Univerzitet u Beogradu
Poljoprivredni fakultet
Institut za poljoprivrednu tehniku
Naučni časopis
POLJOPRIVREDNA TEHNIKA
Godina XLII
Broj 2, 2017.
Strane: 11 - 18

University of Belgrade
Faculty of Agriculture
Institute of Agricultural Engineering
Scientific Journal
AGRICULTURAL ENGINEERING
Year XLII
No. 2, 2017.
pp: 11 - 18

UDK: 664.863

Originalni naučni rad
Original scientific paper

EFFECT OF LAG TIME BETWEEN HARVEST AND PRE-COOLING ON RESPIRATION RATE OF GRAPES (*Thompson Seedless*) DURING STORAGE

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Abstract: During the respiration, the oxygen concentration decreased and the carbon dioxide concentration increased which results in decreased respiration rate. After precooling, the grapes were stored under cold storage. The storage studies was carried out for 40 days during which the changes in respiration rate were analyzed. During 2nd day of storage, grapes stored in ambient condition showed higher respiration rate of 100.36 and grapes precooled immediately after harvest showed minimum respiration rate of 28.73 mg CO_2 kg^{-1} h^{-1}. During 40th day of storage, the respiration rate of grapes precooled immediately after harvest showed 17.57 whereas the respiration rate of grapes precooled with time lag of 6 h was found to be 18.76 and it was 17.05 mg CO_2 kg^{-1} h^{-1} in grapes precooled after time lag of 12 h from harvest, respectively. The grapes stored in ambient condition showed the lowest respiration rate of 6.73 mg CO_2 kg^{-1} h^{-1} during 32nd day of storage.

Key words*: Precooling, Respiration rate, Thompson seedless grapes*

INTRODUCTION

Grapes (*Vitis vinifera*) are the third most widely cultivated fruit after citrus and banana in India. Globally grapes production contributes to about 16% among the total fruit production. India produced 1878 thousand tonnes during 2008 which was about 2.77% of the total world production [5]. Thomson seedless is the major exporting variety from India and approximately, 2.5% (53190 tonnes valued at 48505 thousand US dollars) of fresh

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grapes are exported to the Middle East and European countries. India's share out of total world's export was only 1.46%. Even though the grape production in India is high its contribution to the export market was less due to lack of cold chain management and improper precooling facilities.

Tropical fruits and vegetables are harvested at temperatures in the range of 25 to 30°C. Therefore, the respiration rate of the produce is high and the storage life is short. The time lag before precooling of fruits and vegetables will also affect the respiration rate during storage. Even though the fruits and vegetables are placed in cold storage 2 or 3 days after harvest, the quality of produce cannot be maintained due to increased metabolic activity such as respiration rate and ethylene production immediately after harvest [4].

Respiration rate. Respiration occurs continuously in all active cells of a fruit or a vegetable after harvest. It is an oxidation-reduction process in which photosynthetic compounds were oxidized to carbon dioxide (CO_2) and oxygen (O_2) is reduced to form water. The chemical reaction under aerobic conditions is represented as the following [6]:

$$C_6H_{12}O_6 + 6O_2 = 6CO_2 + 6H_2O + 2872 \text{ kJ/mol} \quad (1)$$

The reaction shown above is based on one mole of glucose ($C_6H_{12}O_6$). The above reaction is simplified for easy understanding. The entire reaction is actually made up of more than 50 component reactions, with each reaction occurring due to a different enzyme. The process of respiration can use many substrates other than $C_6H_{12}O_6$, such as starches, sucrose, fats, organic acids, and proteins [8].

When the process of respiration completely oxidizes the carbohydrates, such as glucose, sucrose, or starch, the amount of CO_2 evolved will equal the amount of O_2 absorbed. If other substrates are used, or if there is incomplete oxidation, then the amount of O_2 used and the amount of CO_2 evolved will not always be equal. The ratio of CO_2 to O_2 is referred to as the respiratory quotient (RQ) and may be expressed as follows.

$$\text{RQ} = \frac{\text{CO}_2\text{evolved (ml CO}_2.\text{kg}^{-1}.\text{h}^{-1})}{\text{O}_2\text{ absorbed (ml O}_2.\text{kg}^{-1}.\text{h}^{-1})} \quad (2)$$

The value of RQ can be useful in determining what type of substrates the cells are using. The difficulty in this is that many substrates can be oxidized at the same time and the RQ value gives an average of the CO_2 and O_2 relations.

The respiration rate depends on enzymatic activity, which is a function of temperature. Thus, temperature plays a significant role on the overall respiration rate since respiration requires the action of over 50 enzymes and the level of enzyme activity is affected by temperature. The effect of temperature on the respiration rate is often quantified by determining the Temperature Coefficient (Q_{10}) [6].

$$\text{Q10} = \frac{[\text{Respiration rate at (T℃} + 10℃)]}{\text{Respiration rate at T℃}} \quad (3)$$

The Q_{10} may be calculated based on the number of ml-kg^{-1}-h^{-1} of CO_2 evolved or O_2 absorbed. Generally, the respiration rate (Q_{10}) is increased by a factor of 2 to 4 for each temperature increase of 10°C [11].

Modification of the gas composition surrounding the produce after harvest may be used to control the respiration rate. It has been observed that increasing the CO_2 level and decreasing the O_2 level tend to decrease the rate of respiration of some produce [12].

MATERIAL AND METHODS

Experimental procedure for on-farm precooling of grapes. The precooling unit was installed in farmer's field (Madampatti village) in Coimbatore district and the experiments were carried out during the month of September and November, 2014. The matured Thompson seedless grape bunches were harvested from the field and immediately precooled with different time lag. [1] reported that weight loss due to transfer of moisture was more while precooling grapes with 3 m/s air velocity and with the air velocity 1.5 m/s the cooling rate was optimum with less moisture loss. Four crates of grapes were placed inside the chamber and the precooling operation was carried out with the air velocity of 1.5 m/s with the air temperature of 2°C. To evaluate the effect of cooling time delay on physiochemical quality during storage period the grapes are precooled with different time lag from harvest such as precooled immediately after harvest (T1), harvested grapes are kept in field under atmospheric condition and then precooled with time lag of 6 h (T2), precooled after time lag of 12 h from harvest (T3), directly stored in cold storage without precooling treatment after lag of 24 h from harvest (T4), stored in ambient condition (T5).

After different precooling treatments, the grapes were placed in crates and stored inside the cold storage maintained at 4°C and 85% RH and the control sample was placed in ambient condition continuously throughout the storage period. The samples were taken once in five days for various bio-chemical analysis throughout the storage period.

Studies on respiration rate of Grapes. The changes in respiration rate that occurred in the grapes during storage were the important criteria for assessing the quality. After precooling, the grapes were stored under cold storage for storage studies except (T5), which was stored under ambient condition as control sample. The storage studies was carried out for 40 days during which the changes in respiration rate were analyzed with 2 days interval. The precooling and storage studies were carried out with three replications and average values were calculated and used for discussion.

Respiration rate of grapes. Respiration is a metabolic process, which consists of oxidative breakdown of organic matter present in the cells such as starch, sugars, acids, fats, proteins into simpler molecules such as carbon dioxide and water along with concurrent production of energy and other molecules which will be used by the cell for synthetic reactions [10]. Though it is necessary to maintain the metabolic process, it hastens senescence which is undesirable for shelf life extension. Respiration results in the loss of moisture from the fresh produce which results in the shrinkage and physiological loss in weight. The extent of respiration can be measured by determining the amount of substrate loss, oxygen consumed, carbon dioxide liberated and heat produced and energy evolved [8].

To measurement the respiration rate of grape stored under cold storage according to different precooling treatments. One kg of grape were taken from storage kept inside the containers for the measurement of respiration rate. The containers were closed with the lids. The lid was made air tight by wrapping the lid with packaging tape. The containers were stored in clean and dry place at ambient condition and cold storage conditions according to the storage treatment [7]. Every one hour, the gas samples were drawn from the container through silicon rubber septum using needle and gas concentration was found out using MAP analyzer and using the recorded gas composition, the respiration rate of oxygen and carbon dioxide were calculated. The respiration rate can be calculated by the change in O_2 or CO_2 concentration with time when the commodity was stored in a closed container as given below [3].

$$Ro_2 = \frac{(y^{ti}o_2 - y^{tf}o_2) \times V}{100 \times M \times (t_f - t_i)} \quad (4)$$

$$Rco_2 = \frac{(y^{tf}co_2 - y^{ti}co_2) \times V}{100 \times M \times (t_f - t_i)} \quad (5)$$

Where, Ro_2 and Rco_2 = Respiration rate, in terms of O_2 consumed and CO_2 evolved respectively (m^3/kg/h), V = Free volume inside the container, $y^{ti}o_2$ and $y^{tf}o_2$ = Volumetric concentration of O_2 (%) at initial and final time respectively, $y^{ti}co_2$ and $y^{tf}co_2$ = Volumetric concentration of CO_2 (%) at initial and final time respectively, M = Mass of the stored product (kg), t_i and t_f = Initial and final time respectively (h).

Statistical analysis was carried out to study the effect of time lag prior to precooling on respiration rate of grapes. Based on the effect of lag time before precooling on the respiration rate have been estimated with the help of statistical analysis using AGRES. Analysis of variance (ANOVA) was conducted to determine whether significant effect exists due to lag time before precooling.

RESULTS AND DISCUSSION

Respiration rate of grapes during storage. The respiration rate of grapes was calculated using the changes in CO_2 and O_2 levels inside a closed container and the change in respiration rate is expressed in mg CO_2 kg^{-1} h^{-1}. The respiration rate of grapes was measured once in two days throughout the storage studies and the respiration rate of grapes was found to be increasing in all the treatments. The respiration rate affected by different precooling treatments (T) and storage period (S) of grapes was presented in Fig.1.

Analysis of variance was performed to find out the effect of different precooling treatments on respiration rate of grapes during storage period and the results were reported in Table.1. The effect of different precooling treatments and the storage days were found

to be highly significant at 1% level and the interactions were also found to be significant at 1% level. During 2nd day of storage, T5 showed higher respiration rate of 100.36 and T1 showed minimum respiration rate of 28.73 mg CO_2 kg^{-1} h^{-1}.

The respiration rate of T2 during 2nd day of storage was found to be 25.33 mg CO_2 kg^{-1} h^{-1}, in T3, it was found to be 36.16 and 69.20 in T4 treatments, respectively. During 20th day of storage T5 showed the higher respiration rate of 55.45 whereas it was 22.76 mg CO_2 kg^{-1} h^{-1} in T1. The other three treatments T2, T3 and T4 showed more or less similar respiration rate of 27.86, 29.36 and 32.63 mg CO_2 kg^{-1} h^{-1}, respectively.

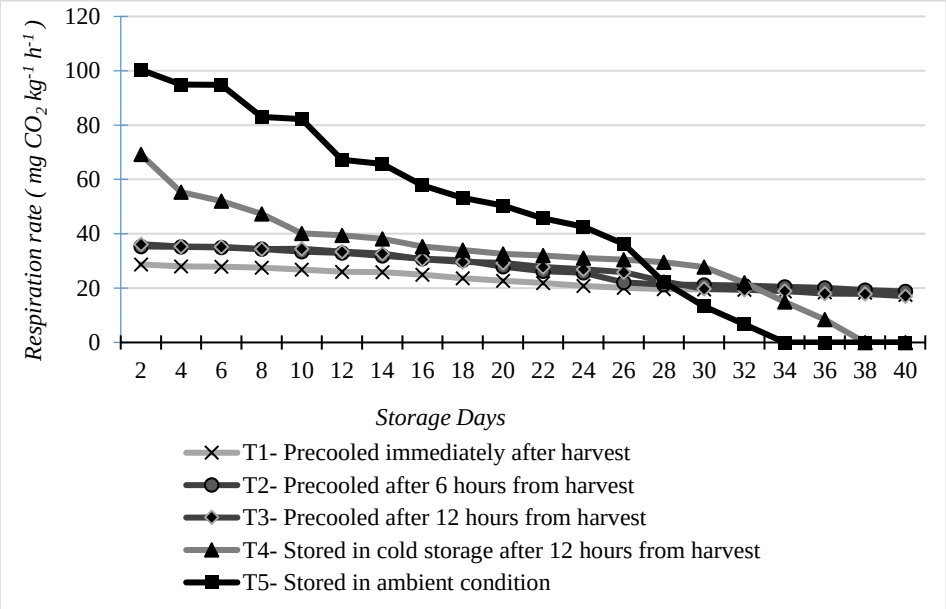

Figure 1. Respiration rate of grapes for different precooling treatments during storage

During the respiration, the oxygen concentration decreased and the carbon dioxide concentration increased which results in decreased respiration rate. The results are in agreement with [2]. Under refrigerated condition the temperature is about 10ºC and the biochemical reactions were found to be lower when compared to ambient condition. The respiration rate decreased with the decrease in temperature due to less reaction rate at lower temperatures [9].

During 40th day of storage, the grapes in T5 and T4 treatments spoiled completely. The respiration rate of grapes in T1 treatment showed 17.57 whereas the respiration rate of grapes in T2 was found to be 18.76 and it was 17.05 mg CO_2 kg^{-1} h^{-1} in T3 treatment, respectively. The grapes stored in ambient condition showed the lowest respiration rate of 6.73 mg CO_2 kg^{-1} h^{-1} during 32nd day of storage. After that the grapes completely spoiled.

Table.1. ANOVA for main effects and its interaction on change in respiration rate of grapes

Source	*df*	*SS*	*MS*	*F*	*PROB*
TOT	*299*	*13711.67*	*45.85*	*301.37*	
Trt	*99*	*13681.24*	*138.19*	*908.18*	*0.062 NS*
Err	*200*	*30.43*	*0.15*	*1.00*	
T	*4*	*2852.06*	*713.0*	*4685.82*	*0.00* **
S	*19*	*5311.77*	*279.56*	*1837.26*	*0.00* **
TS	*76*	*5517.40*	*72.59*	*477.09*	*0.00* **
Err	*200*	*30.43*	*0.15*	*1.00*	
CV	*2.66%*				
	SED		*CD(0.05)*		*CD(0.01)*
T	*0.07*		*0.14*		*0.18*
S	*0.14*		*0.28*		*0.37*
TS	*0.31*		*0.62*		*0.82*

NS- Non Significant,
*** Significant at 1% level,*
** Significant at 5% level.*

CONCLUSIONS

Quality loss after harvest occurs as a result of physiological and biological processes, the rates of which are influenced primarily by product temperature and respiration rate. After harvest, many horticultural products are susceptible to deterioration. Table grapes, for example, should be cooled promptly and thoroughly after harvest in order to maintain their quality. Temperature has a pronounced effect on the respiratory rate of harvested products. As product temperature increases, biological reaction (respiration) rates increase logarithmically. For every 10°C rise in temperature, the rate of respiration is roughly doubled or tripled.

BIBLIOGRAPHY

[1] Ibrahim Dincer. 1995. Air Flow Precooling of Individual Grapes. *Journal of Food Engineering, 26*, 243-240.

[2] Lee, D.S., P.E. Haggar, J. Lee and K.L. Yam. 1991. Model for fresh produce respiration in modified atmospheres based on principles of enzyme kinetics. *Journal of Food Science*. 56: 1580-1585.

[3] Ranjeet Singh, Saroj Kumar Giri, Sitaram and D. Kulkarni. 2013. Respiratory behaviour of mature light green guava (psidium guajava l.) under closed system. Scientific Journal *agricultural engineering*, No. 1, 2013. pp: 23 – 29

[4] Ranjeet Singh, Ashok Kumar, Sandeep Mann and Sitaram D. Kulkarni, 2012. Respiration rate models of fresh chickpea sprouts (*cicer arietinum* l.) under modified atmosphere packaging. Scientific Journal *agricultural engineering*, 2012. pp: 49 – 57.

[5] Anonymous, 2014. Horticultural database of fruits and vegetables. Indian horticulture board, Government of India, pp. 15-75.
[6] Hopkins, W.G. 1995. Introduction to Plant Physiology. John Wiley & Sons, Inc., Toronto, 464 pp.
[7] Kays, S. L. 1997 Postharvest Physiology of Perishable Plant Products. Eaton Press, Athens, Georgia. 532 pp.
[8] Pantastico, E.R.B., T.K. Chattopadhyay and H. Subramanyan. 1975. Storage and commercial storage operations. AVI publishing Company, Inc., Westport, Connecticut. pp.560.
[9] Salisbury, F. B. and C. W. Ross. 1992. Plant Physiology, Fourth Edition. Wadsworth Publishing Company, Belmont, California. 682 pp.
[10] Wills R.B.H., McGlasson W.B., Graham D., Lee T.H. and Hall E.G., 1989. Postharvest: An introduction to the Physiology and Handling of Fruit and Vegetables. Van Nostrand Reinhold. New York.
[11] Kader, A.A. 1987. Ch. 3: Respiration and gas exchange of vegetables. In: Weichmann, J. Postharvest physiology of vegetables. Marcel Dekker, Inc. New York, USA. 597p.
[12] Kader, A. A. 1992. Postharvest Technology of Horticultural Crops. 2n^{d} ed., Cooperative Extension University of California, Davis, CA, Publ. No. 3311, 295 pp.

UTICAJ VREMENA IZMEĐU BERBE I PREDHLAĐENJA NA RESPIRACIJU GROŽĐA (*Thompson Seedless*) TOKOM SKLADIŠTENJA

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Sažetak: Tokom respiracije, koncentracija kiseonika opada i povećava se koncentracija ugljen-dioksida, što dovodi do smanjenja respiracije. Posle predhlađenja, grožđe je skladišteno u hladnom skladištu. Istraživanje je sprovedeno tokom 40 dana i analizirane su promene respiracije. Tokom drugog dana skladištenja, grožđe u normalnim uslovima je pokazalo višu respiraciju od 100.36, dok je grožđe ohlađeno odmah posle berbe pokazalo minimalnu respiraciju od 28.73 mg CO_2 kg^{-1} h^{-1}. Tokom 40-tog dana skladištenja, respiracija grožđa koje je ohlađeno odmah posle berbe iznosila je 17.57, dok je transpiracija grožđa ohlađenog 6 h posle berbe oznosila 18.76, a 17.05 mg CO_2 kg^{-1} h^{-1} kod grožđa sa kašnjenjem hlađenja od 12 h. Grožđe u skladišteno u normalnim uslovima pokazalo je najnižu respiraciju od 6.73 mg CO_2 kg^{-1} h^{-1} tokom 32. dana skladištenja.

Ključne reči: *predhlađenje, respiracija, Thompson loza*

Prijavljen: *Submitted*:	14.06.2016.
Ispravljen: *Revised*:	
Prihvaćen: *Accepted*:	12.03.2017.