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Research Article

Effect of Phosphine Fumigation on Dry Date Storage Quality

Mawahib Yagoub Adam*; Islam Kamal Saeed and Esameldin Bashir Mohamed Kabbashi
National Food Research Center, Ministry of Agriculture and Forestry, Khartoum, Sudan
hoba101@hotmail.com*; +249912105209
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Abstract

Date Palm (*Phoenix dactylifera* L.) fruit is a nutritious and one of the most popular nutritious desserts and hunger quencher in Sudan and Arab world. A number of store pests attack this fruit which include *Ephestia calidella* L. and *Oryzaephilus* spp. Fumigation to control these pests is mainly with few chemicals that include the warranted methyl bromide and phosphine. This study focused on the efficiency of phosphine fumigant in relation to stored dry date quality in Khartoum, Sudan. Two cultivars (Barakawi and Gondaila) were fumigated and stored for nine months for quality. Results reflected no infestation in treated and untreated samples after three months storage. The results taken after six months reflected 16% and 24% infestation in untreated Barakawi and Gondaila, respectively. The corresponding results, after nine months, were 100% and 96%, respectively. No infestation was reported in treated fruits all through the test period. Three species (*E. calidella, O. surinamensis* and *O. Mercator*) were reported from infested fruits. A significant difference between untreated and treated samples reflected in crude protein, crude fiber in both cultivars and in carbohydrates for Barakawi in three months and for its crude protein and fat in six months. The difference was found insignificant in ash and moisture content during the first three months storage. Sensory evaluation of test fruits after 9 months reflected acceptability of the treated fruits and a complete refusal to the untreated fruits with severe inflicted infestation. These results support using phosphine for disinfestation of date fruits at the lowest dose (1 g/ 0.6 m^3).

Keywords: Date Palm, *Phoenix dactylifera* L., Barakawi, Gondaila, pest attack, infestation, sensory evaluation.

Introduction

Date palm (*Phoenix dactylifera* L.) is an old tree fruit in Near East region. It is the major and essential crop in arid and desert zones and marked their oases (Zaid, 1999; l-Shahib and Marshall, 2003). Date palm (*P. dactylifera* L.) represents an essential crop in a lot of countries in the Arab world. Date fruit is a high value nutritive food having a huge readily available energy in form of carbohydrates (70-80%), in simple digestive sugars such as fructose and glucose besides sucrose. This in addition has high value of their dietary fiber that qualifies it for a lot of forms of food (Al–Farsi *et al*., 2005). Date palm cultivars are classified according to their moisture content of the fruit (soft, semi-dry and dry). However, the shape of the fruits varies with different cultivars (Selim*et al*., 1970). The cultivar characteristics are also important and essential in selection of varieties for processing and industry according to consumer preference (Ismail *et al*., 2008). Indexes of fruit quality include dirt clearance, smoothness, size, color and no deviation from normal (infestation, infection, sun damage, oozed sugar and negative odors). Insect infestation and its consequences attribute to great losses.

However, the post-harvest infestation of date fruits can be by a lot of arthropods that include *O. surinamensis*, *O. mercator*, *T. confusum*, *P. interpunctella*, *C. ferrugineus*, and *Cadra* spp. Fumigation of store with recommended insecticides is the answer to get rid of these insect pests (Gunnell *et al*., 2007). Insect infestation of stored dates results in voluminous economic losses. These losses were either direct by insect feeding or indirect by their presence in body or part of it such as antennae, wings or exuviae (USDA-AMS, 2013). Phosphorous organic and chlorinated organic insecticides and the phosphide of some metals are generally used for protection and management of date fruit store insects. However, the phosphine has advantages over other types of control which include reasonable price, generates no residue, available and does not harm the seeds (Chugh, 1992). Aluminum phosphide has a number of brands and formulations. The brands include Phostoxin®, Quickphos®, Celphos®, Alphos®, Phosfume®, Talunex®, Phostek®, Chemfume®, Synfume®, Delicia® and Degesch®. This insecticide can be used in the form of small tablets, pellets, dust andgranules, nevertheless, the most used

*Corresponding author

commercially is the dark grey tablets of 3 g weight and gas in metallic cylinders (Goel and Aggarwal, 2007; Fong, 2008). This insecticide liberate and evolves phosphine gas when touches moisture or air moisture either, that is, the phosphide must be kept in tightly closed containers to avoid losing potency by evolution of phosphine (Tripathi *et al*., 1992). The aim of this study was to determine postharvest quality, due to time and insect infestation, in two popular local date cultivars, Barakawi and Gondaila, in untreated and treated lots with phosphine gas.

Materials and methods

Collection of samples: This study was carried out during 2015 using two date palm cultivars (Barakawi and Gondaila). Date samples, recently harvested, were selected randomly from a local market in Khartoum State. The test was carried out at the postharvest technology department laboratory of the National Food Research Center in Khartoum. Each of these fruit types was divided into two parts; the first one was treated by phosphine.

Samples treatment with phosphine: The test samples were then put in groups of 50 fruits in new small jute sacks (one foot X ½ foot, 30 X 15 cm^2). The treated lot was exposed to phosphine (1 gm tablet Quickphos® brand) in a tightly closed body of an unplugged deep freezer (116 X 80 X 58 cm^3= 0.58 m^3) for one week. Corresponding control lots were also prepared. The treated and untreated (control) lots were then stored, for three, six and nine months, on bench, at the laboratory under an average temperature and an average relative humidity of 31℃ and 18%, respectively. The test was replicated three times. Quality indexes of test fruits (the treated and the control) were checked after every storage regime mentioned (3, 6 months).

Chemical analysis: In order to evaluate the moisture content, the samples were dried in an oven at 105℃. The weight loss on drying to a final constant weight was recorded as the moisture content (AOAC, 2005). Crude fibers were determined according to AOAC (2000) as the residual of sequential extraction of defatted sample with 1.25% H_2SO_4 (sulphuric acid) and 1.25% NaOH (sodium hydroxide) using DOSI Fiber (J.P. Select. S.A), the insoluble were collected by filtration, dried, weighed and freed from ashes to correct for mineral contamination of fiber residue. Crude fat and ash content were determined as described by AOAC (1990). The nitrogen content was determined by the standard Kjeldahl procedure (AOAC, 2000). Protein content was determined by multiplying the nitrogen content by 6.25 factors (food commodities nitrogen/protein factor). Sensory evaluation of the test material was done after nine months storage using the common known attributes (Color, taste, flavor and overall acceptability). That is, acceptability test was done for the treated and untreated date samples according to the ranking procedure of Ihekonorye and Ngoddy (1985). That is, four replicates and two treatments.

Statistical analysis: Data analysis, statistically, (ANOVA) and difference among the means were determined for significance at $P<0.05$ (Gomez and Gomez, 1984).

Results and discussion

The results of the crude protein, fat content, crude fiber, carbohydrates, ash content and moisture content of the test samples after three month storage are summarized in Table 1. Crude fiber, ash content and moisture were less in the treated Barakawi than the untreated control whereas the corresponding results for fat content and carbohydrates were higher in the treated fruits than the untreated control. However, Table 2 displays the corresponding readings after six months storage. Moisture content, fiber, fat, ash and carbohydrates were higher in the treated samples compared to untreated control and only the crude protein is higher in the control date (Table, 2). The differences recorded were all significant at $P\leq0.05$.

Moisture content: The moisture content (%) of the test samples was (9.49 and 9.44) and (5.57 and 5.5) for treated and untreated Barkawi in three and six months storage, respectively. The corresponding data for Gondaila were (9.05 and 4.67) and (8.08 and 4.61), respectively (Tables 1 and 2; Fig. 1). However, the highest moisture content was recorded in the first 3 month of storage and then decreased in the next readings after six months storage. This reduction was due to transpiration and water loss from fruit rind. This result holds true in the different date fruits. Barakawi fruits had the highest moisture content (9.44%) While untreated Gondaila fruits recorded the lowest moisture content (8.08%). These findings confirm that of an earlier study (Yousef *et al*., 2012) who reported rapid moisture loss in mango fruit during storage also these results are in rather close agreement or even less than that reported by Bacha *et al.,* (1987) and Al-Shahib and Marshall (2003).

Fat content: The fat content was decreased consistently in different dates with time. Fat content of untreated Barakawi was 0.305 and 0.206 after three months storage and 6 months storage, respectively. The corresponding results for Gondaila Control were (0.400) and (0.077) (Table 1 and 2; Fig. 2). Crude fat was reported to decrease with time as obtained in an earlier study (Al-Hooti *et al*, 1995). In addition, the crude fat content consistently decreased or remained unchanged as the fruit passes through the different stages of maturity from Kimri to Tamer stages (Sawaya *et al*., 1983). The crude fat of 55 varieties of dates in Saudi Arabia was decreased as the fruit passed from Khalal to Tamer stages through the fruit maturity stages.

*Corresponding author

Table 1. Chemical characteristics of the test date fruits after 3 month storage.

Date sample	Crude protein	Fat content	Crude fiber	Carbohydrates	Ash content	Moisture content (%)
Barak. Control Barakawi	2.900^{c} 0.00±	0.305^{b} 0.01±	3.040^{c} 0.01±	78.49^{b} 0.40±	2.730^{a} 0.03±	9.49^{a} 0.34±
Barakawi	2.730^{d} 0.03±	0.310^{b} 0.01±	2.815^{d} 0.01±	81.95^{a} 2.07±	2.690^{a} 0.11±	9.44^{a} 1.90±
Gond. Control Gondaila	3.810^{a} 0.01±	0.400^{a} 0.03±	4.265^{b} 0.02±	75.94^{b} 0.33±	2.875^{a} 0.49±	9.05^{a} 0.10±
Gondaila	3.500^{b} 0.00±	0.425^{a} 0.04±	4.300^{a} 0.03±	77.55^{b} 0.11±	2.505^{a} 0.08±	8.08^{a} 0.01±
$Lsd_{0.05}$	*0.000878	*0.0878	*0.000878	*2.968	0.7024	2.676
SE±	0.0002236	0.02236	0.002236	0.756	0.1789	0.6815

*Values are mean (means bears different superscripts are significantly different at P≤0.05) according to DMRT.

Table 2. Chemical characteristics of the test date fruits after six month storage.

Date sample	Fat content	Ash content	Crude protein	Carbohydrates	Crude fibre	Moisture content (%)
Control Barakawi	0.206^{ab}	2.465^{a}	2.710^{bc}	79.38^{b}	9.04^{a}	5.500^{a}
Barakawi	0.372^{a}	2.490^{a}	2.650^{c}	79.83^{b}	9.15^{a}	5.565^{a}
Control Gondaila	0.077^{b}	2.535^{a}	3.040^{a}	84.19^{a}	4.65^{b}	4.610^{a}
Gondaila	0.116^{ab}	2.530^{a}	2.925^{ab}	84.70^{a}	4.75^{b}	4.670^{a}
$Lsd_{0.05}$	*0.2776	0.0878$^{n.s}$	*0.2151	*1.48	*0.4477	1.595$^{n.s}$
SE±	0.07071	0.02236	0.05477	0.3768	0.114	0.4062

Fig. 1. Moisture content (%).

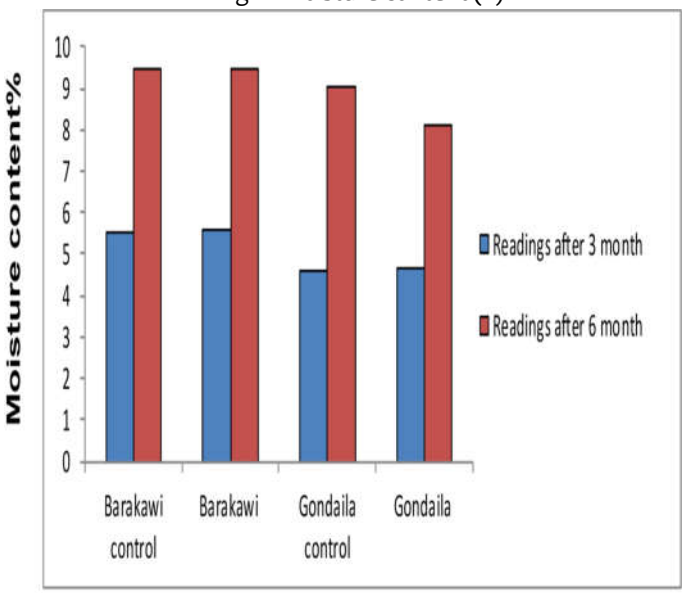
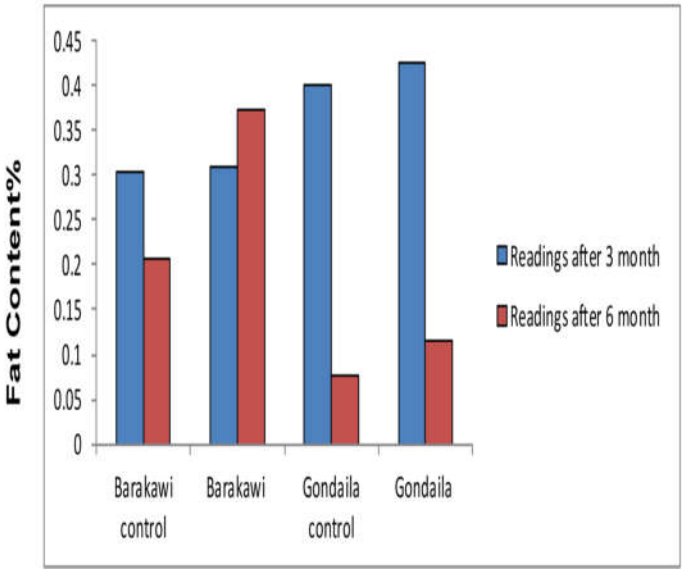


Fig. 2. Fat content (%).



*Corresponding author

Fig. 3. Crude protein content (%).

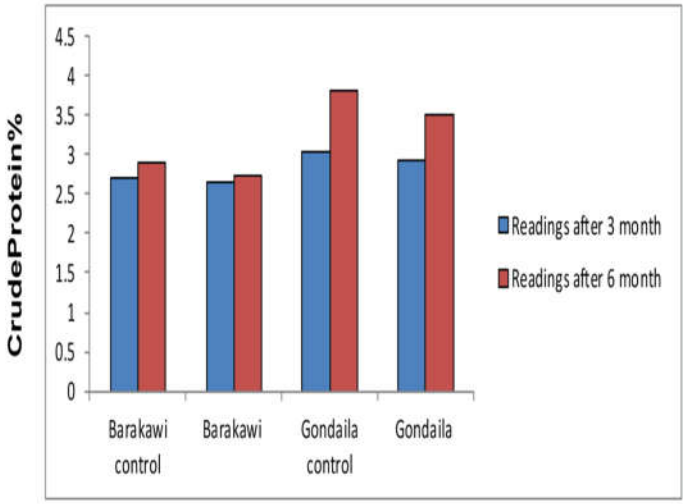


Fig. 4. Crude fibre content (%).

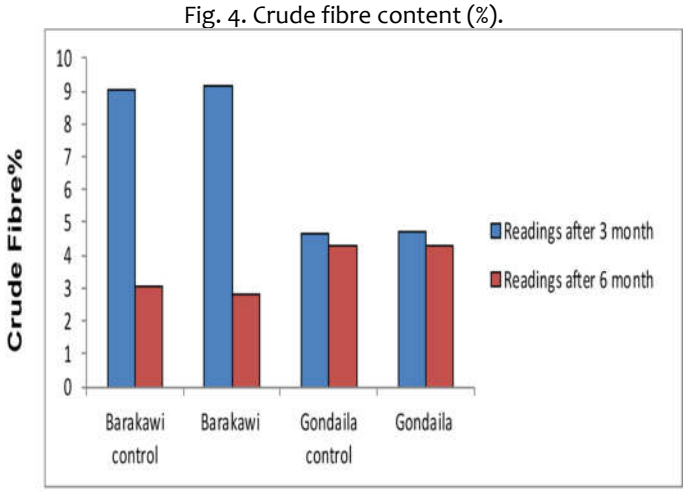


Fig. 5. Ash content (%).

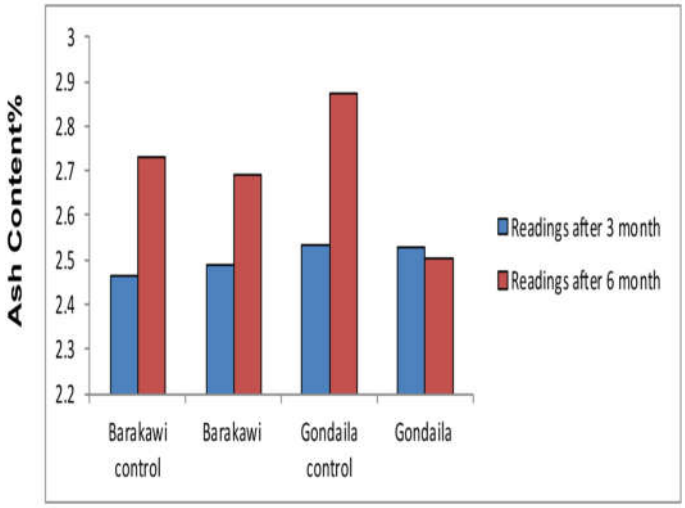
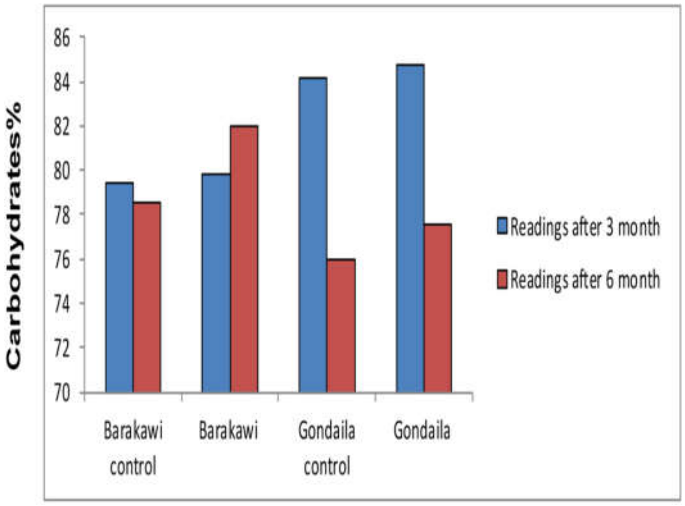


Fig. 6. Carbohydrate content (%).



However, there is a significant difference in the fat content between the treated Gondaila date fruits and the control fruits after 6 month of storage. The Barakawi fruit also reflected a significant difference after 6 month of storage. These results reflected a positive correlation between phosphine treatment and fruit quality of the tested date fruits.

Protein content: The protein content of the test fruits was found to be 2.73 and 2.65; 2.9 and 2.71% for treated and untreated Barakawi, respectively. The corresponding data for Gondaila were found to be 3.5 and 2.93, 3.18 and 3.04 respectively. That is, this compositional parameter of the test fruits decreased with storage. However, these results are yet higher than those reported earlier (Bacha *et al*., 1987) when the protein content of four date varieties was found in a range (2.90-3.40%). Similar results were also reported in another study (Al-Shahib and Marshall, 2003). There is a significant difference in protein between the treated Gondaila and Barakawi and their controls after three months storage (Table 1 and 2; Fig. 3).

Fiber content: The crude fiber content of the treated and the control samples after three and six months were found to be 2.82, 9.15 and 3.04, 9.04 for Barakawi, respectively. The corresponding results for Gondaila were 4.3, 4.8 and 4.27, 4.65, respectively (Table 1 and 2; Fig. 4). These records are higher than those obtained in some other studies (Meligi *et al*., 1983; Salem and Hagazi, 1991). That is, the fiber content of five date varieties was in a range of 1.98-3.50%. There is no significant difference between treated Gondaila date fruits and control fruits after 6 month of storage.

Ash content: Crude ash content was continually decreasing during storage (Table 1 and 2; Fig. 5).

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Table 3. Insect infestation of date fruits during the study period.

Dates variety	Storage period (months)/Infestation (%)		
	3/%	6/%	9/%
Barakawi (control)	0	16	100
Barakawi (treated)	0	0	0
Gondaila (control)	0	24	96
Gondaila (treated)	0	0	0

Table 4. Readings of sensory test of treated and untreated date fruits.

Dates variety	Attribute			
	Color	Taste	Texture	Over all acceptability
Barakawi	15[a]	21[a]	20[a]	19[a]
Control	65[c]	27[b]	45[b]	39[b]
Gondaila	25[b]	25[a]	25[a]	26[a]
Control	70[c]	40[b]	55[b]	56[b]

Figures bear different letters are significantly different (at 5% probability level).

However, there is no significant difference between the treated and untreated lots for both cultivars (Table 1 and 2). The values of the control and treated Barakawi after three and six month storage were 2.69, 2.49 and 2.73, 2.47 respectively. Corresponding results for Gondaila cultivars were 2.51, 2.53 and 2.88, 2.54 respectively (Table 1 and 2; Fig. 5). These results are higher than those obtained in earlier studies (Yousif *et al*., 1982; Al-Hooti *et al*., 1995). That is, the ash content of six date varieties ranged between 2.2-3.8%. However, there is no significant difference in ash between the treated and untreated lots of both test fruit types and for the two different period of storage.

Carbohydrates: The test data of carbohydrates (%) were 81.95, 79.83 and 78.49, 79.38 for Barakawi treated and untreated lots after three and six months, respectively. The corresponding data for Gondaila were 77.5, 84.7 and 75.94, 84.19 for the treated and untreated lots after three and six months, respectively (Table 1 and 2; Fig. 6). There was a significant difference between the treated and the untreated Barakawi after three month storage (Table 1).

Insect infestation: The test fruits were checked after three, six and nine months for insect infestation. There is no infestation reported in all the test fruits treated and untreated control (zero infestation) (Table 3). However, insect incidence was observed in the untreated control fruits of both cultivars. That is, 16% and 24% samples were found infested after 6 month storage in Barakawi and Gondaila, respectively. The corresponding results after nine month storage were 100 and 96%, respectively for Barakawi and Gondaila.

However, all the treated fruits of both study cultivars reflected a complete immunity throughout the study period (9 months). These results infer the potency of phosphine in controlling store insects of date palm fruits. This besides the results obtained in this study concerning the quality indexes which all finally judged phosphine as an improver of the store date fruit quality. Post-harvest losses of stored dates are mainly attributed to insect infestation (USDA-AMS, 2013). However, there is a lot of work done about the efficiency of phosphine gas in controlling the insect pests of stored date palm fruits. It was found that the phosphine dose required to effect total mortality of store insect pests (*E. sceratoniae*; *T. castaneum*; *E. kuehniella*) of date was 3g/ $m^3$for one and two days exposure (Dhouibi *et al*., 2017). These findings reflect that the phosphine dose used in this study against (1 g/0.58 m^3 = 1.7 g/m^3) was sufficient to completely control the reported insects from the untreated dates (*E. calidella, O. surinamensis* and *O. Mercator*). This can be attributed to the efficiency of phosphine and/ or to the susceptibility of these insects to it.

Organoleptic test: An organoleptic test was taken on the untreated and treated dates of this study with four replicates and two treatments (Ihekonorye and Ngoddy, 1985). The results of this test were displayed in Table 4. The treated samples were all better in color, taste, texture and the overall acceptability. The readings of the test showed significant difference between the control and the treated samples in all the test indexes. These support the use of phosphine in the control of insect pest of date fruits and improving its quality. In addition, reckless of these attributes shows the infestation which disqualifies the fruit for market.

***Corresponding author**

Conclusion

Post–harvest storage quality of dry date fruits of Gondaila and Barakawi can be markedly improved by phosphine fumigation. In addition this treatment (at 1 g/0.6 m^3) is very potent in preventing any insect infestation throughout a storage period of nine months. That is, both treated Barakawi and Gondaila samples were far better and incomparable in quality and acceptability to the untreated lots.

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***Corresponding author**