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HORTICULTURE

Respiration behaviour and heat of respiration of mango (*cv.* Langdo) under different storage conditions

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Abstract

Individual agricultural commodity has substantial rate of respiration which varies from commodity to commodity and cultivar to cultivar. Quantification of rate of respiration and thereby heat generated due to respiration is require to develop controlled, modified or cold storage system and to predict the shelf life. A scientific study was carried out to determine the effect of different storage conditions on rate of respiration and heat of respiration of mango fruits (*cv*. Langdo). Air tight multi-chamber temperature and RH control system was developed to conduct the experiment at various temperatures. Mango fruits were stored at 10, 15, 20, 25°C and ambient temperature in the developed air tight multi-chamber system. Rate of respiration and heat of respiration was determined for different storage conditions. At the beginning maximum rate of respiration,61.44, 71.76, 80.03, 83.93, 100.42 mlCO_2/kg/h and heat of respiration, 7164.84, 8221.14, 9009.34, 9287.19, 10745.55 kcal/metric ton/day was observed at 10, 15, 20, 25°C and ambient temperature respectively. It was found that under steady state storage condition the rate of respiration and heat of respiration was increased with increase in temperature whereas decreased with time for all storage conditions.

Highlights

- Multi-chamber temperature and RH control system can be used to study the effect of different storage conditions on rate of respiration.
- As temperature increase the rate of respiration and heat of respiration increases.
- Rate of respiration and heat of respiration decreases with time under steady state storage condition.
- Rate of respiration and heat of respiration were found to be maximum at start of the experiment and minimum at the end of the experiment for all storage conditions.

Keywords: Mango, Air tight multi-chamber system, rate of respiration, heat of respiration

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 of commodities. The respiration is a metabolic process where organic material in living cells are continuously broken down by utilizing O_2 and evolving CO_2, H_2O and energy during respiration.

Nakamura *et al.* (2004) reported that respiration rate is a necessary parameter for designing storage conditions. Further, proper storage environment has great impact on reducing postharvest losses, extension of postharvest life and retaining quality of fruits and vegetables. Maintaining the 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 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 to design the storage system. In consideration to these consequences, research was carried out to determine rate of respiration and heat of respiration of mango (*cv.* Langdo) under various storage conditions.

Materials and Methods

Raw material

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

Air tight multi-chamber temperature and RH control system

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

Mango fruit samples were divided in 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.

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 thermal conductivity detector and Porapack Q column (Make: Chromatopak) was used to analyze the gas sample. Nitrogen gas was used as carrier gas at 30ml/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 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.

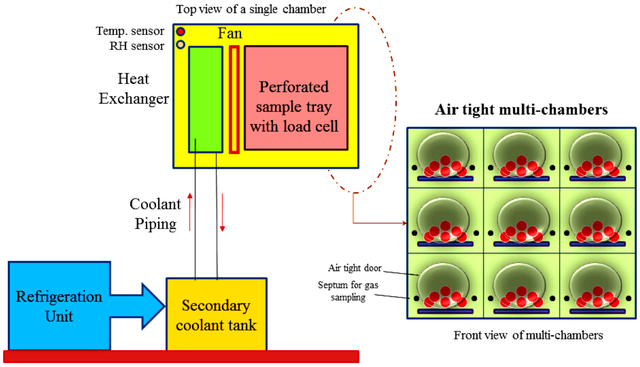

Fig. 1: Air tight multi-chamber temperature and RH control system

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.

$$RR_{CO2}(\text{ml } CO_2/\text{kg/h}) = \frac{\left(C^{F}_{CO_2} - C^{I}_{CO_2}\right) \times P_v}{W_s \times \Delta t} \quad (1)$$

Where;

C^{I}_{CO2} = Initial concentration of CO_2, ml

C^{F}_{CO2} = Final concentration of CO_2, ml

P_V = Partial volume in headspace, ml

W_S = Weight of sample, kg

Δt = Enclosed time interval, h

Heat of respiration

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

$$C_6H_{12}O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2O + 673kcal$$

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

$$HR\ (kcal/metric\ ton/day) = RR_{CO2} \times 61.2 \qquad (2)$$

Where,

RR_{CO2} = Rate of respiration, $mgCO_2$/kg/h

Statistical analysis

The data obtained from experimental results with three replications were subjected to statistical analysis using 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 rate of respiration and heat of respiration at 5% significance level.

Results and Discussion

Physico-chemical properties of mango fruits (*cv.* Langdo) were analysed before starting the experiments to study the respiration behaviour of mango fruit and the results are shown in Table 1.

Table 1: Physico-chemical properties of mango fruits

	Ambient temperature and RH	35.67±0.58 °C and 55.67±9.81 %
Physical properties	Weight	0.2498±0.0087kg
	True density	960.25±27.72kg/m^3
	Firmness	36.81±1.32 N
Chemical Properties	Total soluble solids (TSS)	10.35±0.07 °bx
	pH	4.25±0.21
	Acidity	0.79±0.03 %

All above values are average of fifteen replications

Rate of respiration of mango fruits under steady state condition

Rate of respiration of mango fruits over time for various storage temperatures is shown in Fig. 2. Rate of respiration was found to be increased with increase in temperature. Thus, as temperature increases, fruits respire at faster rate due to rapid breakdown of carbohydrates and other complex organic compounds by various chemical and enzymatic activities. 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 condition. This was due to 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 condition 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 6 h 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 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 condition.

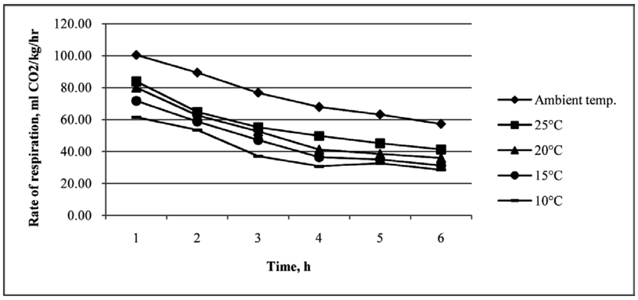

Fig. 2: Rate of respiration of mango fruits at different temperatures under steady state storage condition

Heat of respiration of mango fruits under steady state condition

Heat generated due to the respiration of mango fruits is depicted in Fig. 3. Heat of respiration was found to be increased with increase in storage temperature.

High respiration rate at higher temperature was responsible for higher heat generation at higher temperature. It was noted that heat of respiration was decreased with time at same temperature of storage. Decreased respiration rate led to fall in heat generation under same temperature storage. 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 highest heat generation at the start of experiments and lowest at the end of experiments for all storage temperatures.

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

Source	df	SS	MS	F-value	p-value	
A - Temperature	4	12950.86	3237.714	< 0.0001	21167.83	*
B-Time	5	18308.47	3661.695	< 0.0001	23939.77	*
AB	20	343.1496	17.15748	< 0.0001	112.1738	*
Error	60	9.177267	0.152954			

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

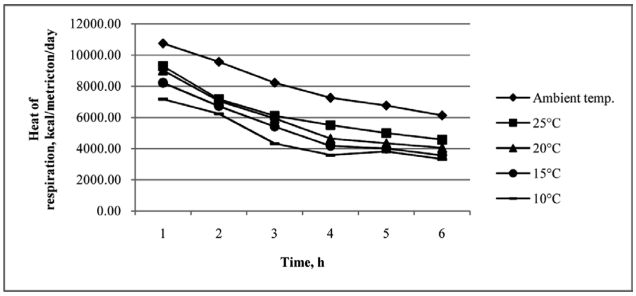

Fig. 3: Heat of respiration of mango fruits at different temperatures under steady state storage condition

ANOVA test results for effect of storage temperature and time on heat of respiration is presented in Table 3. Temperature of storage, duration of storage and its interaction effect had significant effect on heat of respiration under steady state condition.

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

Source	df	SS	MS	F-value	P-value	
A - Temperature	4	1.18E+08	29524493	< 0.0001	16462.6	*
B-Time	5	2.3E+08	46028404	< 0.0001	25665.04	*
AB	20	3920787	196039.3	< 0.0001	109.3098	*
Error	60	107605.7				

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

Physiological loss in weight of mango fruits under steady state condition

Along with release of CO_2 and heat energy the water loss was observed after 6 h respiration study. As shown in Table 4, the physiological loss in weight was due to loss of moisture from the mango fruit. During respiration breakdown of carbohydrate and other organic compounds by various chemical and enzymatic activities liberates water which was observed as condensed moisture on inner surface of storage chamber. Highest physiological loss in weight (0.99%) was observed under ambient storage while it was lower (0.20%) under 10°C storage.

Table 4: Physiological loss in weight at the end of 6 h steady state respiration study

10 °C		15 °C		20 °C		25 °C		Ambient temperature	
Initial wt. (g)	Final wt. (g)	Initial wt. (g)	Final wt. (g)	Initial wt. (g)	Final wt. (g)	Initial wt. (g)	Final wt. (g)	Initial wt. (g)	Final wt. (g)
998	996	972	970	988	986	1030	1026	1008	998
0.20%		0.21%		0.22%		0.39%		0.99%	

Conclusion

From the present study it can be concluded that the rate of respiration and heat of respiration were maximum at the beginning of the experiment and decreased with time under steady state condition for all storage conditions. Also, it can be concluded that the rate of respiration and heat of respiration increased with increase in temperature. For mango fruits (*cv*. Langdo) the highest rate of respiration was 61.44, 71.76, 80.03, 83.93, 100.42 mlCO_2/kg/h,while highest heat of respiration was 7164.84, 8221.14, 9009.34, 9287.19, 10745.55 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 type of storage systems.

Acknowledgements

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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.