DR-1843
[1-4]

RESEARCH ARTICLE   Asian Journal of Dairy and Food Research, Volume Issue : ()

Respiration Behavior and Heat of Respiration of Mango (cv. Alphonso) under Different Storage Conditions

Divyang M. Prajapati, Vipul Jagalan, Kripali D. Dave

10.18805/ajdfr.DR-1843

ABSTRACT

Background: The rate of respiration of each agricultural commodity varies significantly from commodity to commodity and cultivar to cultivar. To build a controlled, modified or cold storage system and determine shelf life, it is necessary to quantify the rate of respiration and the heat generated as a result of respiration.

Methods: A scientific study was carried out to determine the effect of different storage conditions on the rate of respiration and heat of respiration of mango fruits (cv. Alphonso). An air-tight multi-chamber temperature and RH control system was developed to experiment with various temperatures. Mango fruits were stored at 10, 15, 20, 25°C and ambient temperature in the developed air-tight multi-chamber system. The rate of respiration and heat of respiration was determined for different storage conditions.

Result: At the beginning maximum rate of respiration, 63.22, 72.56, 81.13, 86.33, 101.55 ml CO_2/kg/h and heat of respiration, 7096.53, 8322.05, 9119.29, 9589.19, 10547.55 kcal/metric ton/day was observed at 10, 15, 20, 25°C and ambient temperature respectively. It was found that under steady-state storage conditions the rate of respiration and heat of respiration was increased with an increase in temperature whereas decreased with time for all storage conditions.

Key words: Air-tight multi-chamber system, Mango, Rate of respiration, The heat of respiration.

INTRODUCTION

Physiological activities of fruits and vegetables continue even after harvested from their parent plants and they are very much alive. Respiration and transpiration are the two vital processes and are necessary to keep the tissue alive after harvesting commodities. Respiration is a metabolic process where organic material in living cells is continuously broken down by utilizing O_2 and evolving CO_2, HO_2 and energy during respiration. Nakamura *et al*. (2004) reported that respiration rate is a necessary parameter for designing storage conditions. Further, a proper storage environment has a great impact on reducing postharvest losses, an extension of postharvest life and retaining the quality of fruits and vegetables. Maintaining a suitable temperature, relative humidity and gas composition are the key factors for good quality fruits and vegetables during storage. Knowledge of carbon dioxide production and oxygen consumption rates is necessary for the design of controlled atmosphere storage and modified atmosphere packaging.

The heat generation due to respiration tends to increase the temperature of a commodity, thus leading to an increase in transpiration (Becker and Fricke 1996). According to Peiris *et al*. (1997), individual crops have a substantial range in rates of respiration and subsequently heat load placed on the cooling system. Thus, knowledge of the respiratory response and heat generation due to respiration of climacteric fruits like mango is important in predicting the shelf life, determining storage condition requirements and designing the storage system. In consideration of these consequences, research was carried out to determine the rate of respiration and heat of respiration of mango (cv. Alphonso) under various storage conditions.

Center for Agricultural Market Intelligence, Anand Agricultural University, Anand-388 001, Gujarat, India.

Corresponding Author: Divyang M. Prajapati, Center for Agricultural Market Intelligence, Anand Agricultural University, Anand-388 001, Gujarat, India. Email: divyang34@outlook.com

How to cite this article: Prajapati, D.M., Jagalan, V. and Dave, K.D. (2022). Respiration Behavior and Heat of Respiration of Mango (cv. Alphonso) under Different Storage Conditions. Asian Journal of Dairy and Food Research. DOI: 10.18805/ajdfr.DR-1843.

Submitted: 22-11-2021 **Accepted:** 02-02-2022 **Online:** 15-03-2022

MATERIALS AND METHODS

Raw material

Fresh raw mango fruits (cv. Alphonso) of uniform maturity were harvested from the horticulture farm of Anand Agricultural University, Anand, and brought to the laboratory for further study. Physico-chemical properties like average weight, true density, firmness, total soluble solids, pH and titratable acidity were measured as the method described by Devanesan *et al*. (2011).

Chambers with temperature and RH control system

An air-tight multi-chamber temperature and RH control system was developed to experiment with various temperatures (Fig 1). The developed system is made up of 10 chambers each of 45-liter capacities with a perforated sample tray and cooling facility. Each chamber has an opening of 200 mm diameter with a lid to place or removes the sample and a 12 mm hole at the front to which the rubber septum was inserted and sealed tightly for gas sampling.

Mango fruit samples were divided into fifteen different groups, each containing about 1kg mango fruits to conduct experiments at 10, 15, 20, 25°C and ambient temperature with three replications. The samples were immediately placed in the air-tight multi-chamber temperature and RH control system at pre-set temperatures (10, 15, 20, 25°C and ambient) and the chambers were closed with air-tight lids.

The experiments for the study were carried out in the department of post-harvest technology at the college of food processing technology and bio-energy, Anand Agricultural University, Anand, Gujarat in the year 2017.

Gas chromatographic (GC) analysis

The gas sample of 100µl was drawn from each chamber at every one-hour interval for GC analysis. The gas chromatograph (Simadzu, Japan make, Model: GC 2014) equipped with a thermal conductivity detector and Porapack Q column (Make: Chromatopak) was used to analyze the gas sample. Nitrogen gas was used as carrier gas at 30 ml/min flow rate with split mode. Injector, oven and detector temperature were 90, 55 and 105°C respectively. The gas mixture of 1% CO_2 + 20% O_2 + Balance N_2 was used as a gas standard. From the gas chromatographic analysis of the gas standard, the retention of oxygen gas was found at 0.564 min and for carbon dioxide gas it was found at 1.334 min.

Rate of respiration

The rate of respiration (RR_{CO2}) was calculated at every hour from the change in CO_2 concentration as per eq. 1.

$$RR_{CO_2}(\text{mg } CO_2/\text{kg/hr}) = \frac{(C_{CO_2}^{F} - C_{CO_2}^{I}) * P_v}{W_s * \Delta t} \quad ....1$$

Where,

$C_{CO_2}^{F}$: Final concentration of CO_2, ml.

$C_{CO_2}^{I}$: Initial concentration of CO_2, ml.

P_v: Partial volume in headspace, ml.

$W_{s:}$ Weight of sample, kg.

Δt: Enclosed time interval, h.

The heat of respiration

The general respiration of fruits and vegetables is given by the following chemical reaction:

$$C_6H_{12}O6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 67\ 3\text{kcal}$$

The above chemical reaction shows that heat energy is produced during the respiration of fruits and vegetables. From this chemical equation, it can be derived that 1 mg of CO2 production represents the production of 2.55 cal heat energy. Thus, the release of 1 mg CO_2/kg/h due to respiration yields 61.2 kcal/ metric ton/day heat energy. So, the heat of respiration (HR) *i.e.*, heat generated due to respiration of fruit was calculated from the rate of respiration as per eq. 2.

$$HR\ (\text{kcal/metric= ton/day}) = RR_{CO_2} * 61.2 \quad ....2$$

Where,

RR_{CO_2} = Rate of respiration, mgCO_2/kg/h

Statistical analysis

The data obtained from experimental results with three replications were subjected to statistical analysis using a factorial completely randomized design (F-CRD). A statistical package software Design-Expert version 7.0.0 (Stat-Ease Inc., Minneapolis, USA) was used to prepare ANOVA tables and to determine the significance of the influence of temperature and time on the rate of respiration and heat of respiration at a 5% significance level.

RESULTS AND DISCUSSION

Physico-chemical properties of mango fruits (cv. Alphonso) were analyzed before starting the experiments to study the respiration behavior of mango fruit and the results are shown in Table 1.

Rate of respiration of mango fruits under the steady-state condition

The rate of respiration of mango fruits over time for various storage temperatures is shown in Fig 2. The rate of respiration was found to be increased with an increase in temperature. Thus, as temperature increases, fruits respire at a faster rate due to the rapid breakdown of carbohydrates

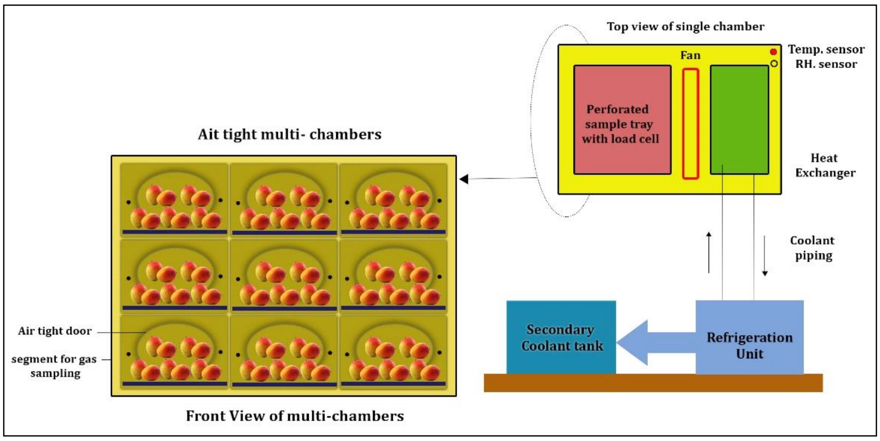

Fig 1: Air-tight multi-chamber temperature and RH control system Rate of Respiration.

and other complex organic compounds by various chemical and enzymatic activities. A similar trend was observed by Sushma Rani *et al*. (2013). Also, it was noted that for the same storage temperature, the rate of respiration decreased gradually with time under steady-state conditions. This was due to an increase in CO_2 concentration and decrease in O_2 concentration inside the storage chamber and due to loss of substrate. Initially, the rate of respiration under ambient and 10°C storage conditions was 100.42 $mlCO_2$/kg/h and 61.44 $mlCO_2$/kg/h respectively. It was decreased to 57.30 $mlCO_2$/kg/h and 28.48 $mlCO_2$/kg/h at the end of the 6-hour respiration study under ambient and 10°C storage conditions respectively. The results are in confirmation with the findings of Raza *et al*. (2013). Kim *et al*. (2010) studied the respiration rate of sweet persimmon fruit depending on cultivar, harvest date, and temperature for consideration as storability index

Table 1: Physico-chemical properties of mango fruits.

Physical properties	Ambient temperature and RH	36.55±0.40°C and 57.76±8.93%
	Weight	0.2501±0.0065 kg
	True density	962.25±25.38 kg/m^3
	Firmness	35.91±1.29 N
Chemical Properties	Total soluble solids(TSS)	12.24±0.05°bx
	pH	4.05±0.61
	Acidity	0.75±0.07%

Note: All above values are average of fifteen replications.

and package design variable. From the ANOVA test, as shown in Table 2, it was found that storage temperature, duration of storage, and its interaction effect had significant on the rate of respiration under steady-state conditions.

The heat of respiration of mango fruits under the steady-state condition

The heat generated due to the respiration of mango fruits is depicted in Fig 3. The heat of respiration was found to be increased with an increase in storage temperature. A high respiration rate at higher temperatures was responsible for higher heat generation at a higher temperature. It was noted that heat of respiration was decreased with time at the same temperature of storage. Decreased respiration rate led to a fall in heat generation under the same temperature storage. The heat of respiration was varied from 3321.77 kcal/metric ton/ day to 10745.55 kcal/metric ton/day among different storage conditions. Mango fruits had the highest heat generation at the start of experiments and lowest at the end of experiments for all storage temperatures.

ANOVA test results for the effect of storage temperature and time on the heat of respiration are presented in Table 3. The temperature of storage, duration of storage, and its interaction effect had a significant effect on the heat of respiration under steady-state conditions.

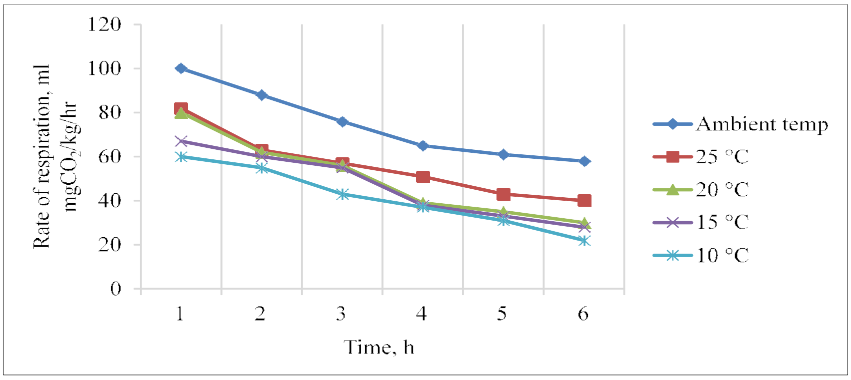

Fig 2: Rate of respiration of mango fruits at different temperatures under steady-state storage condition.

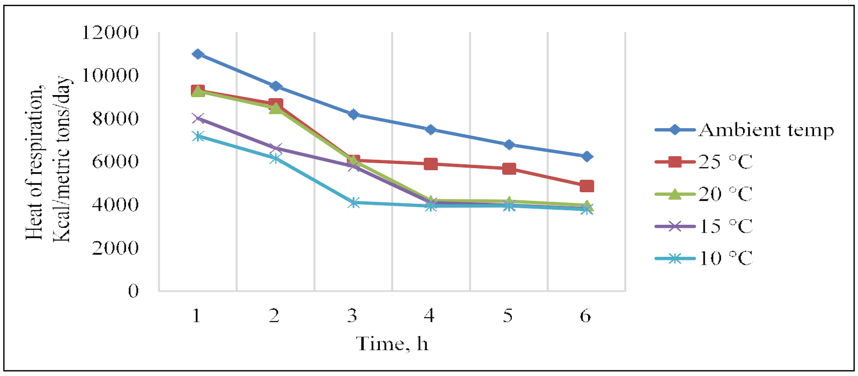

Fig 3: Heat of respiration of mango fruits at different temperatures under steady-state storage condition.

Table 2: ANOVA for the effect of storage temperature and time on the rate of respiration.

Source	df	SS	MS	F-value	p-value
A- Temperature	4	3937.33	984.33	<0.0001	11283.67*
B- Time	5	6688.83	267.55	<0.0001	17849.66*
AB	20	289.15	16.1635	<0.0001	121.56*
Error	60	7.86436	0.12559	<0.0001	

*Indicates the significant effect at 95% confidence level ($p \leq 0.05$).

Table 3: ANOVA for the effect of storage temperature and time on the heat of respiration.

Source	df	SS	MS	F-value	p-value
A- Temperature	4	1.09E+ 07	25933413	<0.0001	13521.7
B- Time	5	1.95E+07	46042464	<0.0001	25225
AB	20	3297087	19706.5	<0.0001	108.91
Error	60	104603.8			

*Indicates the significant effect at 95% confidence level ($p \leq 0.05$).

Physiological loss in weight of mango fruits under the steady-state condition

Along with the release of CO_2 and heat energy the water loss was observed after 6 hour respiration study. As shown in Table 4, the physiological loss in weight was due to the loss of moisture from the mango fruit. During respiration breakdown of carbohydrates and other organic compounds by various chemical and enzymatic activities liberates water which was observed as condensed moisture on the inner surface of the storage chamber. The highest physiological loss in weight (0.96%) was observed under ambient storage while it was lower (0.17%) under 10°C storage.

CONCLUSION

From the present study, it can be concluded that the rate of respiration and heat of respiration was maximum at the beginning of the experiment and decreased with time under steady-state conditions for all storage conditions. Also, it can be concluded that the rate of respiration and heat of respiration increased with an increase in temperature. For mango fruits (cv. Alphonso) the highest rate of respiration was 63.22, 72.56, 81.13, 86.33, 101.55 mlCO_2/kg/h, while highest heat of respiration was 7096.53, 8322.05, 9119.29, 9589.19, 10547.55 kcal/metric ton/day at 10, 15, 20, 25°C and ambient temperature respectively. The study signifies that the rate of respiration and heat of respiration are important factors to determine the optimum modified atmospheric, controlled atmospheric, cold storage, or ripening chamber storage conditions for mango fruits. Also, these data are useful to design such types of storage systems.

Conflict of interest: None.

REFERENCES

Becker, B.R. and Brian, A.F. (1996). Transpiration and respiration of fruits and vegetables. Science et Technique du Froid (France).

Devanesan, J.N., Karuppiah, A. and Kavitha Abirami, C.V. (2011). Effect of storage temperatures, O_2 concentrations and variety on respiration of mangoes. Journal of Agrobiology. 28(2): 119-128.

Kim, H.J., An, D.S., Ahn, G. and Lee, D.S. (2010). Respiration rate of sweet persimmon fruit depending on cultivar, harvest date and temperature. Journal of Food, Agriculture and Environment. 8(2): 74-76.

Nakamura, N., Rao, D.V.S., Shiina, T. and Nawa, Y. (2004). Respiration properties of tree-ripe mango under CA condition. Japan Agricultural Research Quarterly. 38(4): 221-226.

Peiris, K.H.S., Mallon, J.L. and Kays, S.J. (1997). Respiratory rate and vital heat of some specialty vegetables at various storage temperatures. Hraflkhnology. 7(1): 46-49.

Raza, S.A., Khan, A.S., Malik, A.U., Amin, M., Asad, H.U. and Razzaq, K. (2013). Respiration rate, physico-chemical fruit quality and consumer acceptability for Fajri mango under different storage temperatures. Pakistan Journal of Agricultural Sciences. 50(4): 585-590.

Sushma Rani, T., Kavitha Abirami, C.V. and Alagusundaram, K. (2013). Studies on respiration rates in coccinia grandis (ivy gourd) at different temperatures. Journal of Food Processing and Technology. 4(4): 217-221.