



New post-harvest approach for high quality fresh 'Medjool' date



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ABSTRACT

In Israel, 'Medjool' has become the major date fruit variety. In a certain ripeness stage they become super succulent, juicy, tasty ("Super Fresh" 'Medjool') and have a high market value compared to regular 'Medjool' dates. At this particular stage, the dates are very difficult to handle (picking up, removing etc.). Harvesting of 'Medjool' dates after having matured but before ripening (*Khalal* 'Medjool') followed by suitable postharvest treatment to enforce ripening, might provide farmers a method to produce a high quality product. At this pre-ripe stage, dates' total soluble solid (TSS) content varies considerably. The objectives of this study were to find an appropriate post-harvest treatment to produce "Super Fresh" 'Medjool' dates from the *Khalal* fruits and to develop a method for online sorting of *Khalal* 'Medjool' dates according to their TSS content using a mini NIR spectrometer. A cells' conveyor, an automatic sorting apparatus and a NIR (850–1880 nm) scanning device were designed and constructed, simulating a real sorting operation. Spectral models for TSS prediction were developed, based on Partial Least Squares regression. The root mean square prediction error of TSS was in the range of 0.9–1.6% in the different prediction models. This study establishes the basis for sorting dates for consequent postharvest treatment, using NIR spectroscopy, in the production process of "Super Fresh" 'Medjool' dates.

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1. Introduction

Among several palm date cultivars in Israel, 'Medjool' has become the major date fruit variety, due to its large size, pleasant appearance, juicy texture and sweet taste. According to the Israeli Ministry of Agriculture and Plant Board data, in 2012, the export of dates from Israel increased by approximately 20%. The export of dates in 2011 was 11,750 t and in 2012 increased to 14,500 t, to a financial value of approximately 70 million dollars, primarily of the 'Medjool' variety. The FAOSTAT (FAOSTAT, 2014) data are in line with the above numbers as the yield increased from 2011 to 2012, from 6.73 t/ha to 7.79 t/ha, just as the production increased from 37,008 t (2011) to 42,866 t (2012).

The 'Medjool' date (and all the other date varieties) can't be considered as a climacteric fruit, although it behaves very much the same in its ripening. The "ripening hormone" of the dates is Acetaldehyde (instead of ethylene), which induces a very quick transformation of the unripe date to a ripe fruit, without any

parallel increase in Oxygen consumption. Due to this system, anaerobic conditions should accelerate ripening in dates (Serrano et al., 2001).

'Medjool' fruits grow and ripe on bunches through the following stages: the first one is *Kimri*, when the dates are still green, with high moisture and acidity content and low total soluble solids (TSS) level. The following stage is *Khalal*, when the dates turn to yellow, while the acidity decreases and the sugar content increases rapidly. If dates were considered the same as grapes this stage could be considered as the *Veraison*. But the next stage in the dates maturing is *Rutab*, when the dates ripen, lose their astringency and become soft and honey brown colored. At this stage, dates are with notable high sugar content. At the final stage, *Tamar*, the dates lose moisture, till they reach brown/dark brown color, low moisture content (around 18–26%), high TSS content (about 70–85%) and good storability properties (Kader and Hussein, 2009).

At the end of the ripening process (the end of the *Rutab* stage), the 'Medjool' dates possess an attractive taste and an extraordinary texture. Their TSS content ranges between 60 and 65% and their moisture content settles around 30–38%. This is defined as

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Super Fresh product, which attracts consumers, even though its price is far above the fully ripe '*Medjool*'s price. Along with the extraordinary properties at this stage, the dates are very soft and difficult to handle (harvesting, removing etc.). Moreover, in order to harvest the dates at the best stage to get "*Super Fresh*" product it is necessary to go over the trees every 3–5 days, selecting the fruits that started ripening from the bunch. Working according to this protocol means a lot of labor and lifting machines for a period of about one month or more. At the northern Israeli valleys' plantations there are also other varieties, like '*Barhee*' and '*Hayani*', whose ripening occurs almost at the same time as '*Medjool*'s. Due to lack of mechanical equipment and labor, the growers can hardly follow this protocol of intensive selective harvesting. These difficulties motivated the investigation of a new method to produce "*Super Fresh*" '*Medjool*' dates.

Several methods are known to induce and accelerate ripening of *Khalal* dates. Such treatments are freezing, heating combined with high humidity, heating combined with low humidity, immersion into a surfactant or modified atmosphere (Dowson and Aten, 1962; Shomer et al., 1998; Bernstein, 2004).

The main factor that influences proper future ripening of *Khalal* dates is their sugar content (Bernstein, 2004). During the final growing stage (late *Khalal*), before ripening starts, dates accumulate sugars and their water content decreases (Kader and Hussein, 2009). Fruits with sugar content below a critical value will not ripen properly after harvested and will have poor color, texture and taste. The harvest schedule needs to be optimized according to the maturation of the fruits, in order to provide high percentage of high quality "*Super Fresh*" fruits. Early harvesting might yield to a low percent of ripe fruits and so reduce efficiency and profits. Late harvesting might cause a loss because of many overripe fruits.

Several methods are in use for determination of ripeness (TSS or moisture content) of dates. Their sugar content can be estimated by the TSS content of the juice of grated dates using a refractometer. Water content can be measured either by drying the dates in a vacuum oven or by drying the finely grinded sample by using hanging weighing pan with fast heating (Mettler Toledo, Professional Moisture Analyzers). Soaking some dates varieties in Glacial Acetic Acid solution might accelerate ripening (Dowson and Aten, 1962; Bernstein, 2004), so that maturity can be evaluated by counting the percentage of ripe dates after a 12 h treatment. All the above methods are either time or labor (or both) consuming. Moreover, all these methods are destructive, so maturity can't be determined for each harvested fruit.

Near infrared (NIR) spectroscopy is a non-destructive technology which can provide rapid and quantitative determination of quality criteria, such as TSS content (Nicolai et al., 2007). Schmilovitch et al. (2006) developed a semi-automatic system for maturity determination of fresh *Khalal* '*Hayani*' dates and later on the same research team improved this system and created an automatic sorting application according to TSS content (Schmilovitch et al., 2009). In the present study, the later system adapted for "*Super Fresh*" '*Medjool*' dates and was applied for non-destructive TSS content determination and classification.

The main objectives of this research were as follows:

- Establish prediction model of TSS content for the existing non-destructive NIR measuring and sorting system (Schmilovitch et al., 2009).
- Study of TSS accumulation in the fruits of different circle bunches, based on the spectral measuring of the NIR system.
- Examine the relationship between TSS accumulation in the fruits and the rate of fruits ripening in the bunch. Additionally, to determine the optimal time for harvest of the whole bunch.
- Determine the minimal TSS content required in the mature *Khalal* date to get high quality "*Super Fresh*" '*Medjool*' dates.

- Find the appropriate post-harvest treatment to produce "*Super Fresh*" '*Medjool*' dates from the *Khalal* fruits.

2. Materials and methods

2.1. Fruit material and handling

To study the TSS accumulation in the fruits and its relation to ripening percent in the bunch, experiments were performed in three plantations during 2008–2013: Blatt, Segal (in the Jordan Plains) and Gold (in the Jordan Valley). In every plantation five trees were marked for the study. Three to four bunches of each circle on the trunk (1st, 2nd and 3rd circle) were marked as sampling bunches. Every week, a sample of 50 randomly chosen *Khalal* dates from each circle on each palm tree was taken, to determine TSS distribution by the non-destructive NIR system. At the same time, the percentage of ripe fruits in the marked bunches of each circle was evaluated.

For post-harvest ripening treatments: *Khalal* '*Medjool*' dates were harvested in the years of 2008–2013. Dates were collected from several plantations: Kalya (northern Dead Sea shores, 31°44'55.11"N 35°27'58.42"E), Tomer (Jordan Plains, 32°17'33"N 35°26'20"E), Gesher, Afikim, Yavne'el and Deganya (Jordan Valley, 32°42'29"N 35°34'29"E). Dates were harvested selectively from bunches or as a whole bunch.

2.2. Post-harvest treatments

The number of samples in each treatment was 30 dates. Each treatment had five repetitions.

The first post-harvest treatment consisted of freezing the *Khalal* fruits to a temperature of -18°C and then defrosting them to room temperature. This treatment served as a control for the other treatments, as no post-harvest treatment was applied on the *Khalal* fruits before entering the freezer.

The second post-harvest treatment was to treat the *Khalal* fruits with heat ($40\text{--}50^{\circ}\text{C}$) and high humidity (over 90%) till they turn ripe. High humidity was achieved by an ultra-sonic disperser, which created water vapors.

The third treatment was to heat the *Khalal* dates ($40\text{--}50^{\circ}\text{C}$) in a dry atmosphere (relative humidity: 30–40%) for 1–3 days, with or without additional incubation at room temperature, to accelerate their ripening.

The fourth post-harvest treatment was immersion of the *Khalal* dates for a couple of minutes into a mix of 7.5% potassium carbonate, 0.5% olive oil and 0.5% benzophenone-3 surfactant to turn them ripe.

The fifth post-harvest treatment was to store the *Khalal* date fruits in anaerobic conditions (modified atmosphere) for 1–3 days, till they turn ripe. Anaerobic conditions (M.A.) were achieved by vacuuming the air from the plastic bags containing the dates and filling them with Carbon Dioxide or with Nitrogen (CO_2 23%, O_2 1.5%). For the modified atmosphere post-harvest treatment the *Khalal* dates were collected at Grofit, Tomer and Degania plantations (2013).

For the post-harvest treatments, dates were sorted to four groups according to their TSS content, using the automatic non-destructive spectral measurements system and the PLS regression model: group 1: 38–42%; group 2: 42–46%; group 3: 46–50%; group 4: above 50%. The fruits from Grofit were not sorted by TSS content. After harvest, the fruits with brown spots (that indicate start of ripening) were separated from the completely yellow fruits. The completely yellow dates – 12 pieces by trays – were sealed in the presence of nitrogen and stored for artificial ripening. Each day the trays were opened and the dates with brownish

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