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Original Article

The Potential of Using Modified Atmosphere and Cooling for Preserving 'Bronsi' and 'Taboni' Soft Dates at Rutab Stage

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Abstract

The current work investigated the application of modified atmosphere (MA) at 5 and 10% CO_2 percentages, each with 5% O_2 and at 1°C±0.5 for preserving 'Bronsi' and 'Taboni' soft dates at Rutab stage. Samples used were naturally ripe (NR) and ripened by inducing method (IR). NR samples were collected ripe and IR fruits were collected at Balah stage from an orchard located in the suburb of the Libyan capital Tripoli, and IR process was made at the laboratory. Samples of the two ripening treatments were kept under above mentioned MA conditions for 13 weeks. Hunter Lab (L, a, b) measurements of skin color and fruit hardness were made at the beginning of storage and repeated at its end, also sensory analysis was made at the end of storage duration. Results showed no significant effects of ripening method and MA on color attributes (L), (a) and (b) in both cultivars. MA affected color and hardness; color was concentrated and hardness decreased in both cultivars, values were significantly lower at the end of the storage period. MA treatments significantly affected color and hardness, fruit hardness significantly decreased for both cultivars after 13 weeks in storage. No significant differences in taste attributes, namely sweetness, acceptance, chewing hardness, and visual color between the two ripening methods were recorded. The study demonstrated the potential of storing NR and IR fruits for extended period using MA condition of 5% CO_2 and 5% O_2 under cold conditions and their application in packaging and handling.

Keywords: Soft dates, natural ripening, induced ripening, modified atmosphere

Introduction

Soft date cultivars are grown extensively in the western part of the Libyan coastal fertile plain between gulf of Sirt east the Tunisian boarder west, a strip at about 625km long and 50 km deep. In 1982, the number of productive palm trees in the region was reported at 1.2 million, representing about 40% of the palm trees existing in the country that time (Al-Sharafa, 1982), nonetheless, no reliable data on the production volume of soft dates was encountered. Soft cultivars are divided into two groups, some are palatable at Balah (Khalal) stage, ready for consumption after 25 weeks from pollination, the most important cultivars are 'Hellawi', 'Hurra', and 'Lemsi', while others are consumable at Rutab stage, after about 4 weeks from the previous stage (Yahia *et al.,* 2014). Among date development stages, Rutab is the most important and critical,

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better known as the ripening stage; fruits lose astringency, become sweet, darker in color, soft in texture and less moist (Chao and Krueger, 2007). This group comprises many cultivars; most important are 'Taboni', 'Bronsi','Taboni', 'Ammi', 'Bekrari' and 'Bayothi'. Dates of these cultivars are highly demanded, characterized by appealing sweetness, good taste and color. However, under prevailing conditions, handling of soft cultivars is quite challenging, fruits are subjected to severe losses due mechanical injuries, dust, pollutant and souring caused by microorganisms. Losses in dates are rather high due to physical, physiological and pathological reasons (Kader and Husssein, 2009). Generally losses are estimated at about 30% per year (Suhail *et al.,* 2020), for soft cultivars estimates are not far from that (EL-Ansary *et al.,* 2019). Nonetheless, good effort is needed to reduce losses by improving growing, harvesting and handling methods (Mahmoudi *et al.,* 2008). Libyan soft dates in particular are subjected to high losses due to improper handling, packaging, marketing practices and lack of cooling (Fennir and Morghem, 2016). Additionally, autumn weather conditions with high temperature and relative humidity at harvest trigger rotting, disease spread and increase losses.

Traditionally, drying is considered as the best preserving practice, locally known as date-dough; dates are pitted, cut halves and sun dried; kneaded and kept in basket-like enclosures made from date leaves, generally 23-25% moisture content is considered as safe range for keeping dates (Kader and Hussein, 2009). However, despite the effectiveness of the traditional method, it is time consuming and inapplicable in large scale operations. In the last three decades, soft date freeze-storage has become widely used, perhaps due to the widespread of low cost household freezers. However, freezing at low rate results in large ice crystals; leading to negative impact on frozen products (Mowafy *et al.,* 2020). Even with its advantages in preserving dates such as 'Deglet Noor' (Jemni *et al.,* 2019), it is still energy consuming and leads to some negative physical effects after thawing, such as tissue softening, damage, color and taste changes (Alhamdan *et al.,* 2016; Bourne, 2002), also from a commercial point of view, serious challenges in keeping the produce frozen throughout handling and marketing chains are encountered.

Modified atmosphere (MA) methods are applied in preserving quality and delaying deterioration in many agricultural commodities, foods, meat and fishery (Kader, 1992, El-Rayes and Ahmed, 2001, Al-Redhaiman, 2005), nonetheless, their use in storing dates is still not widely applied (Fennir *et al.,* 2017). It is a safe and effective technique based on reducing O_2 and increasing CO_2 for the purposes of reducing respiration rate, retarding physiological activities, retaining quality attributes and extending shelf life of foods and fresh agricultural commodities (Fennir, 2002, Thompson, 1998). The current investigation dealt with the use of MA treatments combined with cooling at near zero conditions for storing dates of two Libyan soft cultivars, 'Bronsi' and 'Taboni' at Rutab stage.

Materials and Methods

Plant Materials:

In the 2018 harvesting season, 'Bronsi' and 'Taboni' samples were collected early morning from an orchard located in Soug Al-Gomaa east of Tripoli and transferred to the postharvest laboratory (PL) at the department of Agricultural Engineering, Faculty of Agriculture, Tripoli, Libya. Fruits were ripened using modified incubation ,method, wherein fruits at Balah stage were kept in an airtight enclosure, CO_2 increased, O_2 decreases and ethylene (C_2H_4) accumulates until fruit ripening starts, details of the method can be found in previous investigation (Fennir and Morghem, 2019). Naturally ripe fruits were collected form the same tree by shaking the cluster above a basket, and made by an expert.

Enclosures:

Two liter plastic bottles were used for keeping samples; they were transparent with 42mm wide mouth; facilitating easy inserting and removing samples. A brass tire valve was installed on the lid; enabling air tightness in addition to easy air withdrawal for analysis and adjustment. Samples were filled in, enclosures were checked for tightness, and placed on racks in a walk-in cold room adjusted at 1°C ±0.5.

Maintaining air compositions and air analysis:

Targeted air compositions were obtained using valve-based air mixing system. It is consisted of N_2, O_2 and CO_2 cylinders; each is equipped with pressure regulator. The regulators are connected to lever valves; facilitating selecting air from one cylinder to enter a small mixing room. On the room a rubber hose is connected, and on its end a female connection is installed; facilitating easy connection to the enclosure lid. The setup facilitates air composition adjustment and measurements, in addition to airtightness. Air composition of CO_2 and O_2 were measured periodically using portable air analyzer (Model CANAL120 O_2& CO_2 Gas Analyzer, EMCO Packaging Systems Ltd, Kent, CT14 0BD UK). Measurements were made weekly and air compositions were adjusted whenever deviated from their set point by ±2%.

Color measurement:

Fruit skin color was measured at the start of the experiment and at its end using a hand-held colorimeter (Minolta CR 400, Minolta Corp., New Jersey, USA). (L) with numerical values between 0 and 100 indicates color brightness, (a) with values between (-100 and 0) for green and between (0 and 100) for red, and (b) with values between (-100 and 0) for blue and between (0 and 100) for yellow.

Fruit Firmness:

Fruit hardness was measured using hand-held penetrometer (Model FHT 803, General Tools & Instruments™, New York, NY, 10013, USA). Fruit was cut longwise, bit was removed and one half was placed against hard surface and the instrument tip size 7.9mm was used to pressure the sample. Breaking force was recorded in Newton when the fruit tissue collapsed.

Samples follow up:

Samples were inspected on weekly basis for 13 weeks; observation on negative changes such as Fungal infection and other deformation were made.

Sensory analysis:

Sensory evaluation was made according to quantitative and descriptive method used by (Oliveira *et al.,* 2011) right after the end of the storage duration using untrained taste panel randomly taken from staff, student and employee of the department of Agricultural Engineering, Faculty of Agriculture, Tripoli, Libya. Coded samples were introduced autonomously to each member, and asked to assign his/her evaluation on a 100mm scale ranged from 0 as bad to 100 as excellent. Fresh water was provided for rinsing between samples. The scale represents five taste evaluation criterion, sweetness, taste, color, flavor, and hardness.

Statistical Analysis:

A factorial ANOVA test was applied with induced and natural ripening, and MA treatments of 5 and 10% CO_2 each with 5% O_2 and regular atmosphere as control treatment. Effects of treatments recorded on color, hardness were measured at the beginning of the experiment and its end. Also, sensory analysis was made on five attributes, sweetness, taste, acceptance, color and hardness. Analysis of variance was made at 0.05 significance level using SPSS ver. 20, eight replicate were used for color properties, five for firmness and seven for sensory test. Comparisons among significant differences were made by Tukey Kramer.

Results and discussion

Performance of MA treatments:

Figures 1 and 2 show means of CO_2 and O_2 inside enclosures used for keeping 'Bronsi' and 'Taboni' fruits at 1°C±0.5 for 13 weeks. Stable CO_2 and O_2 concentration can be observed, O_2 levels were maintained at 5%, while CO_2 levels were also kept close to targeted percentages at 5 and 10%. Means of CO_2 were 4.5 and 8.5% for the two MA treatments, respectively. Despite manual weekly adjustments, the recorded MA conditions were close to targeted percentages.

Performance of regular air treatment:

Samples of regular air (RA) were kept in similar enclosures that used for MA treatments, but they were equipped with an opening on the lid; avoiding CO_2 accumulation inside, also air exchange was periodically made. RA treatments showed severe deterioration and fungal infection after 4 weeks for the two cultivars, but it was more severe for 'Taboni', especially for the induced ripening treatment. Therefore, RA treatments were discarded after 4 weeks. Infection at early stage may be related to field condition in addition to high moisture content and O_2 levels. The moisture content for the natural ripened 'Bronsi' was 55% and 56% for the induced, while the natural ripened 'Taboni' was 39% and 45% for the induced. High moisture content and high oxygen levels are indeed important factors in the spread of disease.

Effect of ripening method and MA on color properties L, a and b:

A factorial ANOVA test was carried out to examine the effect of ripening method whether natural or induced on color properties (L), (a) and (b). Results for 'Taboni' at 0.05 level were ($F_{(1,42)} = 0.18$ p=0.18), ($F_{(1, 42)} = 0.30$ p=0.59), and ($F_{(1,42)} = 6.7$ p=0.13) for the three color properties, respectively. No interaction between the ripening

treatments and MA conditions were recorded for the three color properties. No significant differences among MA treatments were observed in color properties after 100 days of storage, but they were different from time zero values, clearly seen by large values of the color difference (ΔE). Results for 'Bronsi' cultivar were ($F_{(1,24)}$ = 0.00 p= 0.995), ($F_{(1, 42)}$ = 0.026 p= 0.87) and ($F_{(1, 42)}$ = 139.7 p< 0.001) for (L), (a) and (b) properties respectively; showing no changes in the first two color properties, however significant changes were recorded for the (b) color property, but such change does not indicate noticeable overall color changes. Therefore, such observation was considered as unimportant color changes. No references dealt with color changes in relation to ripening method of dates in general and soft cultivars in particular were found in the literature.

MA treatment showed significant effect on color properties for 'Taboni' cultivar they were ($F_{(1, 42)}$ = 41.36 p< 0.001), ($F_{(1, 42)}$ = 53.575 p< 0.001) and ($F_{(1, 42)}$ = 113.29 p< 0.001) for (L), (a) and (b) properties, respectively.MA treatment showed significant effect on color attributes at 0.05 level, values of the three attributes were lower than values obtained at time zero. On the other hand, color analysis for 'Bronsi' cultivar was quite different, MA treatments did not affect (L) values ($F_{(1, 42)}$ = 2.085 p= 0.138), but significantly affected (a) values at ($F_{(1, 42)}$ = 78.99 p< 0.001), similar effects were recorded on (b) values ($F_{(1, 42)}$ = 120.68 p< 0.001). As it can be seen in table 1, similarities in effects of the two MA treatments (5% and 10% CO_2) on color properties for the two cultivars existed, yet they were less than values recorded at the time zero. (L) values for 'Bronsi' cultivar were not affected by time and MA treatments; this may be due to the dark color of the cultivar comparing with 'Taboni' which has lighter color. Once again, MA conditions after 100 days significantly affected (b) and (a) color properties, it can be observed in color change in (ΔE). Similar changes in color of fresh dates of 'Khenaizy' cultivar had been reported as (ΔE) after 30 days under MA conditions (Aleid and Saikhan, 2017).

For the other two color properties (a) and (b); lower (a) values indicate reduced redness while lower (b) positive values indicate lower yellowness. Generally, lower values of the three color properties approaching zero means dark brown color. Similar observations were reported for keeping 'Barhy' cultivar dates under CA conditions at Khalal and Rutab stages (El-Rayes, 2009) and in Libyan 'Hurra' and 'Hellawi' cultivars (Fennir and Morghem, 2016, Fennir *et al.,* 2017). Also, significant color changes were reported in 'Burhi' and 'Majhool' cultivars under MA conditions (Almsairat *et al.,* 2013). It is worth mentioning that darkness in dates is a quite normal change and it increases with storage time advances mainly due to fruit composition.

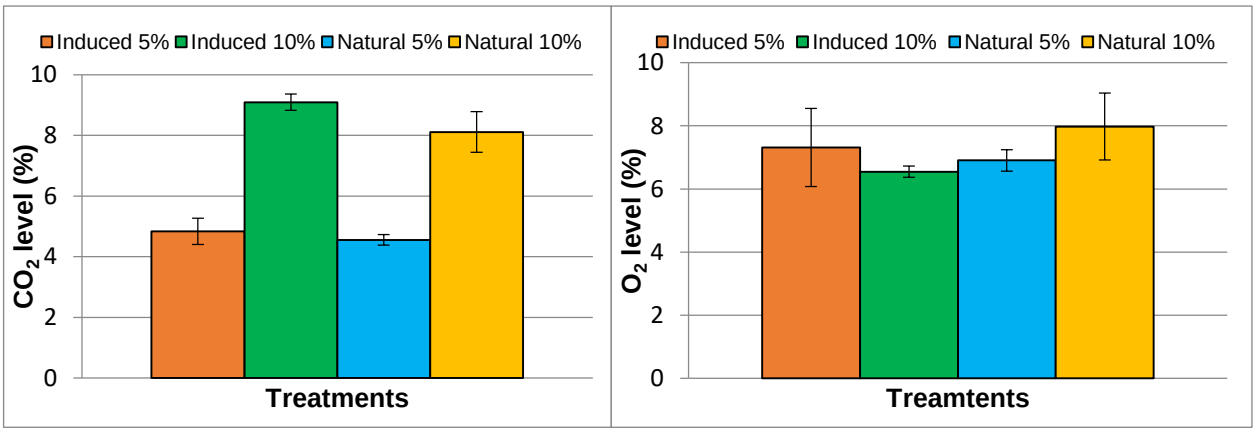

Fig. 1- Means of CO_2 and O_2 levels during storage period for 'Taboni' dates

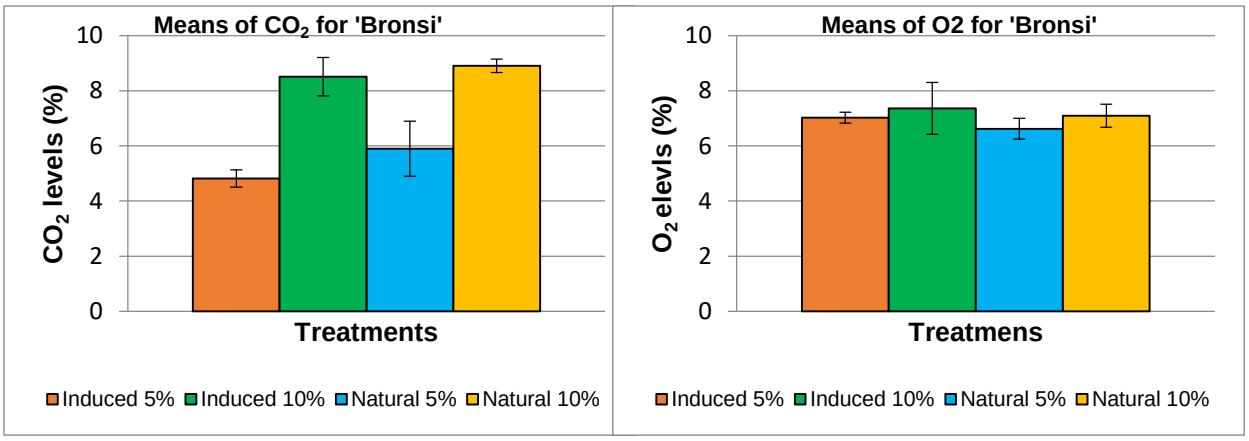

Figure.2 Means of CO_2 and O_2 levels during storage period for 'Bronsi' dates

Gurjinder *et al.,* (2020) found linear function resulted in a threshold soil electrical

Effect of ripening method and MA on fruit firmness:

Fruit firmness is an important property in dates at Rutab stage. ANOVA results for 'Taboni' showed insignificant difference between the two ripening methods at 0.05 level, ($F_{(1, 42)}$ = 0.795 p = 0.381), but MA treatment did have significant effect ($F_{(1, 42)}$ = 11.75 p< 0.001). Similar results were recorded on the ripening method of 'Bronsi' ($F_{(1, 42)}$ = 1.731 p = 0.201). On the other hand, MA treatment showed significant effect ($F_{(1, 42)}$ = 6.123 p = 0.007). Fruit were reported in firmness reduction during ripening of 'Negaros' date cultivar (Seranno *et al.,* 2000). Nonetheless, dates at Rutab stage are subjected to substantial structure changes compared with other fruits. In general, reduced firmness is very much related to enzymatic activities that normally occur during ripening and may extend their activity at Rutab stage (Akasha, 2014).Between MA treatments, insignificant hardness was recorded; indicating no difference between using 10% or 5% CO_2 in the MA air. It is worth mentioning that soft cultivar dates are quite different from dry and semidry cultivars; they undergo enzymatic activities, elevated respiration rate and sugar changes due to their physiology and high moisture content. Indeed, reduced hardness is

due to physiological changes, fruit maturity and senescence (Kader, 1992).

Sensory analysis:

Figure 3 shows sensory analysis results for taste and acceptance attributes of 'Taboni' and 'Bronsi' dates that are naturally and induced ripened presented herein as an example. Sensory analysis was made after 13 weeks of storage under MA conditions. For 'Taboni' cultivar, no significant differences due to ripening method were recorded at 0.05 level on sweetness, taste, acceptance, color and hardness. ANOVA results were ($F_{(1,16)}$ = 0.569 p=0.462), ($F_{(1,16)}$ = 0.09825 p=0.758), ($F_{(1,16)}$ = 0.084 p=0.776), ($F_{(1,16)}$ = 6.376 p=0.23), ($F_{(1,16)}$ = 0.766 p=0.395) for the five tested attributes, respectively. Similarities between natural an induced ripening were recorded. Similarly, MA treatments for the five tested attributes also were not significant, their ANOVA results were ($F_{(1,16)}$ = 0.569 p=0.462), ($F_{(1,16)}$ = 1,736 p=0.206), ($F_{(1,16)}$ = 0.598 p=0.451), ($F_{(1,16)}$ = 0.417 p=0.527), and ($F_{(1,16)}$ = 0.358 p=0.558) for sweetness, taste, acceptance, color and hardness attributes, respectively. 'Bronsi' fruits sensory attributes namely; sweetness, taste, acceptance, color, and hardness were also tested at 0.05, level, ANOVA results were ($F_{(1,16)}$ = 0.108 p=0.747), ($F_{(1,16)}$=0. 018 p = 0.896), ($F_{(1,16)}$ = 0.026 p=0.874, ($F_{(1,16)}$ = 4,125 p=0.059), ($F_{(1,16)}$ = 0.113 p=0.742) for the five tested attributes, respectively. MA treatments showed also insignificant effects of the MA treatment on the five tested color attributes, ANOVA results at 0.05 level were ($F_{(1,16)}$ = 0.404 p=0.534), ($F_{(1,16)}$ = 1.138 p=0.302), ($F_{(1,16)}$ = 0.00 p=0.986), ($F_{(1,16)}$ = 1.318 p=0.268), and ($F_{(1,16)}$ = 0.113 p=0.742) for sweetness, taste, acceptance, color, hardness sensory attributes, respectively. Similar findings were recorded for 'Bronsi', ANOVA results at 0.05 level showed no significant differences due to ripening treatment. For the two cultivars, ripening method and MA treatments did not show significant effect on all tested sensory attributes. It is worth mentioning that sensory test was made for MA treatments only; since RA treatment was discarded after 4 weeks due to severe deterioration and fungal infections. Such results confirm that whether fruits ripened naturally or be induced they had the same taste properties. Nonetheless, MA treatments of 5 and 10% CO_2 combined with 5% O_2 led to preventing microbial infections, maintaining acceptable level of quality attributes, such as taste, acceptance, color and hardness.

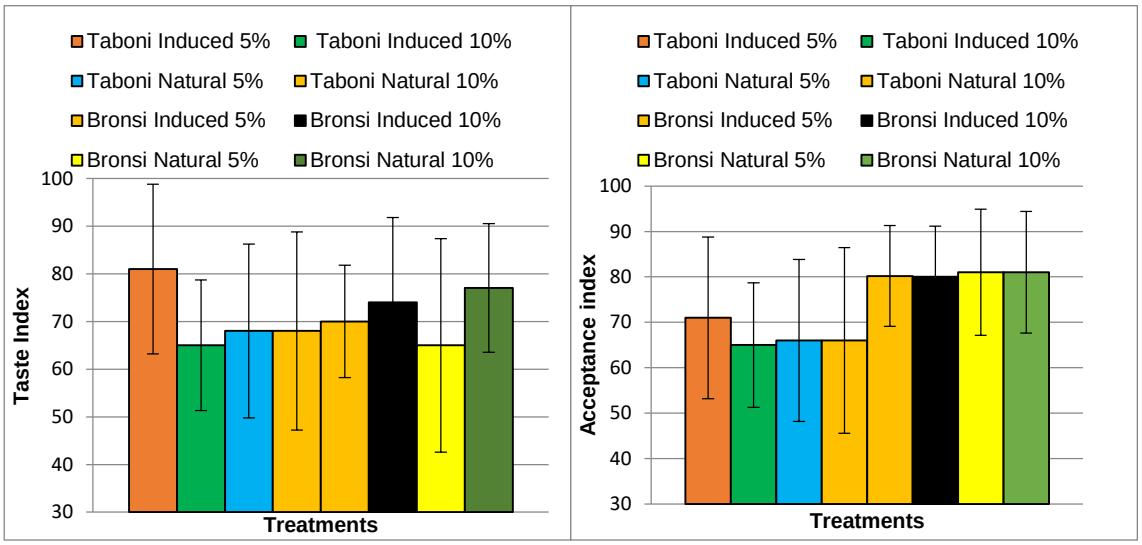

Fig 3.Sensory results means of acceptance and taste for 'Taboni' and 'Bronsi'.

Table 1. Effect of ripening method and MA treatment on color properties.

Ripening Method	Source	L	a	b	ΔE
		'Taboni' cultivar			
Natural	5% CO_2	18.42[a]	3.88[a]	5.04[a]	17.3[a]
	10% CO_2	19.48[a]	3.71[a]	4.88[a]	16.9[a]
	time zero	28.51[b]	9.61[b]	17.87[b]	--
Induced	5% CO_2	19.71[a]	7.84[a]	3.51[a]	14.95[a]
	10% CO_2	18.44[a]	2.264[b]	3.70[a]	16.65[a]
	time zero	29.59[b]	7.84[a]	14.73[b]	--
	MA		1.274[a]	1.18[a]	
	5% CO_2				
		'Bronsi' cultivar			
Natural	MA 10% CO_2	18.1[a]	0.84[a]	1.10[a]	3.04[b]
	time zero	16.25[a]	2.89[b]	2.36[b]	--
Induced	MA 5% CO_2	18.35[a]	1.21[a]	0.25[a]	4.13[a]
	MA 10% CO_2	19.68[a]	1.03[b]	0.64[a]	4.42[a]
	time zero	17.29[a]	2.83[a]	3.90[b]	--

Means with same letter in the same column are not significantly different at $p<0.05$ (Tukey Kramer test).

ΔE= overall change in color, $\Delta E=\sqrt{(\Delta L^2+\Delta a^2+\Delta b^2)}$.

Table 2. Firmness for 'Taboni' and' Bronsi' fruits (penetrating force as Newton).

Ripening method	5% CO_2	10% CO_2	Time zero
		'Taboni'	
Natural	17.128[a]	16.10[a]	24.86[b]
Induced	9.781[a]	10.035[a]	30.72[b]
		'Bronsi'	
Natural	10.41[a]	10.70[a]	14.62[b]
Induced	8.45[a]	8.71[a]	31.71[b]

Means with the same letter in the same raw are not significantly different according to Tukey Kramer at $p<0.05$.

Conclusions

Soft dates of 'Taboni' and 'Bronsi' cultivars ripened naturally and by induced method showed similar properties in color, firmness, and taste. Also they exhibited similar response to MA storage of 5 and 10% CO_2 combined with 5% O_2, they lasted for 100 days of storage compared with RA treatment which lasted 4 weeks. Both treatments were not significantly different in tested quality attributes of color, firmness and taste. The study demonstrated the potential of induced ripening of soft date cultivars and the effectiveness of storing them under MA conditions of 5% CO_2 and 5% O_2 and near zero cooled conditions. MA conditions combined with near zero cold conditions can be used in soft date storage, packaging and handling.

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المجلة الليبية للعلوم الزراعية
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ورقة أصيلة

فعالية استخدام الهواء المعدل والتبريد في حفظ تمور البرنسي والطابوني في مرحلة الرطب

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قسم الهندسة الزراعية، كلية الزراعة، جامعة طرابلس

المستخلص

تناولت الدراسة استخدام الهواء المعدل بتركيبتين هوائيتين 5 و 10% ثاني أكسيد الكربون كل منهما مع 5% أكسجين عند درجة حرارة 1°م ± 0.5 في حفظ ثمار الصنفين الرطبين البرنسي والطابوني في مرحلة الرطب. العينات المستخدمة ناضجة طبيعياً وأخرى أنضجت بالتحفيز. جُمعت الثمار الناضجة طبيعياً، بينما جمعت الثمار المُنضجة بالتحفيز في مرحلة البلح من حقل يقع في ضواحي العاصمة الليبية طرابلس، وأجريت عملية الإنضاج المُحفز بالمعمل. حُفظت الثمار الناضجة بالطريقتين في ظروف الهواء المعدل المذكورة أعلاه إضافة إلى معاملة الهواء العادي كشاهد لثلاثة عشر أسبوعاً. قِيس لون قشرة الثمار باستخدام نظام (Lab Hunter)، كذلك قيست صلابتها في بداية التجربة وعند نهاية فترة الحفظ، وأجريَ اختبار تذوق. لم تسجل فروقاً معنويةً لطريقة الإنضاج على خصائص اللون (L) و (a) و (b) للصنفين. من ناحية أخرى أثرت ظروف الهواء المعدل معنوياً في الصلابة واللون، حيث ازداد تركيز اللون وانخفضت الصلابة عند نهاية فترة الحفظ مقارنة بتلك المسجلة في بدايتها. أما طريقة الانضاج، فلم تسجل فروق معنوية لتأثير طريقتي النضج على خصائص التذوق، والمتمثلة في الحلاوة، وصلابة المضغ، واللون المقدر بصرياً، والقبول. أثبتت الدراسة فعالية حفظ ثمار صنفي البرنسي والطابوني الناضجة طبيعياً وتلك الناضجة بالتحفيز لفترة طويلة في ظروف الهواء المعدل عند 5% ثاني أكسيد الكربون و 5% أكسجين مع التبريد وإمكانية استخدامها في مراحل التعبئة والمناولة.

الكلمات الدالة: ا التمور الرطبة، النضج الطبيعي، الانضاج المحفز، الهواء المعدل

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