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Influence of Packaging and Cold Storage Conditions on the Physiochemical Properties of Barhi Date Fruits

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Abstract

The fruit of date palm (*Phoenix dactylifera* L.) 'Barhi' is mainly harvested at Khalal stage, whereas fruits are physiologically mature, hard and crisp. Fruits are suitable for consumption at Khalal stage but due to their high moisture content, they are very perishable with low storage life. The physicochemical properties of Barhi fruits grown at Americana framers, Giza, Egypt, which packed in-polyamide/polyethylene (PA/PE), polyethylene (PE) and polypropylene (PP), under cold storage temperatures (5±1 ºC) in response to vacuum and modified atmosphere packaging (MAP) with N_2 were studied. Fruits were analyzed at four time intervals after packing (0, 3, 6 and 9 weeks) and evaluated for their quality characteristics: texture, weight loss, total soluble solids (TSS), pH, moisture content, acidity and sugar content. The obtained results showed that the joint fruits stored in PP packages under MAP conditions with nitrogen had recorded the highest quality. These fruits had lowest TSS, weight loss, pH, acidity and moisture content and lowest change occurred in sugar content with a good texture.

Keywords: *Barhi fruits, storage, modified atmosphere packing, quality attributes.*

Introduction

Date (*Phoenix dactylifera* L.) is one of the oldest crops known to human in the Middle-East. Date palm has been cultivated at least since 6000 BC (AL-Qarawi *et al.,* 2003). It's known that the date fruitis climacteric, and during the course of maturation, physiological changes occur that are attributed to the ethylene hormone (Chao and Krueger, 2007). Mehyar *et al*. (2014) explain that the Barhi date is a yellow variety of date that undergoes four physiological stages which are commonly described using Arabic terms, Kimri, Khalal (hard, yellowand edible), Rutab and Tamar. These phases of maturity are associated with distinctive texture, sensory, and chemical attributes.

In general, when fruits reach the Khalal stage, they are ready for trading as "fresh" date fruits but this applies only to those varieties which are sweet, with a low amount of tannin and low astringency (Barreveld, 1993). Some date cultivars are apposite for marketing at the Khalal stage including Barhi, Bereim, Hayany and Khalas (Glasner *et al*., 2002). The Barhi cultivar is one among the most favorable cultivars for marketing at the Khalal stage worldwide. Fresh dates are subject to biologicalprocesses such as respiration, ripening, and senescence, which can rapidly influence their quality characteristics (Mehyar *et al*., 2014).

During maturation of Barhi fruits, the moisture and tannins are reduced and reach their lowest levels

at the Tamr stage. At Rutab stage fruit acidity reaches its highest level, while it's lowest at the Tamr stage, in contrast soluble solids, total and reducing sugars continuously increase throughout ripening. On the contrary, there is a continuous decrease in firmness, its reaches minimum values when the fruit is at the Rutab stage. At Tamr stage, Barhi fruits can still be quite soft (Al-Redhaiman, 2004 and Ismail *et al*., 2008).

The modified atmosphere packaging (MAP) includes modifying the concentrations of gases (O_2 and CO_2) inside a package to preserve product quality by retaining moisture, lowering the rate of metabolic activity and retarding microbial deterioration (Caleb *et al*,. 2012).

Vacuum packaging (VP) and modified atmosphere packaging (MAP) are now being used for extend shelf-life and reduce the wastage of a wide range of fruits and vegetables. In the VP and MAP systems, the gas mixture surrounding fruits in the package is changed. The MAP technique can be employed to minimize such postharvest losses and maintain the quality of fresh fruits and vegetables (Mphahlele *et al*. 2016; Ochoa-Velasco and Guerrero-Beltran 2016; Anurag *et al*., 2016).

Al-Redhaiman (2004) stored Barhi date fruits full mature under three CO_2 concentrations (5, 10 or 20%) at 0°C, and showed that the fruits under 20% CO_2 have a statically longer storage period, lasted for 26 weeks. Furthermore, package type and storage temperature had significant effects on quality characteristics and shelf-life of date fruits; passive MAP resulted in the best maintenance of quality characters that were measured. Storage of Khalal dates under low temperatures e.g. storage in a refrigerator would retard metabolic reactions, respiration rate and ethylene production and help to prolong fruit shelf-life (Mortazavi *et al*., 2007).

Few trials have been carried out to improve the storage period and maintain fruit quality by using low temperatures (Al-Yahia, 1986), coating of fruits with polypropylene films (Thompson and Abboodi, 2003) or storing them in polyethylene bags (Hegazy *et al*., 2003).

Mortazavi *et al*. (2010) concluded the significant improvement in postharvest storage of Khalal Barhi date fruits that can be achieved, under modified atmosphere conditions. A conservative recommendation to minimize quality losses would be to keep the Khalal fruits under 5% CO_2 level during storage.

Alsawmahi *et al*. (2018) showed that MAP can be effectively employed to preserve the quality and improve the shelf-lifeof Barhi fruits using polypropylene (PP) as the packaging material during storage for 2 weeks at 5^{o}C.

Materials and Methods

Materials:

Fruits of Barhi date cultivar at Khalal stage were purchased from Americana Framers at Giza, Egypt, during August, 2018 and after quick precooling, fruits were transported to the laboratory on the same day. Any damaged, crumbled fruits and fruits with Rutab spots were removed. The healthy fruits of uniform size and appearance were cleaned prior to packaging. Polyamide/Polyethylene (PA/PE), Polyethylene (PE) and

Polypropylene (PP) plastic containers with a wall thickness of 20 µm were obtained from Food Engineering and Packaging Department, Agricultural Research Center, Giza. Fruits were evaluated every 3 weeks. The control sample was fresh Barhi fruits on zero day, at thestart of various experiments.

Packing under modified atmosphere

Fruits were divided into eighteen lots, every one lot was divided into three replicates of 20 fruits (200±5 g). Each set of three replicates was put into a dish tray and placed in a container (PA/PE), (PE) and (PP) plastic bag (17×32 cm). Some techniques are used for treating dates before storage, as follows (Table, 1).

Barhi fruits were packed in PA/PE, PE and PP containers and tightly closed (control), Barhi fruits were packed in PA/PE, PE and PP containers under vacuum and Barhi fruits were treated by nitrogen gas. All samples were stored at 5±1°C for 9 weeks.

All active MAP treatments were performed by creating a vacuum in a Henkelman vacuum pack instrument (200A) followed by flushing the gas mixture 1 bar pressure before heat sealing and N_2 used as a balance gas.

Table 1. Barhi date samples, package types and treatments:

Fruits	Packages	Treatments
1- Joint fruits 2- Detached fruits	1- PA/PE 2- PE 3- PP	1- Control 2- Vacuum 3- N_2

Analytical methods:

Moisture content, Brix, total acidity, pH value, sugar content, reducing and non-reducing sugar, ash and fiber were measured according to AOAC (2005). The fruits subjected to all treatments were weighed before and after storage, then the results were expressed as percentage of weight loss. Fruit texture was measured by a Texture analyzer.

The experimental design and statistical analysis:

The current study consisted of four experiments (four storage periods). Each one was factorial experiment arranged in randomized complete block design (RCBD) using two factors i.e. packages (PA/PE, PE and PP) and treatments **(**control joint and detached, vacuum joint and detached, nitrogen joint and detached). A combined analysis overall storage periods was performed using SAS software version 9.2 (SAS, Institute 2008).

Results and Discussion

Physical properties of Barhi fruits:

The obtained data of physical properties of fresh Barhi fruits are shown in Table (2). The mean weight of fresh fruits, pulp and stone were 20.35, 19.08 and 1.27 g, respectively. The percentage of fruit pulp and stone was 93.75 and 6.24, respectively. The mean values of fruit volume and texture were 18.94 cm^3 and 521.5g/cm^2, respectively. Total soluble solids (TSS) and pH values were 26.6% and 6.15, respectively.

Table 2. Physical properties of fresh Barhi fruits at Khalal stage:

Property	Value*
Fruit weight (g)	20.35
Pulp weight (g)	19.08
Stone weight (g)	1.27
Pulp %	93.75
Stone %	6.24
Volume (Cm^3)	18.94
Texture (g/Cm^2)	521.5
TSS%	26.6
pH value	6.15

*Mean of three replicates.

Chemical properties of Barhi fruits:

As shown in Table (3) the fresh Barhi fruits had high moisture content (61.9%), this indicates that these fruits were highly perishable.The mean value of acidity was 0.09%. Total sugar content was 74.2%, and the non-reducing sugar was the predominate level (66.6%), while the reducing sugar recorded the lowest value (7.6%). Ash and fiber of the studied fruits were 1.2 and 7.35%, respectively.

Table 3. Chemical properties of fresh Barhi fruits at Khalal stage:

Component*(%)	Value**
Moisture	61.90
Acidity	0.09
Total sugar	74.20
Non-Reducing sugar	66.60
Reducing sugar	7.60
Ash	1.20
Fiber	7.35

*On dry weight basis, except moisture and acidity.
**Mean of three replicates.

Effect of packaging, treatments and storage periods on physical properties of fresh Barhi fruits:

Effect of packaging materials; Polyamide/Polyethylene (PA/PE), Polyethylene (PE) and Polypropylene (PP) used for making containers on different quality characteristics of fresh Barhi fruits stored for 9 weeks at 5±1°C was found in Table (4). The control sample was fresh Barhi at zero time of the storage.

Texture

The measured initial texture of fruit at the start of experiment was 521.17 mg/cm. Date fruits at Khalal stage had a hard and crisp texture. When the fruits changed to Rutab stage, its texture decreased. Mortazavi *et al*. (2010) reported that MAP caused minimum changes up to Rutab stage of fruits with maximum texture.

The interaction between packages, treatments and storage periods (Table, 4) had a significantly affected on texture. The lowest values were obtained by joint fruits stored in PP packages under MAP conditions with nitrogen (521.07, 508.50 and 495.57 mg/cm^3), while the highest values were obtained by control detached fruits stored in PA/PE packages (512.27, 471.33 and 436.30 mg/cm^3) at 3, 6 and 9 weeks, respectively. A similar trend was observed by Al-Redhaiman (2004).

The Khalal fruits that lose their hard and crisp texture have reduced quality and attract lower prices. Softening of fruit texture is related to activation of pectin decomposing enzymes such as poly-galactronase (PG) which hydrolyses α (1-4) linkage between galactronic acid residues in pectin (Wills, 1998). Changed gas mixture surrounding fruits under modified atmosphere packaging caused slowing enzymatic reactions of fruits such as softening (Kader *et al*., 1989).

Table 4. Effect of interaction between packages, treatments and storage period on texture and weight loss on fresh Barhi fruits*:

Storage period	Treatments	Texture			Weight loss (%)		
		Packages			Packages		
		PA/PE	PE	PP	PA/PE	PE	PP
Zero time		521.17^{abc}	521.17^{abc}	521.17^{bcd}	0.00^{ijkl}	0.00^{ijkl}	0.00^{ijkl}
3 weeks	Control-A	512.38^{abc}	514.90^{abc}	514.93^{abcd}	5.05^{efg}	4.90^{fgh}	4.55^{fgh}
	Control-B	512.27^{abc}	513.17^{abc}	514.40^{abc}	5.31^{cde}	5.71^{jkl}	4.90^{ijk}
	Vacuum-A	514.30^{abc}	515.37^{abc}	517.90^{abc}	4.53^{hij}	4.06^{hijk}	3.82^{jkl}
	Vacuum-B	513.23^{abcd}	515.37^{bcd}	517.70^{bcde}	4.82^{ghi}	4.53^{hij}	4.24^{ijk}
	Nitrogen-A	520.53^{abc}	520.73^{abcd}	521.07^{cde}	3.75^{ijk}	3.03^{ijkl}	2.47^{jkl}
	Nitrogen-B	519.57^{abc}	520.27^{abcd}	520.70^{cde}	4.02^{ijk}	3.52^{jkl}	2.54^{jkl}
6 weeks	Control-A	471.70^{abcd}	469.20^{abcd}	485.03^{bcd}	5.62^{abc}	5.58^{abc}	5.27^{cde}
	Control-B	471.33^{bcde}	480.90^{bcde}	483.60^{bcde}	5.85^{def}	5.75^{efg}	5.45^{efg}
	Vacuum-A	480.50^{def}	483.90^{def}	489.43^{defg}	5.07^{efg}	4.84^{ghi}	4.52^{hij}
	Vacuum-B	476.23^{defg}	477.33^{efgh}	486.90^{fgh}	5.21^{def}	5.30^{ghi}	4.76^{ijk}
	Nitrogen-A	496.87^{abc}	507.23^{bcd}	508.50^{cdef}	4.52^{cde}	4.03^{def}	3.70^{efg}
	Nitrogen-B	503.27^{abc}	504.37^{bcd}	506.70^{cdef}	4.76^{bcd}	4.52^{cde}	4.04^{efg}
9 weeks	Control-A	435.23^{cdef}	465.73^{cdef}	465.67^{cdef}	6.74^{fgh}	6.24^{fgh}	5.92^{cdef}
	Control-B	434.50^{cdef}	462.30^{cdef}	462.33^{cdef}	7.09^{fgh}	6.56^{fgh}	6.08^{cdef}
	Vacuum-A	442.50^{cdef}	472.50^{cdef}	472.50^{defg}	5.75^{fgh}	5.76^{fgh}	5.07^{cdef}
	Vacuum-B	436.30^{cdef}	464.20^{cdef}	464.23^{defg}	6.32^{fgh}	6.07^{fgh}	5.54^{cdef}
	Nitrogen-A	467.63^{abcd}	495.60^{abcd}	495.57^{bcde}	5.23^{def}	5.02^{efg}	4.75^{fghi}
	Nitrogen-B	463.43^{bcde}	492.13^{bcde}	492.10^{cdef}	5.52^{def}	5.25^{efg}	4.92^{fghi}
R LSD		6.68			0.09		

- A: joint fruits, B: detached fruits.
- PA/PE: Polyamide/polyethylene, PE: polyethylene and PP: polypropylene.

*Mean of three replicates.

- Means followed by the same small letter(s) do not significantly different at 0.05 level of probability.

Weight loss

Data in Table (4) showed that interaction betweenpackages, treatments and storage period under MAP had a significant affected on weight loss. The highest weight loss were recorded inthe detached Barhi fruits (control B) stored in PA/PE packages were 5.31, 5.85 and 7.09 % while, the lowest losses were found in joint fruits stored in PP packages under MAP conditions with nitrogen (nitrogen A) which recorded 2.47, 3.70 and 4.75%, at 3, 6 and 9 weeks, respectively. Fruits at Khalal stage have high moisture content and active metabolism so unfavorable factors that cause water evaporation from fruits, increase weight loss (Mortazavi1 *et al*., 2007). Similar results were obtained by Al-Yahia (1986), he reported that Barhi fruit weight loss, which occurred during storage period, is most probably due to fruit water loss. Weight loss is a physiological event caused by loss of water from the fruit surface to the surrounding atmosphere and loss of carbon on formation of CO_2 during respiration (Mortazavi1 *et al*. 2010 and Rizzo and Muratore, 2009).

Total soluble solids (TSS)

The initial TSS of Barhi fruits measured at the start of experiment was 26.68% (Table, 5). The same data demonstrated that the interaction between packages, treatments and storage period on TSS of fruits had a

significantly affected. In all treatments TSS increased by increment the storage period, (Mortazavi *et al*., 2007). The lowest increment values were obtained by joint fruits stored in PP packages under MAP conditions with nitrogen were 26.81, 27.79 and 27.78%, while, the highest increment values were obtained by the detached fruits (control) stored in PA/PE packages were 28.52, 29.35 and 30.54% at 3, 6 and 9 weeks, respectively. This increase could be due to the conversion of some insoluble compounds into soluble compounds (such as the conversion of proto-pectin into pectin), or as a result of the water loss from the fruits, and thus lower moisture contents as shown by Thompson and Abboodi (2003). These results are agreement with Al-Kahtani *et al*. (1998); Afoakwa and Sefa-Dedeh (2001) and Azelmat *et al*. (2005); they reported that the TSS content in date fruits increased gradually with the increase of storage time. The TSS is one of the most important maturity and quality markers in variousfruits, specially date fruits at Khalal stage, (Barreveld, 1993).

pH value

The measured initial pH value of Barhi fruits at the start of experiment was 6.50 (Table, 5). As the storage period increased, pH decrease in the MAP samples stored at 5±1°C. Data in Table (5) revealed that the interaction between packages, treatments and storage period had a significant effect on pH values. The highest values were recorded by control detached fruits stored in PA/PE packages were 6.46, 6.42 and 6.38 while, the lowest values were obtained by joint fruits stored in PP packages under MAP conditions with nitrogen were 6.37, 6.34 and 6.32, at 3, 6 and 9 weeks, respectively. Aleid *et al.* (2014) reported that the continuous fall in pH during storage period demonstrated that both oxidative and non-oxidative mechanisms might be the cause for pH changes.

According to Baloch *et al*. (2006), the pH of Dhakki dates stored at 40°C for 4 months gradually declines in samples stored under air, O_2 or N_2. A pH value decrease of Sayer dates stored at 30°C under different MAP conditions less pronounced than that obtained in control sample Dehghan-Shoar *et al*. (2010). Therefore, the pH reduction was mostly due to CO_2 solubility in the fruits' flesh, and to the activity of microorganisms and insects.

Table 5. Effect of interaction between packages, treatments and storage period on TSS and pH on fresh Barhi fruits*:

Storageperiod	Treatments	TSS%			pH		
		Packages			Packages		
		PA/PE	PE	PP	PA/PE	PE	PP
Zero time		26.68^{abc}	26.68^{bcd}	26.68^{cde}	6.50^{abc}	6.50^{abc}	6.50^{abc}
3 weeks	Control-A	28.23^{def}	28.01^{def}	28.04^{de}	6.43^{bcd}	6.41^{bcd}	6.42^{bcd}
	Control-B	28.52^{cde}	28.35^{cde}	28.23^{def}	6.46^{bc}	6.43^{bc}	6.42^{bcd}
	Vacuum-A	27.54^{efg}	27.49^{efg}	27.37^{cde}	6.41^{def}	6.39^{def}	6.37^{defg}
	Vacuum-B	27.96^{fgh}	27.85^{efg}	27.52^{efg}	6.41^{cde}	6.40^{cde}	6.40^{cdef}
	Nitrogen-A	27.12^{abc}	26.95^{abc}	26.81^{bcd}	6.38^{efg}	6.37^{efg}	6.37^{efgh}
	Nitrogen-B	27.47^{bcd}	27.41^{bcd}	27.05^{def}	6.39^{def}	6.38^{def}	6.39^{defg}
6 weeks	Control-A	28.96^{abc}	28.75^{bcd}	28.38^{cde}	6.41^{cde}	6.40^{cde}	6.39^{def}
	Control-B	29.35^{abc}	28.92^{bcd}	28.75^{def}	6.42^{bcd}	6.42^{bcd}	6.42^{cde}
	Vacuum-A	28.43^{cde}	28.37^{cde}	27.99^{def}	6.33^{fgh}	6.35^{fgh}	6.37^{ghi}
	Vacuum-B	29.27^{bcd}	28.54^{cde}	28.21^{cde}	6.35^{efg}	6.35^{efg}	6.38^{efgh}
	Nitrogen-A	28.78^{cde}	28.46^{def}	27.79^{efg}	6.35^{fgh}	6.35^{fgh}	6.34^{fgh}
	Nitrogen-B	28.52^{cde}	28.14^{def}	28.26^{efg}	6.37^{fg}	6.36^{fg}	6.35^{fg}
9 weeks	Control-A	29.73^{abc}	29.64^{bcd}	29.20^{cde}	6.35^{efg}	6.39^{fgh}	6.37^{fgh}
	Control-B	30.54^{abc}	29.99^{abc}	29.55^{cde}	6.38^{efg}	6.37^{fgh}	6.37^{fgh}
	Vacuum-A	29.52^{bcd}	29.32^{cde}	28.56^{def}	6.30^{ghi}	6.33^{ghij}	6.35^{ghij}
	Vacuum-B	30.25^{abc}	30.18^{bcd}	28.75^{cde}	6.32^{fgh}	6.35^{fghi}	6.38^{fghi}
	Nitrogen-A	28.55^{def}	28.48^{cde}	27.78^{efg}	6.32^{hij}	6.32^{hi}	6.32^{hijk}
	Nitrogen-B	28.20^{efg}	28.07^{cde}	27.88^{def}	6.34^{hg}	6.34^{hi}	6.32^{hij}
R LSD		1.74			0.07		

- A: joint fruits, B: detached fruits.
- PA/PE: Polyamide/polyethylene, PE: polyethylene and PP: polypropylene.

*Mean of three replicates.

- Means followed by the same small letter(s) do not significantly different at 0.05 level of probability.

Effect of packaging, treatments and storage periods on chemical properties of fresh Barhi fruits

Moisture content

Data in Table (6) showed that interaction between packages, treatments and storage period had significantly affected on moisture content of the studied samples. The moisture wasdecreaseduring storage period. At the harvest the moisture content of fruits was 61.09%. The highest moisture contents were obtained by control detached fruits stored in PA/PE packages (55.40, 52.30 and 49.50%) while, the lowest values were obtained by joint fruits stored in PP packages under MAP conditions with nitrogen 59.20, 56.20 and 54.23%, at 3, 6 and 9 weeks, respectively.

Loss of moisture was previously reported in date fruits during storage as they changed from the Kimri to Rutab stage (Tafti and Fooladi, 2005; Awad, 2011 and Iqbal *et al*., 2011). Moisture levels of fruits have been reported to remain more or less constant under low temperature storage, but prolonged storage often leads to a decrease in moisture content (Afoakwa and Sefa-Dedeh, 2001; Omoigho and Ikenebomeh, 2000 and Zare *et al*., 2002). Ihsanullah *et al*. (2005) reported that moisture

content of date fruits packed in white polythene decreased from 14.1 to 9.7% over 5 months period. Khan *et al*. (2008) suggested that moisture content of dry date fruits decreased from 12.8 to 14.2% after 12 months storage at ambient temperature. However, Aleid *et al*. (2014) observed that the significant increases in moisture content of Khalas and Sukkary cultivars, which could be attributed to the initially low level of moisture and the high TSS content in date fruits that would bound water leaving very little of free water to be lost.

Table 6. Effect of interaction between packages, treatments and storage periods on chemical properties on fresh Barhi fruits*:

Storage period	Treatments	Moisture content %			Acidity%		
		Packages			Packages		
		PA/PE	PE	PP	PA/PE	PE	PP
Zero time		61.09^{bcd}	61.09^{abc}	61.09^{abc}	0.09^{hi}	0.09^{hi}	0.09^{hij}
3 weeks	Control-A	56.40^{bcde}	57.61^{bcde}	56.70^{cdef}	0.17^{efg}	0.17^{efg}	0.15^{hij}
	Control-B	55.40^{cdef}	55.90^{def}	56.30^{def}	0.17^{efg}	0.17^{efg}	0.16^{ghi}
	Vacuum-A	57.40^{cde}	57.51^{cdef}	57.63^{cdef}	0.15^{hij}	0.15	0.14^{fgh}
	Vacuum-B	57.70^{cde}	57.07^{def}	57.30^{def}	0.16^{ghi}	0.16^{ghi}	0.14^{fgh}
	Nitrogen-A	59.45^{abc}	59.35^{bcde}	59.20^{bcde}	0.15^{h}	0.14^{fgh}	0.13^{fghi}
	Nitrogen-B	58.50^{bcd}	58.32^{cde}	58.25^{def}	0.15^{h}	0.14^{fgh}	0.13^{fghi}
6 weeks	Control-A	53.70^{cde}	54.20^{def}	54.50^{def}	0.23^{cde}	0.25^{de}	0.22^{def}
	Control-B	52.30^{def}	52.70^{def}	53.30^{efg}	0.24^{bcd}	0.23^{bcde}	0.24^{abcd}
	Vacuum-A	54.93^{efg}	55.30^{efg}	55.70^{fgh}	0.22^{e}	0.21^{e}	0.21^{ef}
	Vacuum-B	54.03^{efg}	54.70^{efg}	55.20^{fgh}	0.22^{cde}	0.24^{cde}	0.21^{cde}
	Nitrogen-A	56.47^{cde}	56.30^{def}	56.20^{efgh}	0.20^{f}	0.20	0.19^{fgh}
	Nitrogen-B	55.17^{def}	55.70^{defg}	55.40^{fgh}	0.20^{f}	0.20	0.20^{fgh}
9 weeks	Control-A	50.30^{efg}	50.70^{fgh}	51.30^{fgh}	0.27^{a}	0.28^{a}	0.27
	Control-B	49.50^{fg}	52.87^{fg}	50.80^{fgh}	0.28^{a}	0.26^{a}	0.28
	Vacuum-A	51.70^{gh}	52.90^{ghi}	53.20^{hij}	0.25^{bc}	0.26^{bc}	0.24^{cde}
	Vacuum-B	51.20^{gh}	52.30^{ghi}	51.70^{hi}	0.25^{b}	0.25^{b}	0.26^{bd}
	Nitrogen-A	53.90^{g}	55.17^{gh}	54. 23^{ghi}	0.24^{d}	0.23^{d}	0.23^{de}
	Nitrogen-B	53.20^{g}	55.03^{gh}	54. 10^{ghij}	0.24^{cd}	0.23^{cd}	0.24^{def}
R LSD		4.43			0.04		

- A: joint fruits, B: detached fruits.
- PA/PE: Polyamide/polyethylene, PE: polyethylene and PP: polypropylene.

*Mean of three replicates.

- Means followed by the same small letter(s) do not significantly different at 0.05 level of probability.

Acidity

Data in Table (6) demonstrated that the interaction between packages, treatments and storage periods had significantly affect on fruit samples acidity. At harvest, the level of acidity was 0.09 % and acidity was increased significantly throughout the evaluation period for all samples. The highest acidity (0.17, 0.24and 0.28%) was scored by control detached fruits stored in PA/PE packages while, the lowest values (0.13, 0.19 and 0.23), were scored by joint fruits stored in PP packages under MAP conditions with nitrogen at 3, 6 and 9 weeks, respectively. These results are agreement with Mortazavi *et al*. (2010) and Jemni *et al*. (2016). Wang *et al*. (1993) suggested that, the organic

acid composition of fruits is of interest because of its influence on the sensory properties of fruits, even though they are minor components of fruits, in combination with sugars. However, generally during growth and maturation of date fruit the acid content tends to go down. Barreveld (1993) reported that upon storage and more specifically at the onset of deterioration, second generation organic acids are formed.

Total sugar

At the beginning of the experiment, total sugar content of Barhi fruits was 74.24% (Table, 7) and increased at different rates during storage. The obtained data demonstrated that the interaction between packages, treatments and storage period had a significantly affect on fruit total sugars. The highest change were occurred in control detached fruits stored in PA/PE packages were 78.77, 86.24 and 87.30% while, the lowest change were occurred in joint fruits stored in PP packages under MAP conditions with nitrogen were 76.49, 77.35 and 78.74%, at 3, 6 and 9 weeks, respectively. These results are agreement with Al-Redhaiman, (2004) who found that an increase of total sugar in Barhi fruits stored at 0°C under 5, 10 and 20% CO_2 concluding that 20% $CO_2$was the best storage condition.

Table 7. Effect of interaction between packages, treatments and storage periods on total sugar on fresh Barhi fruits*:

Storage period	Treatments	Total sugar		
		Packages		
		PA/PE	PE	PP
Zero time		74.24 ^{abc}	74.24 ^{bcd}	74.24 ^{cde}
3 weeks	Control-A	78.77 ^{abcd}	80.23 ^{bcd}	79.32 ^{abc}
	Control-B	79.27 ^{abc}	81.54 ^{bcd}	80.25 ^{abc}
	Vacuum-A	76.63 ^{cd}	78.45 ^{def}	76.70 ^{cde}
	Vacuum-B	77.76 ^{bcde}	79.27 ^{cde}	78.54 ^{bcde}
	Nitrogen-A	75.40 ^{bc}	77.45 ^{bcd}	76.49 ^{abcd}
	Nitrogen-B	76.31 ^{bcd}	77.90 ^{bcde}	76.73 ^{bcd}
6 weeks	Control-A	84.32 ^{cdef}	83.16 ^{def}	80.53 ^{defg}
	Control-B	86.24 ^{cdef}	83.96 ^{def}	81.75 ^{defg}
	Vacuum-A	82.24 ^{defg}	80.57 ^{efgh}	78.90 ^{efghi}
	Vacuum-B	82.94 ^{defg}	81.25 ^{efgh}	79.32 ^{efghi}
	Nitrogen-A	80.96 ^{def}	78.52 ^{efg}	77.35 ^{def}
	Nitrogen-B	81.35 ^{efg}	79.34 ^{efg}	78.58 ^{defg}
9 weeks	Control-A	85.67 ^{defg}	84.24 ^{efg}	82.50 ^{fgh}
	Control-B	87.30 ^{defg}	85.45 ^{efg}	83.73 ^{fgh}
	Vacuum-A	83.79 ^{efg}	82.60 ^{ghi}	80.21 ^{ghij}
	Vacuum-B	84.95 ^{efg}	83.76 ^{ghi}	80.96 ^{ghij}
	Nitrogen-A	81.33 ^{defg}	81.31 ^{fghi}	78.74 ^{cdef}
	Nitrogen-B	82.55 ^{defg}	82.22 ^{fghi}	79.55 ^{defg}
R LSD		6.57		

- A: joint fruits, B: detached fruits.
- PA/PE: Polyamide/polyethylene, PE: polyethylene and PP: polypropylene.

*Mean of three replicates.

- Means followed by the same small letter(s) do not significantly different at 0.05 level of probability.

Jemni *et al*. (2016) observed that the MAP and VP treatments had a significant effect on concentration of total sugars, of dates stored at 20°C for 30 days. Moreover, after storage, it was found a decrease of total sugars. These differences could be very probably due to different storage temperature, being more stimulated the respiration rate and global metabolism in our experiment at a considerably higher temperature. In fact, it is well known that sugars are excellent respiratory substrates.

Conclusion:

From the obtained results, it can be concluded that the cold storage and packing types could affect the quality of Barhi fruits. There were significant changes in quality properties were associated with storage. Detaching fruit from stalk showed trivial positive effects on preserve of the studied quality factors.The joint fruits stored in PP packages under MAP conditions with nitrogen recorded the best quality properties.

Utilization vacuum packing (VP) and modified atmosphere packing (MAP) of fresh Barhi date fruits to obtained the quality attributes need more studies, especially, regarding the health and economic benefits from this important fruit.

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تأثير التعبئة وظروف التخزين المبرد علي الخواص الفيزوكيمائية لثمار البلح البرحي

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الملخص

ثمار البلح البرحي يتم حصادها في مرحلة الخلال حيث تكون الثمار ناضجة فسيولوجياً، وتكون مناسبة للإستهلاك في هذه المرحلة ونظراً لارتفاع محتوي رطوبتها فإنها تكون سريعة التلف مما يؤدي الي انخفاض العمر التخزيني لها.

تم دراسة الخواص الفيزوكيمائية لثمار بلح البرحي (صنف رطب عالي الجودة) والتي تم الحصول عليها من مزارع امريكانا بالجيزة- مصر، والمعبأة في عبوات من البولي أميد/بولي إيثيلين، البولي إيثلين والبولي بروبلين تحت ظروف التخزين المبرد (٥±١°م)، وكذلك دراسة مدي تأثرجودة هذه الثمار بالتعبئة تحت تفريغ وتحت جو غازي معدل من النيتروجين. تم تحليل الثمار علي مدي أربع فترات تخزينية بعد التعبئة (٠، ٣، ٦ و ٩ أسابيع). وقد تم تقييم الثمار خلال الاربع فترات تخزينية من حيث خواص الجودة: القوام، الفقد في الوزن، المواد الصلبة الذائبة الكلية، الأس الهيدروجيني، محتوي الرطوبة، الحموضة والسكريات الكلية.

تبين من النتائج المتحصل عليها أن الثمار بالشماريخ المعبأة في عبوات من البولي بروبلين تحت جو غازي معدل من النيتروجين اظهرت اقل تغير بالنسبة لكل من: القوام، الفقد في الوزن، المواد الصلبة الذائبة الكلية، الأس الهيدروجيني، محتوي الرطوبة والحموضة كما كان التغير في محتوي السكريات الكلية الأقل مقارنة بالمعاملات الأخري.