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# STUDY ON PHYSICO-CHEMICAL AND PHYSIOLOGICAL CHARACTERISTICS OF DATE PALM FRUITS (*Phoenix dactylifera* L.) CV. UM-ALDEHIN

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This investigation was conducted on 'um-aldehin' date cultivar (*Phoenix dactylifera* L.) during the growing season of 2010 to study changes in physico-chemical and physiological characteristics during the different stages of fruit development. The results showed that the pattern of fruit growth and development on the basis of increase in the fresh weight of fruit, volume, length and diameter followed a single sigmoid growth curve. These specifications increased as the fruits developed and reached to the highest values at Khalal stage. Results also showed a decrease in values of moisture content, total titratable acidity, fatty compounds with an increase in total soluble solids, total and reducing sugars as fruits advanced toward the stages of Rutab and Tamer. Changes in respiration rate associated with ethylene production of fruits indicated to an increase in respiration rate when fruits entered the ripening stage (Rutab) while the highest increment of ethylene production occurred 7 days before the rapid increase in respiration rate. According to the results, there was a significant increase in the activities of invertase and cellulase enzymes at the end of Khalal stage and also at the beginning of Rutab stage.
**Keywords:** date fruits, um-aldehin, fresh weight, Khalal stage, total sugars, acidity

## INTRODUCTION

Date palm (*Phoenix dactylifera* L.) is a major fruit tree in Iraq because of the high nutritional fruit value which contain many chemical components such as sugars , vitamins and some mineral elements particularly iron, manganese and copper (Shabana *et al*., 2006).

During their development, date fruits pass some stages. After fruit set, a fruit fresh weight, volume, length and diameter of fruit gradually increases due to the cells division and the cells enlargement lasting until the end of Khalal stage which considers as maturation stage. Thereafter fruits enter ripening stage (Rutab), through it, many biochemical changes take place in fruit tissues such as increasing of glucose and fructose and decreasing of sucrose levels due to invertase activity, softening due to the activity of cellulase, pectinase, pectin esterase and polygalacturonase enzymes, losing of water content and other changes. The last stage of fruit life called Tamer stage which could be considered as senescence (Mater, 1991; Shabana *et al*., 2006). Some investigations were undertaken to study the growth curve of date palm fruits for different cultivars (Abd Al-Laytef, 1988; Blakt, 1988; Tafti *et al*., 2005; Taain, 2010) which reported that fruits of studied cultivars exhibited a single sigmoid growth curve. On the other hand, date fruits are classified as climacteric fruits according to Biale's classification (Rhodes, 1980). Some works reported the occurrence of climacteric rise in respiration rate of date palm fruits (Hejeri, 1981; Abd Al-Laytef, 1988; Abbas and Ibrahim, 1996; Taain, 2010).

Abd-Al-Wahid and Abid (2004) studied the activity of the enzyme invertase in the Hillawi date palm fruits and indicated the absence of any activity of the enzyme during the early growth stages, but the activity increased in Khalal stage and reached 2720 unit/kg/min. However, these levels declined to their lowest level in Tamer stage (100 unit/kg/min). Mustafa *et al*. (2006) observed during their study on invertase enzyme in three Sudanese date palm cultivars (Tawa, Bentamoda and Mishrig wad laggai ), that there were high levels of enzyme during physiological maturity (Khalal) in three cultivars and levels of invertase enzyme began increasing when fruits entered ripening stage. Um-aldehin cultivar is one of date palm cultivar grown in Basrah. It has a good taste and yellow color at maturation (Al-Baker, 1972). Due to the limited work conducted to study the fruit characteristics and the fruit growth curve of this cultivar and the relation between ripening of fruits and the changes in respiration rate and ethylene production in addition to the role of invertase and cellulase activities in the process of ripening of fruits (which determined for the first time in Um-aldehin cultivar according to the available literature), the present study was carried out to provide more knowledge regarding physico-chemical and physiological characteristics of fruits of Um-aldehin cultivar during their developmental stages.

## MATERIAL AND METHODS

One commercial orchard was selected in Abu-Al-Khasib region, south of Basrah and nine date palm trees of uniform size and vigour were selected for the present study during the growth season of 2010. Selected trees were grown on clay soil and were subjected to regular agricultural management practices. The number of inflorescences per date palm was adjusted to nine and chosen in different directions of the tree. Hand pollination was carried out on the 3rd April, 2010, using pollen grains from the male palms of Ghannami Akhdar cultivar.

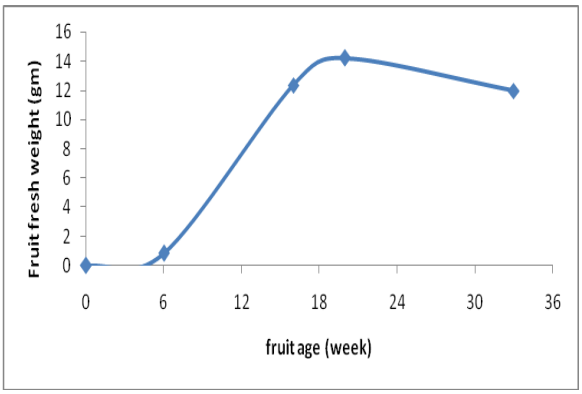
Twenty five fruits were picked randomly from all bunches of each replicate at biweekly intervals to determine their fresh weight, volume, length and diameter. Chemical analysis of fruits was made at the stages of Kimri (16 weeks from pollination), Khalal (20 weeks from pollination), Rutab (22 weeks from pollination) and Tamer (23 weeks from pollination). Fruit pulp was dried in an oven at 70°C for 48 hours to determine fruit moisture content (%). Total soluble solids (TSS) of fruit pulp were measured by hand refractometer (°Brix). Total and reducing sugars (%) of fruits were determined according to the method of Lane and Eynon outlined in AOAC (1990). A closed system method was used for determining the respiration rate quantitatively (Al-Ani, 1985), while the ethylene production was determined by using Gas Chromatography instrument (Hewlett Packard-HP 5840). Total titratable acidity was determined according to AOAC (1990), fatty compounds were extracted using Soxhlet instrument and the activities of invertase and cellulase enzymes were determined by extracting the samples and estimating the light absorption for each sample by using spectrophotometer (wavelength = 540 Nm) according to methods described in Ibrahim *et al.* (2002). Climatic information obtained from Meteorological Department at Basrah International Airport during the whole period of investigation is given in Table 1.

**Table 1. Monthly average Temperature (maximum and minimum) and relative humidity of growth season during year 2010**

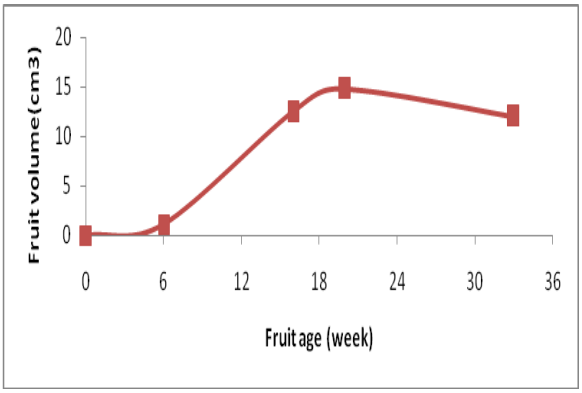
| Months | Maximum temperature (°C) | Maximum temperature (°C) | Relative humidity (%) |
|---|---|---|---|
| January | 21.47 | 10.36 | 91.39 |
| February | 24.65 | 12.16 | 70.99 |
| March | 31.03 | 16.01 | 61.25 |
| April | 34.15 | 20.39 | 58.57 |
| May | 39.58 | 25.19 | 48.28 |
| June | 46.52 | 27.42 | 42.14 |
| July | 47.20 | 29.15 | 23.11 |
| August | 47.43 | 29.24 | 33.13 |
| September | 44.55 | 27.11 | 47.21 |
| October | 37.45 | 21.33 | 56.12 |

## RESULTS AND DISCUSSION

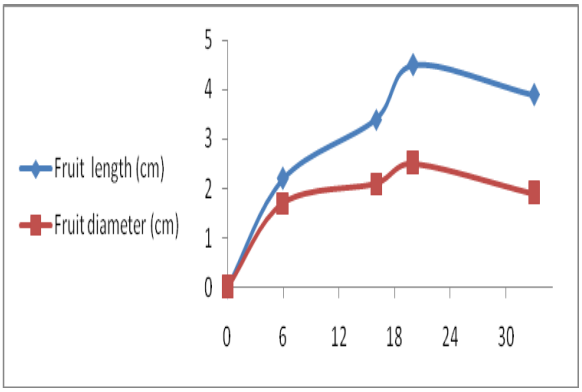
***Studying the curve of fruits growth*:** The results presented in Figure 1 show that the growth curve of fruit of Um-aldehin cultivar on the basis of fresh weight could be divided into three stages.




RLSD0.05=8.14




RLSD0.05=9.33




RLSD0.05( length)=1.1, RLSD0.05 ( diameter)=1.7

**Figure 1. Growth curve of fruits on the basis of increase in fresh weight, volume, length and diameter**

The first was rather slow growth period essentially due to cells division up to the end of the sixth week after pollination. Thereafter fruits entered into the rapid phase of growth which called Kimiri stage (16 week from pollination). The increment in average fresh weight of fruit was rapid to reach the highest values at Khalal stage (20 weeks from pollination). In maturation (Al-Khalal), the increment in average fresh weight of fruit was slower than that of Kimiri stage, then fruits entered ripening "Rutab" (22 weeks from pollination) in which the average fresh weight of fruits significantly decreased and reached to the lowest value at Tamer stage (23 weeks from pollination) which may be considered as senescence stage. The rapid increment of fruit fresh weight at Kimiri and Khalal stages is essentially the result of the increase in the size of cells with the continued process of cell division, and the increment of turgor pressure of fruit cells due to the accumulation of sugars which increase the value of osmotic potential and thus, water move into cells. In addition, the increase of auxin and gibberellins level at Kimiri and Khalal stages led to make the cell walls more elastic (Hopkins and Muner, 2008). The reason for the decrease in fruit fresh weight at Rutab and Tamer stages may be due to the loss of water content in the ripe fruits (Rygg, 1977). Fruit weight was (12.35g) at Kimiri stage and gradually increased to a maximum of (14.21g) at Khalal stage. Similar behaviour could be reported with regard to fruit volume, length and diameter which reached to the maximum values at Khalal stage (14.77cm$^3$, 4.5cm and 2.5cm, respectively). The increment in the fruit volume in Khalal stage matched closely with that of fresh weight of fruits which may be due to the accumulation of nutrients in the cells as well as turgid in water.

As previously stated, Um-aldehin fruits followed single sigmoid growth curve. These findings are in accordance with those previously reported by Abd Al-Laytef (1988) and Taain (2010) for other date cultivars.

***Chemical characteristics*:** Chemical characteristics of Um-aldehin date fruits at Kimiri, Khalal, Rutab and Tamer stage are presented in Table 2. As the fruits advanced to Tamer stage, there was a reduction in moisture content being significantly higher than those of other stages. The loss of moisture content in the fruits was, therefore, associated with the process of ripening and is in agreement with the results of Attaha and Taain (2009) for Sayer cultivar and Taain (2010) for Barhi cultivar.

The reason for the increment of moisture content at the stage of rapid growth (Kimiri) was due to occurrence of maximum expansion of cells by sugar accumulation and thus, osmotic potential becomes more negative which make water moves into cells on the basis of the difference in water potential (Hopkins and Muner, 2008). At Khalal stage there was a decline in moisture content of fruits, which lasted until Tamer stage.

Similar results were recorded regarding the content of fruit pulp of fatty compounds which was (0.63%) at Kimiri stage, then decreased at Tamer stage (0.52%). Total titratable acidity reduced gradually as fruits advanced toward the stages of Rutab and Tamer which may be due to either the loss of organic acids during respiration process or changed into sugars content (Hulme, 1970).

The patterns of changes in average total soluble solids values of fruits were almost similar to that of total and reducing sugars, with a rapid accumulation of total soluble solids, total and reducing sugars rapidly increased at ripening to harvest time. The accumulation of reducing sugars was rapid as the fruits entering ripening stage. These findings indicate a rapid conversion of sucrose into reducing sugars, thus, enhancing the ripening of fruits. These observations are in accordance with those previously reported by Abd-Al-Wahid (1997), and Attaha and Taain (2009).

**Physiological characteristics:**

***Respiration rate and ethylene production*:** Changes in respiration rate of Um-aldehin fruits are shown in Fig. 2. The rate of respiration was the highest at the early phase of the growth. Then the rate decreased gradually and reached to the value 33.55 mg $CO_2$ /kg/h at the end of Kimiri stage (16 weeks after pollination). At Khalal stage the respiration rate began to rise again and lasted up to the peak (93.22 mg $CO_2$ /kg/h) at early phase of Rutab stage. This rise in respiration rate is called the climacteric. Thereafter the respiration rate decreased and reached to the lowest value at Tamer stage of fruit age. The reason for this rise in respiration may be due to an increase in ethylene production in fruit tissues which caused this rise in respiration (McGlasson, 1985; Brady, 1987). The ethylene production increased gradually at Khalal stage and reached to the peak

**Table 2. Changes in chemical characteristics (%) of Um-aldehin date palm fruits during different developmental stages**

| Fruit stages | Moisture content | Total soluble solids | Total sugars | Reducing sugars | Sucrose | Acidity | Fatty components |
|---|---|---|---|---|---|---|---|
| Kimiri | 85.66 | 12.4 | 7.15 | 4.23 | 2.92 | 0.37 | 0.63 |
| Khalal | 80.12 | 35.2 | 26.33 | 22.13 | 4.2 | 0.33 | 0.58 |
| Rutab | 33.54 | 61.16 | 52.16 | 31.22 | 20.94 | 0.29 | 0.55 |
| Tamer | 21.15 | 76.4 | 62.28 | 62.28 | 0.00 | 0.27 | 0.52 |
| RLSD0.05 | 11.64 | 14.33 | 13.17 | 21.16 | 17.31 | 0.04 | 0.06 |

at the end of this stage, and then the ethylene production decreased at Rutab stage (Fig. 3). The highest increment of ethylene production occurred 7 days before the rapid increase in respiration rate (Fig. 3). These results are in agreement with Hejeri (1981); Abd Al-Laytef (1988); Abbas and Ibrahim (1996) and Taain (2010).

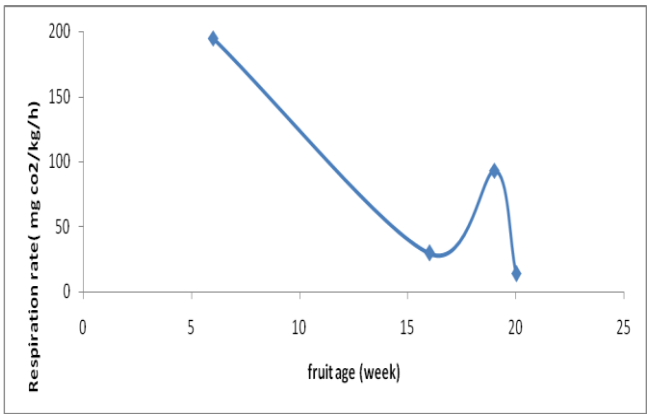



**Figure 2. Changes in respiration rate (mg $CO_2$/Kg/h) of Um-aldehin date palm fruits (RLSD 0.05 = 61.22)**

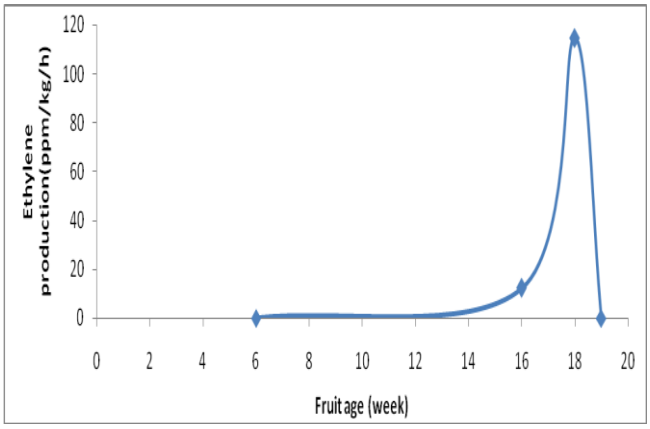



**Figure 3. Changes in ethylene production (ppm/Kg/h) of Um-aldehin date palm fruits (RLSD 0.05 = 75.03)**

***Invertase and cellulase activities*:** As indicated in Table 3, the rapid increase in the activity of the invertase enzyme appeared at the end of Khalal stage and reached to 8674.22 unit/kg/min whereas the activity of enzyme decreased to 853.81unit/kg/min at Rutab stage. Ripening is a complex process of biochemical and histological changes that leads the fruits to the stages of Rutab and Tamer. Invertase activates at Khalal in order to make conversion of sucrose to glucose and fructose (Shabana *et al*., 2006). These results are in agreement with Aati (2009) and Abd-Al-Wahid (2011) for Hillawi date palm cultivar. The activity of invertase was at the highest level when the fruits started ripening and turned to Rutab and Tamer stages (Mater, 1991). Softness of the fruit influenced not only by moisture content, but also by the activity of a number of hydrolysis enzymes associated with the stages of ripening such as invertase. The activity of cellulase at the end of Khalal reached to 1322.21unit/kg/min and then declined to 253.02 unit/kg/min at Rutab. The reason for the absence of cellulase activity at Kimiri stage may be due to the role of this enzyme in dissolving cell walls during ripening stage only (Giovannoni, 2004).

**Table 3. Changes in invertase and cellulase activities (unit/kg/min) of Um-aldehin date palm fruits during different developmental stages**

| Fruit stages | Invertase activity (unit/kg/min) | Cellulose activity (unit/kg/min) |
|---|---|---|
| Kimiri | 498.33 | 131.65 |
| Khalal | 8674.22 | 1322.21 |
| Rutab | 853.81 | 253.02 |
| RLSD0.05 | 288.66 | 195.31 |

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