

# Execution of strands thinning improves the phytochemicals and sugars profiling in date palm (*Phoenix dactylifera* L.) fruit

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**Abstract:** Date fruit is a rich and quick source of phytochemicals and sugars (glucose, fructose, sucrose) which playing a vital role to nourish the human beings worldwide. The present study therefore, was conducted to explore the role of strands thinning on phytochemicals and sugars profiling in date palm (Cvs. Hillawi and Khadrawi). The experiment was comprised of different strand thinning treatments viz. @ 20% RCS (removal of central strands), 30% RCS, 20% STT (shortening of terminal tips), 30% STT, 20% RCS + 20% STT and 30% RCS+30% STT) including control. The results obtained from the current study showed that strand thinning significantly improves the level of phytochemicals and sugars in date fruit harvested at rutab stage as compared to un-thinned fruit clusters. Higher level of phytochemicals and sugars were found in fruit clusters thinned @ 30% RCS alone and in combination of 30% RCS+30%STT than other fruit thinning intensities. In conclusion; Strand thinning should be employed as an imperative managerial approach to improve the nutritional and phytochemical value of date palm fruit and to fulfill the quick energy requirement of the human body.

**Keywords:** Strands thinning, date palm, phytochemicals, sugars, Hillawi, Khadrawi

## INTRODUCTION

Date fruit is considered as an important nutritional component in the food of inhabitants where, it is cultivated. The fruit of date palm also becomes a vital part in daily life of the people for those countries, which import this fruit (El-Hadrami and El-Hadrami, 2009). Date fruit is a rich source of chemical constituents, which are variable due to numerous factors such as cultivar type, area of cultivation, climatic conditions, fertilizer application and different management operations. (Al-Rawahi *et al.*, 2005). Dates are rich source of carbohydrates (70%), mostly are present in the form of sugars. Invert sugar is entirely found in most of the date varieties, as it rapidly dissolved in the human body (Ahmed *et al.*, 1995; Al-Hooti *et al.*, 1997; Myhara *et al.*, 1999). Date fruit (100g flesh) provides an approximate energy of 12 to 15% for each adult each day. Sugars such as glucose, fructose and sucrose are the key sugars and are the major components of the date's fruit being a vital and rich energy source for human beings. Glucose plays an important role to elevate the level of blood sugars because it is freely absorbed in digestive tract of the human body (Liu *et al.*, 2013). In ancient times, date fruits and seeds have been used as medication in numerous traditional systems where date palm is cultivated (Duke, 1992). Worldwide, dates are commonly used due to its biological significance for human beings as it contains anti-oxidant and anti-mutagenic properties (Vayalil, 2012). According to an ethno-medicinal survey, dates have been traditionally used for the treatment of hypertensive and diabetics patients in southeast Morocco (Tahraoui *et al.*, 2007).

The fruit of date palm is an important source of phytochemicals such as antioxidants, phenolic compounds, sterols, carotenoids, anthocyanins, procyanidins, tannin contents and flavonoids contents. The production or accumulation of these components depends upon the type of fruit, harvesting stage, locality and type of soils. These phytonutrients have a role in the nutritional and sensorial characteristics date fruit (Abdelhak *et al.*, 2005; Abdul and Allaith, 2008; Al Farsi *et al.*, 2005b; Ahmed *et al.*, 1995; Fayadh and Al-Showiman, 1990). Dried dates contains contain higher amounts of these phytonutrients as compared to other kinds of dates which represents a strong relationship among antioxidants, phenolic compounds and flavonoids (Biglari *et al.*, 2008). Carbohydrates are the main chemical components found in date fruit, mainly invert or reducing sugars such as glucose and fructose and sucrose (non-reducing) and minute amount of little concentrations of starch and cellulose (Al-Shahib and Marshall, 2003).

Fruit thinning has the certain advantages viz. reducing number of flowers or fruits, increases fruit size, improves fruit quality, prevents alternate bearing and balances the fruit to shoot ratio, enhances assimilates in fruits and shoots, resulting good quality fruit (Ali-Dinar *et al.*, 2002). Fruit thinning results in good economic returns by increasing the individual fruit weight, accelerates fruit maturity and improved flower bud formation (Myers *et al.*, 1993). Cluster thinning results more exposure of light due to less fruits density; it is because light plays an important role in processes, which are responsible for the accumulation of anthocyanins and phenolic compounds (Wicks and Kliewer 1983, Dokoozlian and Kliewer 1996). Bubola *et al.* (2011) and Profio *et al.* (2012)

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reported that cluster thinning significantly increased the accumulation of phenolics in grape berries. On the other hand, un-thinned fruits could not attain proper return due to less availability of light or air circulation that affects the rate of photosynthetic carbon assimilation rate (Morrison and Noble, 1990). By keeping in view the aforementioned problems the study was carried out with an objective; to explore the role of strands thinning on phytochemicals and sugars profiling in date palm.

### Methodology

The current study was conducted on date palm (Cvs. Hillawi and Khadrawi) at Experimental Fruit Orchard, Post Graduate Agricultural Research Station (PARS), Institute of Horticultural Sciences, University of Agriculture, Faisalabad, Pakistan during the two successive seasons 2011-2012. The experimental material comprised of seven 'Hillawi' date palm trees, of 20-25 years old, with uniform size and vigor, regular cultural practices were applied throughout the year. The experiment comprised of different strand thinning treatments (20% RCS, 30% RCS, 20% STT, 30% STT, 20% RCS + 20% STT and 30% RCS + 30% STT) including control repeated three times under randomized complete block design (RCBD).

### Method and time of thinning

Thinning was performed with a small hand carrying pruning scissor made up of stainless steel at early kimri stage (4 weeks after pollination). Thinning was carried out with removal of central strands and shortening of terminal tips with different intensities and combination of both. For the removal of central strands, firstly these were counted from each selected bunch for performing the required intensity of thinning. Whereas, for shortening of terminal tips, the strands length was measured with a hand scale from selected bunches and then the required intensity of thinning was executed as mentioned above in the treatments layout.

### Fruit harvesting and analysis

During the entire harvesting season, rutab/ripe fruits were periodically collected from the selected bunches and weighed. Fruits showing soft brownish tip were considered as ripe or rutab fruits. Immediately after harvesting at rutab stage, fruits were selected (for freedom from defects and color uniformity) and stored at -20°C until analysis. Three replicates were carried out and 30 dates were used for each replicate for each type of date) for performing phytochemical and sugars analysis.

### Chemicals and reagents

All chemicals, standards and reagents used for analysis were purchased from Sigma-Aldrich Co. Ltd. (Pakistan).

### Extraction method

Fruit extracts for the estimation of phytochemicals were prepared according to the method of Al-Farsi *et al.*, (2005b). Briefly, sample (200mg) was extracted with 2mL

of 50% methanol for 2h at room temperature on an orbital shaker set at 200 rpm. After centrifugation at 1000 ×g for 15min, the supernatant was decanted and the pellets were extracted under identical conditions. Supernatants were combined and used for total phenolics, total flavonoids, total antioxidants and total tannins.

### Estimation of total phenolic contents

Total phenolic contents (TPC) were calculated by using Folin-Ciocalteu reagent method as reported by Ainsworth and Gillespie (2007). The FC-reagent (10mL) was dissolved in distilled water to make the solution 100mL. In each sample (100mL), FC-reagent (200μL) was added and vortex thoroughly. The 700mM Na<sub>2</sub>CO<sub>3</sub> (800μL) was added into each sample and incubated at room temperature for 2h. Sample (200μL) was transferred to a clear 96-well plate and absorbance of each well was measured at 765nm. Amount of TPC was calculated using a calibration curve for Gallic acid. The results were expressed as Gallic acid equivalent.

### Estimation of total antioxidants

Total antioxidants activity of the date fruits (skin +pulp) was assessed by measuring their scavenging abilities to 2, 2-diphenyl-1-picrylhydrazyl stable radicals as described by Amira *et al.* (2012). The absorbance was read against blank at 517 nm using micro-plate ELISA reader (BioTek, USA). Inhibition of free radical by DPPH in percent was calculated by following formula:

$$I\% = (A_{\text{blank}} - A_{\text{sample}} / A_{\text{blank}}) \times 100$$

Where  $A_{\text{blank}}$  is the absorbance of the control reaction mixture excluding fruit sample, and  $A_{\text{sample}}$  is the absorbance of the test compounds. IC<sub>50</sub> values, which represented the concentration of date fruit extracts that caused 50% neutralization of DPPH radicals, were calculated from the plot of inhibition percentage against concentrations.

### Estimation of total flavonoids

Flavonoids were determined by the method of Kim *et al.* (2003). Distilled water (4ml) was added to 1ml of extracted aliquot. Then, 5% sodium nitrite solution (0.3ml) was added, followed by 10% aluminum chloride solution (0.3ml). Test tubes were incubated at ambient temperature for 5min and then 2ml of 1M sodium hydroxide were added to the mixture and then the volume of reaction mixture was made up to 10 ml with distilled water. The mixture was thoroughly vortex and the absorbance of the pink colour developed was determined in a UV-visible spectrophotometer (IRMECO, U2020-Germany) at 510nm. A calibration curve was prepared with catechin and the results were expressed as mg catechin equivalents. All the measurements were taken in triplicate and the mean values were calculated.

### Estimation of total tannin contents

Total tannins contents were estimated according to the method of (AOAC, 1980) by titrating the extracted fruit samples with standard potassium permanganate solution

**Table 1:** Effects of different strands thinning intensities on total phenolic contents (mg GAE/100 g) of Hillawi and Khadrawi date palm fruit.

| Thinning Treatments                                               | 2011                                |          |         | 2012                                |          |          |
|-------------------------------------------------------------------|-------------------------------------|----------|---------|-------------------------------------|----------|----------|
|                                                                   | Hillawi                             | Khadrawi | Mean    | Hillawi                             | Khadrawi | Mean     |
| No thinning                                                       | 114.48                              | 118.52   | 116.50D | 107.92                              | 117.62   | 112.77E  |
| 20% RCS                                                           | 162.47                              | 166.54   | 164.51B | 157.21                              | 166.81   | 162.01BC |
| 30% RCS                                                           | 175.29                              | 180.78   | 178.03A | 168.10                              | 182.74   | 175.42A  |
| 20% STT                                                           | 151.14                              | 156.95   | 154.04C | 147.28                              | 153.11   | 150.20D  |
| 30% STT                                                           | 153.25                              | 159.92   | 156.58C | 153.47                              | 164.22   | 158.85C  |
| 20% RCS+20%STT                                                    | 163.18                              | 169.18   | 166.18B | 159.36                              | 169.65   | 164.51B  |
| 30%RCS+30%STT                                                     | 176.18                              | 185.45   | 180.81A | 169.10                              | 188.69   | 178.90A  |
| Mean                                                              | 156.57B                             | 162.48A  |         | 151.78B                             | 163.26A  |          |
| LSD values                                                        | Treatments = 4.75, Varieties = 2.54 |          |         | Treatments = 5.46, Varieties = 2.92 |          |          |
| RCS= Removal of central strands, STT= Shortening of terminal tips |                                     |          |         |                                     |          |          |

**Table 2:** Effects of different strands thinning intensities on total flavonoids contents (mg CEQ/100 g) of Hillawi and Khadrawi date palm fruit.

| Thinning Treatments                                               | 2011                                |          |        | 2012                                |          |        |
|-------------------------------------------------------------------|-------------------------------------|----------|--------|-------------------------------------|----------|--------|
|                                                                   | Hillawi                             | Khadrawi | Mean   | Hillawi                             | Khadrawi | Mean   |
| No thinning                                                       | 25.80                               | 18.07    | 21.93E | 23.73                               | 19.70    | 21.71D |
| 20% RCS                                                           | 51.06                               | 46.84    | 48.95B | 53.00                               | 49.14    | 51.07B |
| 30% RCS                                                           | 60.47                               | 51.77    | 56.12A | 60.06                               | 53.70    | 56.88A |
| 20% STT                                                           | 46.39                               | 41.43    | 43.91D | 46.17                               | 43.40    | 44.79C |
| 30% STT                                                           | 48.76                               | 43.66    | 46.21C | 52.06                               | 48.09    | 50.06B |
| 20% RCS+20%STT                                                    | 52.18                               | 47.28    | 49.73B | 51.44                               | 48.58    | 50.01B |
| 30%RCS+30%STT                                                     | 61.51                               | 54.10    | 57.81A | 61.77                               | 43.88    | 57.82A |
| Mean                                                              | 49.45A                              | 43.31B   |        | 49.74A                              | 45.21B   |        |
| LSD values                                                        | Treatments = 2.18, Varieties = 1.16 |          |        | Treatments = 2.61, Varieties = 1.39 |          |        |
| RCS= Removal of central strands. STT= Shortening of terminal tips |                                     |          |        |                                     |          |        |

Means sharing same case letter for main effects and interaction, do not differ significantly at 5% probability level.

by using indigo carmine as an indicator until colour changed to faint pink and values were expressed as percentage.

#### Estimation of sugars through HPLC

For the estimation of sugars date fruits were extracted from the date flesh (2g) in HPLC grade ethanol (80% v/v). The available extracts were then centrifuged at 13000xg for 10 min and then supernatants were separated and analysed by high performance liquid chromatography (HPLC). Liquid chromatographic (LC) separation was carried out at room temperature on a Razex RCM-Monosaccharide Ca<sup>2+</sup>, Phenomenex column with flow rate of 0.60ml/min at 80°C. The mobile phase was 100% double distilled water (DDH<sub>2</sub>O). The HPLC was connected to a refractive index detector (ReID) RID-10 AL (Shimadzu, Japan) having the range of (bipolar, 1250 mV) with peak width of 0.200min. Identified sugars were quantified on the basis of peak areas of external standards consisting of glucose (1%), fructose (1%) and sucrose (1%) solutions. Reducing sugars were calculated as a sum of glucose and fructose values and total sugars were

calculated by sum of glucose, fructose and sucrose. Each sample was carried out from integrated peak areas of the sample against the corresponding standard graph. Results were expressed as percentage of fresh weight.

#### STATISTICAL ANALYSIS

The collected data were statistically analyzed using computer software MSTAT-C. Analysis of variance was used to test the significance of variance. While difference among treatment means were compared using LSD test (p=0.05) (Steel *et al.*, 1997).

#### RESULTS

##### Phytochemicals

Phytochemicals present in plants possess diverse health benefits, which includes antioxidant and radical scavenging activities, to relieve some long-lasting illnesses, decreased the heart problems and different types of tumors. Strands thinning significantly increased the level of TPC in treated fruits as compared to fruits of

**Table 3:** Effects of different strands thinning intensities on total antioxidants (%) of Hillawi and Khadrawi date palm fruit.

| Thinning Treatments                                               | 2011                                |          |        | 2012                                 |          |         |
|-------------------------------------------------------------------|-------------------------------------|----------|--------|--------------------------------------|----------|---------|
|                                                                   | Hillawi                             | Khadrawi | Mean   | Hillawi                              | Khadrawi | Mean    |
| No thinning                                                       | 38.43                               | 40.81    | 39.62E | 35.47                                | 38.63    | 37.05E  |
| 20% RCS                                                           | 62.47                               | 66.28    | 64.38B | 57.51                                | 61.89    | 59.70C  |
| 30% RCS                                                           | 67.94                               | 71.07    | 69.51A | 68.91                                | 72.48    | 70.69A  |
| 20% STT                                                           | 53.03                               | 55.65    | 54.34D | 54.03                                | 58.87    | 56.45D  |
| 30% STT                                                           | 56.61                               | 57.65    | 57.13C | 56.25                                | 59.91    | 58.08CD |
| 20% RCS+20%STT                                                    | 64.51                               | 67.28    | 65.89B | 59.32                                | 66.91    | 63.11B  |
| 30%RCS+30%STT                                                     | 68.31                               | 72.37    | 70.34A | 69.02                                | 73.11    | 71.06A  |
| Mean                                                              | 58.76B                              | 61.59A   |        | 57.21B                               | 61.69A   |         |
| LSD values                                                        | Treatments = 2.43, Varieties = 1.30 |          |        | Treatments = 1.80, Varieties = 0.962 |          |         |
| RCS= Removal of central strands, STT= Shortening of terminal tips |                                     |          |        |                                      |          |         |

**Table 4:** Effects of different strands thinning intensities on total tannin contents (%) of Hillawi and Khadrawi date palm fruit.

| Thinning Treatments                                               | 2011                                  |          |         | 2012                                  |          |        |
|-------------------------------------------------------------------|---------------------------------------|----------|---------|---------------------------------------|----------|--------|
|                                                                   | Hillawi                               | Khadrawi | Mean    | Hillawi                               | Khadrawi | Mean   |
| No thinning                                                       | 0.613                                 | 0.680    | 0.646A  | 0.633                                 | 0.693    | 0.663A |
| 20% RCS                                                           | 0.276                                 | 0.296    | 0.286C  | 0.300                                 | 0.320    | 0.310D |
| 30% RCS                                                           | 0.240                                 | 0.263    | 0.251DE | 0.223                                 | 0.276    | 0.250E |
| 20% STT                                                           | 0.453                                 | 0.483    | 0.468B  | 0.470                                 | 0.503    | 0.486B |
| 30% STT                                                           | 0.426                                 | 0.453    | 0.440B  | 0.443                                 | 0.440    | 0.441C |
| 20% RCS+20%STT                                                    | 0.266                                 | 0.283    | 0.275CD | 0.293                                 | 0.306    | 0.300D |
| 30%RCS+30%STT                                                     | 0.226                                 | 0.250    | 0.238E  | 0.210                                 | 0.263    | 0.236E |
| Mean                                                              | 0.357B                                | 0.387A   |         | 0.362B                                | 0.401A   |        |
| LSD values                                                        | Treatments = 0.031, Varieties = 0.016 |          |         | Treatments = 0.027, Varieties = 0.014 |          |        |
| RCS= Removal of central strands, STT= Shortening of terminal tips |                                       |          |         |                                       |          |        |

Means sharing same case letter for main effects and interaction, do not differ significantly at 5% probability level.

control (without thinning) in both date palm cultivars during both study years. Strands thinning intensity @ 30% RCS + 30% STT showed higher levels of TPC (62.79 and 62.15mg GAE/100g) in fruits and these fruits were statistically at par with the fruits treated as thinning intensity @ 30% RCS alone where TPC were 61.65 and 59.56 mg GAE/100g but these were greater than the fruits of all other treatments in both cultivars during the both years, respectively. Lower amounts of TPC (37.56 and 37.68 mg GAE/100g) were noted in untreated fruits (no thinning) in both cultivars during the both years (table 1). Strands thinning significantly increased the TFC contents in fruits as compared to untreated fruits (no thinning) in both cultivars. Strands thinning intensity @ 30% RCS + 30% STT showed maximum amounts of TFC (57.81 and 57.82mg CEQ/100g) in fruits these were at par to the fruits of thinning intensity @ 30% RCS (56.12 and 56.88 mg CEQ/100g) in both cultivars during the both years, respectively. Whereas, lower levels of TFC (21.93 and 21.71mg GAE/100g) were noted in fruits where no thinning was practiced in both date palm cultivars during the both years (table 2). Strands thinning efficiently increased the total antioxidants activities in fruits as compared to fruits where no thinning was performed.

Higher thinning intensity @ 30% RCS + 30% STT showed higher antioxidants of 70.34 and 71.06% in fruits and these were at par with the fruits of thinning intensity @ 30% RCS alone but these were greater than the fruits of other treatments in both date palm cultivars during the both years, respectively. Whereas, lower antioxidants (39.62 and 37.05%) were recorded in untreated fruits (no thinning) in both cultivars during the both study years, respectively (table 3). Strands thinning treatments effectively reduced the level of total tannin contents in fruits as compared to the fruits subjected to no thinning in both date palm cultivars. Strands thinning intensity @ 30% RCS + 30% STT showed lower amounts of total tannin contents (0.238 and 0.236%) in fruits than the fruits of all other thinning treatments in both cultivars during the both seasons, respectively. Maximum values of total tannins (0.646 and 0.663%) were noted in fruits subjected to no thinning treatments in both cultivars during the both years, respectively (table 4).

#### Individual sugars

Sugars in date fruit exert a number of valuable effects on the human health. Occurrence of high amounts of fructose in dates may provide several beneficial effects on human

**Table 5:** Effects of different strands thinning intensities on glucose contents (%) of Hillawi and Khadrawi date palm fruit.

| Thinning Treatments                                               | 2011                                                         |          |         | 2012                                                          |          |        |
|-------------------------------------------------------------------|--------------------------------------------------------------|----------|---------|---------------------------------------------------------------|----------|--------|
|                                                                   | Hillawi                                                      | Khadrawi | Mean    | Hillawi                                                       | Khadrawi | Mean   |
| No thinning                                                       | 18.59g                                                       | 16.92h   | 17.75E  | 17.92i                                                        | 16.84i   | 17.38D |
| 20% RCS                                                           | 28.09b                                                       | 25.77cde | 26.93C  | 27.23cd                                                       | 25.03ef  | 26.13B |
| 30% RCS                                                           | 30.25a                                                       | 26.36cd  | 28.31AB | 29.18ab                                                       | 25.11ef  | 27.14B |
| 20% STT                                                           | 24.91e                                                       | 22.66f   | 23.78D  | 24.57fg                                                       | 21.96h   | 23.26C |
| 30% STT                                                           | 25.21de                                                      | 23.51f   | 24.36D  | 24.66f                                                        | 23.20gh  | 23.93C |
| 20% RCS+20%STT                                                    | 29.80a                                                       | 25.88cde | 27.84BC | 28.26bc                                                       | 24.87f   | 26.56B |
| 30%RCS+30%STT                                                     | 30.65a                                                       | 26.95bc  | 28.80A  | 30.07a                                                        | 26.40de  | 28.23A |
| Mean                                                              | 26.78A                                                       | 24.00B   |         | 25.98A                                                        | 23.34B   |        |
| LSD values                                                        | Treatments = 0.932, Varieties = 0.498,<br>Interaction = 1.31 |          |         | Treatments = 0.1.02, Varieties = 0.546,<br>Interaction = 1.44 |          |        |
| RCS= Removal of central strands, STT= Shortening of terminal tips |                                                              |          |         |                                                               |          |        |

**Table 6:** Effects of different strands thinning intensities on fructose contents (%) of Hillawi and Khadrawi date palm fruit.

| Thinning Treatments                                               | 2011                                                        |          |         | 2012                                                        |          |        |
|-------------------------------------------------------------------|-------------------------------------------------------------|----------|---------|-------------------------------------------------------------|----------|--------|
|                                                                   | Hillawi                                                     | Khadrawi | Mean    | Hillawi                                                     | Khadrawi | Mean   |
| No thinning                                                       | 16.77g                                                      | 15.96g   | 16.36E  | 16.95g                                                      | 16.25g   | 16.60D |
| 20% RCS                                                           | 26.66b                                                      | 24.02cd  | 25.34C  | 26.54cd                                                     | 23.62e   | 25.08B |
| 30% RCS                                                           | 28.65a                                                      | 25.32bc  | 26.99AB | 28.47ab                                                     | 23.88e   | 26.17B |
| 20% STT                                                           | 23.21de                                                     | 21.47f   | 22.34D  | 22.92ef                                                     | 21.37f   | 22.14C |
| 30% STT                                                           | 23.77d                                                      | 21.84ef  | 22.80D  | 23.73e                                                      | 22.59ef  | 23.16C |
| 20% RCS+20%STT                                                    | 28.36a                                                      | 24.10cd  | 26.23BC | 27.44bc                                                     | 23.99e   | 25.71B |
| 30%RCS+30%STT                                                     | 29.47a                                                      | 25.40bc  | 27.43A  | 29.33a                                                      | 29.33a   | 27.51A |
| Mean                                                              | 25.27A                                                      | 22.59B   |         | 25.05A                                                      | 22.48B   |        |
| LSD values                                                        | Treatments = 1.01, Varieties = 0.543,<br>Interaction = 1.43 |          |         | Treatments = 1.11, Varieties = 0.595,<br>Interaction = 1.57 |          |        |
| RCS= Removal of central strands. STT= Shortening of terminal tips |                                                             |          |         |                                                             |          |        |

Means sharing same case letter for main effects and interaction, do not differ significantly at 5% probability level.

health by delaying or preventing the long-lasting diseases. Strands thinning significantly increased the level of glucose contents in fruits as compared to fruits where no thinning was practiced in both date palm cultivars. Fruits subjected to higher degree of strand thinning showed maximum level of glucose contents than fruits treated with lower thinning intensities. Strand thinning intensity @ 30% RCS + 30% STT attained higher levels of glucose contents (28.80 and 28.30%) in fruits and these were statistically at par with the fruits treated with thinning intensity @ 30% RCS alone but glucose contents of these fruits were significantly lower as compared to fruits of all other treatments in both cultivars during the both years, respectively. Minimum amounts of glucose contents (17.75 and 17.38%) were recorded in fruits subjected to no thinning treatments during the both years (table 5). Fruits treated with different strand thinning intensities showed greater amounts of fructose contents than untreated fruits (no thinning). Thinning intensity @ 30% RCS + 30% STT showed higher levels of fructose

contents (27.43 and 27.51%) in fruits and these were statistically at par with those fruits treated with thinning intensity @ 30% RCS alone where fructose contents were 26.99 and 26.17% in both date palm cultivars during the first and second season, respectively. Whereas, minimum levels of fructose contents (16.36 and 16.60%) were noted in control fruits during the both years (table 6). Strands thinning treatments significantly increased the level of sucrose contents in fruits as compared to fruits where no thinning was practiced in both date palm cultivars. Strands thinning intensity @ 30% RCS + 30% STT achieved higher amounts of sucrose contents (6.55 and 6.41%) in fruits and those were at par with the fruits treated with thinning intensity @ 30% RCS alone but sucrose contents were greater in these fruits as compared to the fruits of all the treatments (6.35 and 6.24%) during both years. Minimum amounts of sucrose contents (3.43 and 3.70%) were noted in fruits subjected to no thinning treatments in both cultivars during the both years (table 7).

**Table 7:** Effects of different strands thinning intensities on sucrose contents (%) of Hillawi and Khadrawi date palm fruit.

| Thinning Treatments                                               | 2011                                                          |          |        | 2012                                                          |          |       |
|-------------------------------------------------------------------|---------------------------------------------------------------|----------|--------|---------------------------------------------------------------|----------|-------|
|                                                                   | Hillawi                                                       | Khadrawi | Mean   | Hillawi                                                       | Khadrawi | Mean  |
| No thinning                                                       | 3.76h                                                         | 3.10i    | 3.43E  | 4.06i                                                         | 3.34j    | 3.70E |
| 20% RCS                                                           | 6.32bc                                                        | 5.08g    | 5.70C  | 6.09cd                                                        | 5.24f    | 5.66C |
| 30% RCS                                                           | 6.92a                                                         | 5.79def  | 6.35A  | 6.62ab                                                        | 5.85de   | 6.24A |
| 20% STT                                                           | 5.54ef                                                        | 5.03g    | 5.29D  | 4.76gh                                                        | 4.51h    | 4.63D |
| 30% STT                                                           | 5.87de                                                        | 5.13g    | 5.50CD | 4.98fg                                                        | 4.66gh   | 4.82D |
| 20% RCS+20%STT                                                    | 6.45b                                                         | 5.47f    | 5.96B  | 6.30bc                                                        | 5.61e    | 5.96B |
| 30%RCS+30%STT                                                     | 7.04a                                                         | 6.06cd   | 6.55A  | 6.89a                                                         | 5.93de   | 6.41A |
| Mean                                                              | 5.98A                                                         | 5.09B    |        | 5.67A                                                         | 5.02B    |       |
| LSD values                                                        | Treatments = 0.231, Varieties = 0.123,<br>Interaction = 0.327 |          |        | Treatments = 0.058, Varieties = 0.133,<br>Interaction = 0.352 |          |       |
| RCS= Removal of central strands, STT= Shortening of terminal tips |                                                               |          |        |                                                               |          |       |

Means sharing same case letter for main effects and interaction, do not differ significantly at 5% probability level.

## DISCUSSION

Fruit quality is a chief component to attain maximum economic return and develop healthy relationship between supply and demand and good for human health. The fruit of date palm is an important source of phytochemicals such as antioxidants, phenolic compounds, sterols, carotenoids, anthocyanins, procyanidins, tannin and flavonoids contents. In the current study, strands thinning significantly improved the phytochemicals and sugars profiling in date fruit and tannin contents were decreased in both date palm cultivars. Strands thinning @ 30% RCS alone and in combination with 30% RCS + 30% STT showed higher levels of phytochemicals in fruits at rutab stage than no thinning treatments. The greater improvement in quality of TPC, TFC, total antioxidants and reduction of total tannins in thinning treatments were due to more exposure of light because of less fruits density; as light plays an important role in those processes which are responsible for the accumulation of anthocyanins and phenolic compounds (Wicks and Kliever 1983, Dokoozlian and Kliever 1996). These findings were supported by Bubola *et al.*, (2011) and Profio *et al.*, (2012) who reported that cluster thinning significantly increased the accumulation of phenolics in grape berries. On the other hand, un-thinned fruits could not attain proper return due to less availability of light or air circulation that affects the rate of photosynthetic carbon assimilation rate (Morrison and Noble, 1990).

Strands thinning treatments efficiently improved the level of sugars in fruits as compared to un-thinned fruits in both cultivars. Strands thinning intensity @ 30% RCS alone and 30% RCS + 30% STT showed higher glucose, fructose and as compared to no thinning. The increase in glucose, fructose and sucrose are supported by different co-workers (Mostafa and El-Akkad, 2011; Iizadi *et al.*, 2010; Soliman *et al.*, 2011). Higher sugars accumulation

in thinned fruits is also in line with Brown and Coombe (1985) and (Crippen and Morrison, 1986) who reported that light exposure regulates the activity of invertase enzyme, which is responsible for sugars accumulation in grape berries.

## CONCLUSION

The findings of the present study have an important commercial implication that strands thinning at early fruit stages (4 weeks after pollination) improved the phytochemicals and sugars composition in both date palm cultivars. These findings could be helpful in achieving the desired goal to fulfill the quick energy requirements in human body.

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## REFERENCES

- Abdelhak M, E Guendez E, Eugene K and Kefalas P (2005). Phenolic profile and antioxidant activity of the Algerian ripe date palm fruit (*Phoenix dactylifera*). *Food Chem.*, **89**: 411-420.
- Abdul A and Allaith A (2008). Antioxidant activity of Bahraini date palm (*Phoenix dactylifera* L.) fruit of various cultivars. *Int. J. Food Sci. Technol.*, **43**: 1033-1040.
- Ahmed A, Ahmed AW and Robinson RK (1995). Chemical composition of date varieties as influenced by the stage of ripening. *Food Chem.*, **54**: 305-309.
- Ainsworth AA and Gillespie KM (2007). Estimation of total phenolic content and other oxidation substrates in

- plant tissues using Folin-Ciocalteu reagent. *Nature*, **4**: 875-877.
- Al-Farsi M, Alasalvar C, Morris A, Baron M and Shahidi F (2005b). Comparison of antioxidant activity, anthocyanins, carotenoids and phenolics of three native fresh and sun-dried date (*Phoenix dactylifera* L.) varieties grown in Oman. *J. Agric. Food Chem.*, **53**: 7592-7599.
- Al-Hooti S, Sidhu JS and Qabazard H (1997). Physicochemical characteristics of five date fruit cultivars grown in the United Arab emirates. *Plant Food Hum. Nutr.*, **50**: 101-113.
- Ali-Dinar HM, Alkhateeb AA, Al. Abdulhadi I, Alkhateeb A, Abugulia KA and Abdulla GR (2002). Bunch thinning improves yield and fruit quality of date palm (*Phoenix dactylifera* L.). *Egypt. J. Appl. Sci.*, **17**: 228-238.
- Al-Rawahi AS, Kasapis S and Al-Bulushi IM (2005). Development of a date confectionary: Part I. Relating formulation to instrumental texture. *Intr. J. Food Prop.*, **8**: 457-468.
- Al-Shahib W and Marshall RJ (2003). The fruit of the date palm: Its possible use as the best food for the future? *Int. J. Food Sci. Nutr.*, **54**: 247-259.
- Amira EA, Saafi EB, Mechri B, Lahouar L, Issaoui M, Hammami M and Achour L (2012). Effects of the ripening stage on phenolic profile, phytochemical composition and antioxidant activity of date palm fruit. *J. Agric. Food Chem.*, **60**: 10896-10902.
- AOAC (1980). Official Methods of Analysis. Association of Analytical Chemists. 13<sup>th</sup> Edition, Washington DC. USA. pp.291-858.
- Biglari F, AlKarkhi AFM and Easa AM (2008). Antioxidant activity and phenolic content of various date palm (*Phoenix dactylifera* L.) fruits from Iran. *Food Chem.*, **107**: 1636-1641.
- Brown SC and Coombe BG (1985). Solute accumulation by grape pericarp cells. III. Sugar changes *in vivo* and the effect of shading. *Biochem. Physiol.*, **180**: 371-381.
- Bubola M, Peršurić D and K Ganić (2011). Impact of cluster thinning on productive characteristics and wine phenolic composition of cv. Merlot. *J. Food Agric. Environ.*, **9**: 36-39.
- Crippen DD and Morrison JC (1986). The effects of sun exposure on the compositional development of 'Cabernet Sauvignon' berries. *Amer. J. Enol. Viticul.*, **37**: 235-242.
- Dokoozlian NK and Kliewer WM (1996). Influence of light on grape berry growth and composition varies during fruit development. *J. Amer. Soc. Hort. Sci.*, **121**: 869-874.
- Duke JA (1992). Handbook of phytochemicals of GRAS herbs and other economic plants. CRC Press, Boca Raton, FL, USA.
- El-Hadrami I and El-Hadrami A (2009). Breeding date palm. In: SM Jain and PM Priyadarshan, (Eds.). Breeding Plantation Tree Crops. Springer, New York. pp.191-216.
- Fayadh JM and Al-Showiman SS (1990). Chemical composition of date palm (*Phoenix dactylifera* L.). *J. Chem. Soc. Pak.*, **12**: 84-103.
- Iizadi M, Shirazi MP, Avoodian AD and Damankeshan B (2010). Effect of bunch thinning methods on date bunch fading disorder at pollination and kimri stages. Fourth International Date Palm Conference, Abu Dhabi, U.A.E. 15-17 March, p.57.
- Kim DO, Jeong SW and Lee CY (2003). Antioxidant capacity of phenolic phytochemicals from various cultivars of plums. *Food Chem.*, **81**: 321-326.
- Liu H, Cao Y, Huang W, Guo Y and Kang Y (2013). Effect of ethylene on total phenolics, antioxidant activity, and the activity of metabolic enzymes in mung bean sprouts. *Eur. Food Res. Technol.*, **237**: 755-764.
- Morrison JC and Noble AC (1990). The effects of leaf and cluster shading on the composition of Cabernet Sauvignon grapes and on fruit and wine sensory properties. *Amer. J. Enol. Viticul.*, **41**: 193-200.
- Mostafa RAA and El Akkad MM (2011). Effect of fruit thinning rate on yield and fruit quality of zaghloul and haiany date palms. *Aust. J. Basic App. Sci.*, **5**: 3233-3239.
- Myers SC, King A and Savelle AT (1993). Bloom thinning of 'Wimble' peach and 'Fantasia' nectarine with monocarbamide dihydrogensulfate. *HortScience*, **28**: 616-617.
- Myhara RM, Karkalas J and Taylor MS (1999). The composition of maturing Omani dates. *J. Sci. Food Agric.*, **79**: 1345-1350.
- Profio FD, Andrew G, Reynolds and Kasimos A (2012). Canopy Management and Enzyme Impacts on Merlot, Cabernet franc and Cabernet Sauvignon. I. Yield and Berry Composition. *Amer. J. Enol. Viticul.*, **63**: 325-332.
- Soliman SS, Al-Obeed RS and Harhash MM (2011). Effects of bunch thinning on yield and fruit quality of Khalas date Palm cultivar. *World Appl. Sci. J.*, **12**: 1187-1191.
- Steel RGD, Torrie JH and Dickey DA (1997). Principles and Procedures of Statistics. New York: McGraw-Hill.
- Tahraoui A, El-Hilalym J, Israili ZH and Lyoussi B (2007). Ethno pharmacological survey of plants used in the traditional treatment of hypertension and diabetes in southeastern morocco (Errachidia province). *J. Ethno-Pharmacol.*, **110**: 105-117.
- Vayalil PK (2012). Date Fruits (*Phoenix dactylifera* Linn): an emerging medicinal food. *Crit. Rev. Food Sci. Nutr.*, **52**: 249-271.
- Wicks AS and Kliewer WM (1983). Further investigations into the relationship between anthocyanins, phenolics and soluble carbohydrates in grape berry skins. *Amer. J. Enol. Viticul.*, **34**: 114-116.