if not needed for processing. Spearmint oil

treatment was preferred by Consumers for making chips and French fries.

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