

Respiration Rates of Ten Libyan Date Cultivars (*Phoenix Dactylifera*) Measured at Balah Stage

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Abstract. Respiration rates for ten Libyan date cultivars were measured at 'Balah' stage. They were five soft cultivars selected from the coastal region and five semidry cultivars from Jufra region located 750 km south of Tripoli. Respiration rates were measured at 1, 10, 20, 30 and 40°C as CO₂ produced and O₂ consumed. Rates were found in good agreements with those reported in literature at 20°C. Respiration rates followed general fruit respiration trends, and exhibited second order polynomial pattern ($R^2 > 0.95$). Respiration quotients were also determined for the two groups, they were within reported limits for other fruits, but no specific pattern was exhibited. Further investigations of respiration rates for other cultivars and under controlled atmosphere conditions is recommended.

Keywords: Dates, Libya, Respiration, Soft, Semidry, Cultivars.

1. Introduction

Date palm (*Phoenix dactylifera*) is a very important tree to societies in dry regions and desert oases. Libya has the second largest area in the Mediterranean next to Algeria, with 1.75 million square kilometers, extends between latitudes 24:57°N and 32:75°N. According to FAO statistics, Libya attains the tenth place among date producing countries, with annual production exceeding 170 thousand metric tons [1]. In general, date cultivars are classified into three groups based on their moisture content at ripening, soft (>30%), semidry (20-30%) and dry (<20%) [2]. Sugar-wise, soft cultivars contain mainly fructose and glucose, but dry cultivars have the highest percentage of sucrose [3]. For its climate, the three groups of cultivars are cultivated in Libya, soft cultivars are cultivated in the coastal region around 30°N, semidry cultivars are cultivated in Jufra and Wahat oases around 29°N, and dry cultivars are cultivated in the Fezzan region between 24:57°N and 27°N. Soft and semidry cultivars have good market potential, thus there is great expansion in their cultivation, marketing, also are targeted in research and development strategies.

Dates fruits have four development stages, in Libya they are named as: 'Gamag' (unripe, green in color, solid, better, or pungent), 'Balah' (full size crunchy, yet not sweet in most cultivars), 'Rutab' (ripe, sweet, and soft) and 'Tamer' (full ripe, low moisture content) [2], [4]. In general, dates exhibit high respiration and ethylene rates during 'Balah' stage, thus are treated as climacteric fruits [2]. Respiration rate data at 'Balah' stage is quite scarce, especially for Libyan cultivars, however, respiration rates values of few cultivars grown in other regions exist [5].

Unlike other fruits, dates are marketed at more than one development stage, depends on cultivar variations; quite few are marketed at 'Balah', others at 'Rutab', and others are marketed at 'Tamer' stage, while some others are marketed at two stages. For instance, in the Middle East, 'Barhi' dates are marketed at 'Balah' and 'Rutab' stages [6]. In Libya however, soft cultivars such as 'Helawi' and 'Hurra' are marketed merely at 'Balah' stage, while other soft cultivars such as 'Bronsi' and 'Taboni' are marketed only as 'Rutab', whereas dry and semidry varieties are marketed as either 'Rutab' or 'Tamer'.

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Respiration is indeed the most important biological activity in fruits and vegetables, it maintains produce freshness, yet has to be reduced to its minimum levels. Low respiration rates lead to extending marketability and storage period [7]. In addition, respiration rate is an important information that is needed for designing controlled atmosphere storage [8], [9]. Also, it can be invaluable information for artificial ripening applications.

This paper reports measuring respiration rates of ten date fruit cultivars grown in two Libyan regions; five from the Coastal region near Tripoli and other five from Jufra located at 750km south.

2. Materials and Methods

2.1. Plant Materials

Soft cultivars collected from locations near Tripoli were: 'Helawi', 'Taboni', 'Hurra', 'Bronsi', and 'Bekrari', while cultivars chosen from Jufra region were semidry cultivars; they were 'Deglat', 'Tagyat', 'Abbel', 'Khadraya', and 'Saidi'. Bunches were cut at 'Balah' stage, brought cooled in insulated food containers to the postharvest laboratory at the department of Agricultural Engineering, Tripoli University. Fruits were kept at 5°C in a walk-in cold room until respiration measurements started. Ripe fruits at 'Rutab' stage were excluded in all measurements.

2.2. Enclosure

For maintaining airtight conditions, 1L bottles with an opening wide enough for entering fruits equipped with threaded cap were selected. On the cap two tire valve were installed (Fig. 1), one for drawing air samples and the other was used for circulating air whenever CO₂ level exceeded 3%. A plastic pipe with treaded joints was used for connecting the tire valve with the gas analyzer.



Fig. 1: Enclosure used in respiration measurement setup

2.3. Measurement

Fruits were separated from their branch, weighed in 400 to 500g sample size, depending on the cultivar, filled in the bottle and free volume was determined using displacement method. Bottles were kept open to equilibrate with measuring temperature, then were tightly closed. Starting time was recorded and samples were kept closed for enough time to accumulate CO₂. Samples were aerated whenever CO₂ level exceeded 3% as suggested by [10]. All measurements were performed in triplicates.

2.4. Air Analysis

Connection was installed between the tire valve on the cap and air intake orifice of a portable gas analyzer (Model CANAL120 O₂ & CO₂ Gas Analyzer, EMCO Packaging Systems Ltd, Kent, CT14 0BD UK). The analyzer draws small volume air sample, analyze it, and displays O₂ & CO₂ percentage on an LCD screen.

2.5. Respiration Rate Calculations

Respiration rate was calculated as CO₂ produced and O₂ consumed using equations 1 and 2, while respiration quotients were determined using equation 3.

$$RR_{CO_2} = \frac{DC O_2 \% * V}{m Dt} \quad (1)$$

Where:

RR_{CO_2} = Respiration rate expressed as CO₂ produced (ml.kg⁻¹.h⁻¹)

$DO_2\%$ = Change in CO₂ concentration (%),

V= Free bottle volume (ml)

m= produce mass (kg),

Dt = time between closure and measurement (h)

$$RR_{O_2} = \frac{DO_2\% * V}{m Dt} \quad (2)$$

Where:

RR_{O_2} = Respiration rate expressed as O₂ produced (ml.kg⁻¹.h⁻¹)

$DO_2\%$ = Change in O₂ concentration (%),

V= Free bottle volume (ml)

m= produce mass (kg),

Dt = time between closure and measurement (h)

Respiration Quotient (RQ) is the ratio between CO₂ produced and O₂ consumed rates, was calculated using equation 3.

$$RQ = \frac{RR_{CO_2}}{RR_{O_2}} \quad (3)$$

3. Results and Discussions

Fig. 2. shows respiration rate as CO₂ produced (top) and respiration quotients (bottom), trends similar to respiration rates for other commodities reported in literature were followed [11]. Soft cultivars (left up) exhibited similarity among the five cultivars. In semidry cultivars however, 'Kadraya' and 'Deglah' exhibited different trends from the others, perhaps due to cultivar differences. Nonetheless, mean respiration rate as CO₂ produced for the five semidry cultivars at 20°C was 8.4 (±1.23) ml.kg⁻¹.h⁻¹, while for soft cultivars, mean rate was 10.5 (±4.15) ml.kg⁻¹.h⁻¹. Considering mean respiration rate (8.5 ml.kg⁻¹.h⁻¹) of 'Zahidi', 'Diri' and 'Soltani' measured at 20°C, as reported in the literature [5]. It is quite evident that respiration rates measured for cultivars in this investigation are in good agreement with those reported in the literature. At higher temperatures however, no respiration rates of date cultivars at such temperatures have been found in the literature, however they can be considered as quite good. Fig. 3 presents data fitting for respiration rates of Libyan soft and semidry cultivars. The two groups followed second order polynomial pattern (R²>0.95). However, such patterns are in good agreement with general respiration trend proposed in the literature [11]. Respiration rates at high temperature for dates is rather scarce, nevertheless, indeed they can be invaluable information for artificial ripening applications.

Respiration quotients (RQ) of soft and semidry cultivars were not consistent (Fig. 2 bottom), their ranges were (0.762 to 1.32) and (0.719 to 1.046) for soft and semidry cultivars, respectively. Such ranges are not correlated with temperature, and no specific trend was followed. RQ values were near unity at low temperatures, at 10 and 20°C were blow unity, while at higher temperatures, they were above unity for soft cultivars, and near unity for semidry ones. RQ for the soft cultivar 'Bekrari' exhibited different trend from all cultivars, this perhaps referred to the cultivar itself. Generally, RQ at unity means a glucose respiration substrate, less and above unity are related to either other substrates or anaerobic conditions [12], [13]. Such unclear trends may be attributed to the fact that most cultivars do not contain glucose as they were unripe, except 'Helawi' which marketed as 'Balah'. It is a sweet cultivar, its sugar content about 50% and therefore consumed at 'Balah' stage, showed RQ unity at most temperatures, except at 10°C where it was 0.73. RQ for 'Helawi' was indeed related to its high glucose content, other cultivars with very low glucose content exhibited different RQs. Respiration quotient is indeed affected by several factors, such as substrate, CO₂

effect, O₂ intake, enzymatic activities, state of equilibrium and many other factors [13]. Hence, it is quite difficult to draw firm conclusion, unless special experiments are applied.

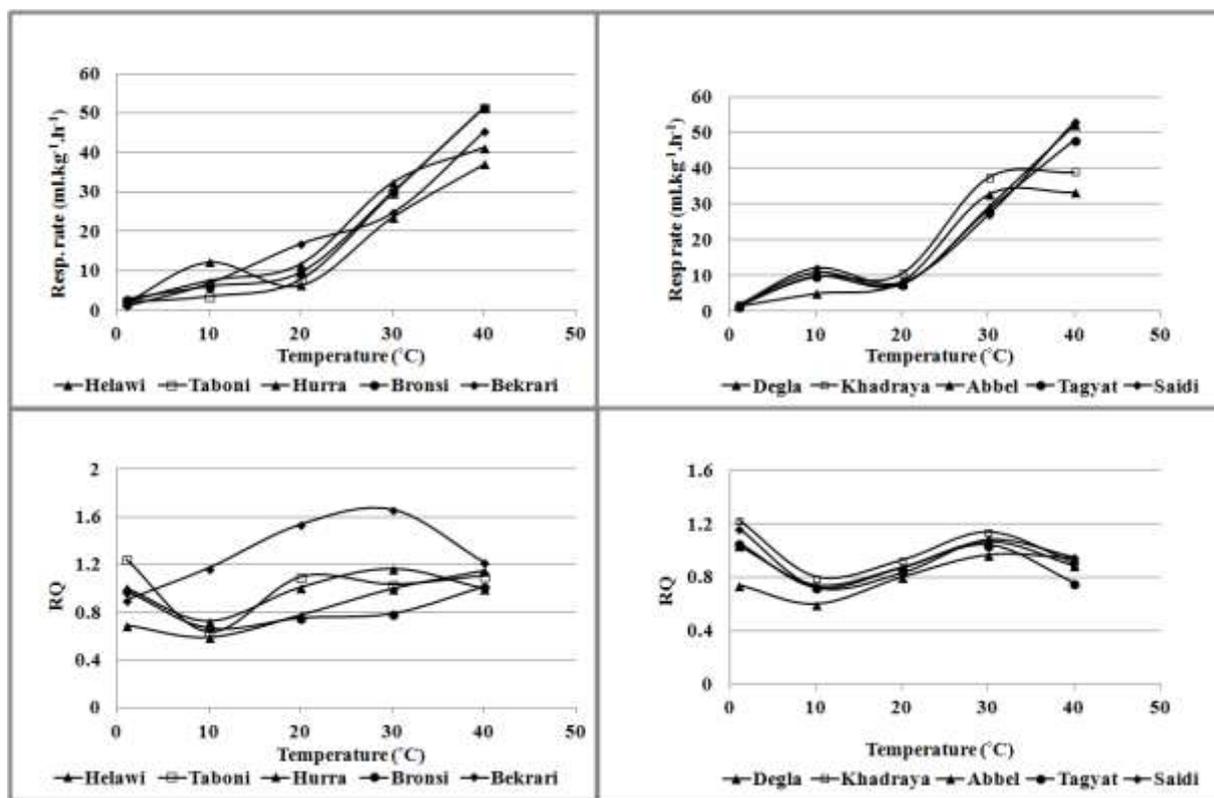


Fig. 2: Respiration rates and respiration quotient for soft and semidry date cultivars.

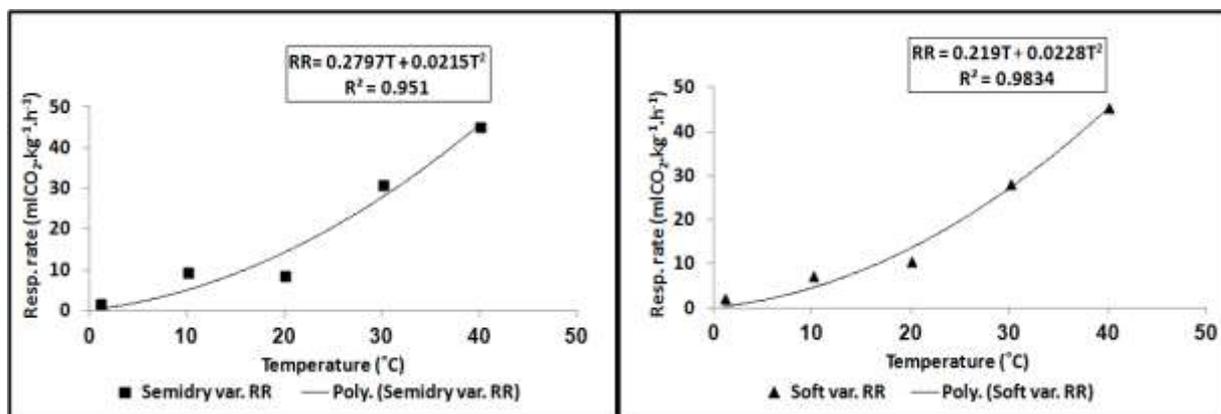


Fig. 3: Respiration rate curve of soft and semidry date cultivars.

4. Conclusions

Respiration rates of ten Libyan date cultivars were measured, five soft cultivars from the coastal region near Tripoli, while other five semidry cultivars from in Jufra region at 750km south. Respiration rates were determined at 1, 10, 20, 30 and 40°C, and measured as CO₂ produced and O₂ consumed, from which respiration quotients were determined. Respiration rates were found in good agreements in some values and trends with those reported in literature. Respiration-temperature relations for the two groups exhibited second order exponential patterns, and agreed with those reported in the literature. However, respiration quotients did not exhibit specific trends, but they were within acceptable ranges. Further investigations of respiration rates of more cultivars, as well as other conditions, such as controlled and modified atmosphere effects on respiration rates at 'Balah' and 'Rutab' stages worth further investigations.

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