

Studies on Respiration Rates in *Coccinia grandis* (Ivy Gourd) at Different Temperatures

T. Sushma Rani^{1*}, C. V. Kavitha Abirami² and K. Alagusundaram³

¹Indian Institute of Crop Processing Technology, Thanjavur, Tamilnadu, India

²Associate Professor and Head (Department of Academics and HRD), Indian Institute of Crop Processing Technology, Thanjavur, Tamilnadu, India

³Director IICPT, Indian Institute of Crop Processing Technology, Thanjavur, Tamilnadu, India

Abstract

Ivy gourd is one of the indigenous vegetable grown in India. The edible part of the ivy gourd is fruit and are mostly used for culinary purposes and also consider as a nutritious vegetable. Though it is a nutritious vegetable, the shelf life of ivy gourd is only 3-4 days in room temperature and 7-8 days in refrigerated conditions. The research maturity index and respiration rate are important in designing a packaging material for extending the shelf life at different storage conditions. Measurement of Respiration rates were carried out by conducting experiments at different temperatures of 10, 15, 20, 30 and 40°C. The respiration rates were calculated as the rate of release of CO₂ relevant to the rate of O₂ consumption of ivy gourd. The CO₂ production and O₂ consumption is maximum at higher temperature of 40°C. The O₂ concentration decreased from 19.5 to 10.41 percentages and the rate CO₂ release increased from 0.60 to 19.33%. The predictive models were developed for calculating the CO₂ release rate and O₂ consumption rates.

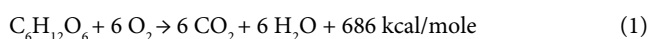
Keywords: Ivy guard; Respiration rate; Temperature; O₂; CO₂

Introduction

Ivy gourd (*Coccinia grandis*) is a unique tropical plant that is a member of Cucurbitaceae family. The common names for *Coccinia grandis* fruit are ivy gourd, scarlet fruited gourd, Tindori, tindola and Kovaikai [1]. It grows well in India, Thailand and in tropical areas such as Hawaii. The edible parts of plant ivy gourd are differing from place to place due to variation in food habit. In Thailand leaves are edible, in Hawaii both fruits and leaves and in India, raw fruits are mostly consumed as a vegetable. Two varieties of *C. grandis* are recognized; tender fruits are bitter in one variety and not bitter in another, and the latter is used in Asian cooking [2-4].

The raw fruits are used to prepare an array of delicious dishes like stir fries, stuffed curries, stews, pickles and salads [3]. The tender green fruits are nutritious and are good source of protein, calcium, fiber and beta-carotene- vitamin A as precursor. The harvesting maturity of ivy gourd is determined by the fruit colour which changes from green to light green. The normal storage life is 3 to 4 days and 7 to 10 days at room and refrigerated temperature conditions respectively. The Ivy gourd turns to a pink color due to initiation of ripening and loses its weight due to rapid wilting during storage [5]. The ripened pink colour fruits are not suitable for culinary preparations. The quality deterioration with less shelf life of ivy gourd is primarily due to continuous respiration resulting in the process of ripening after harvest. The control of respiration maintains of freshness and keeping qualities on the shelves.

Ripening is a complex physiological process that increases the softening, coloring, sweetening and aromatic compounds in most of the fruits and vegetables. The respiration is a metabolic process by which organic material in living cells are continuously broken down by utilizing O₂ and evolving CO₂, H₂O and energy [6]. The metabolic reaction during respirations is shown below:



The rate of any reaction can be determined by measuring the rate at which the substrates disintegration and the formation of new

substrates. In all respiration, due to the biochemical reaction the stored food substrate like glucose will be converted into energy in the presence of oxygen. The loss of water is small during respiration compared to the very high water content of most harvested commodities especially fruits and vegetables. The increased carbon dioxide and decreased oxygen cause a reduction of the respiration rate of the fruit tissue. This reduces the energy available for chemical changes that occur in fruits and vegetables, resulting in lower rates of ripening and prolonged pre-ripening storability of produce i.e. lesser the respiration rate longer is the shelf life of the fruit [7].

Respiration is affected by a wide range of environmental factors that include light, chemical stress (e.g. fumigants), radiation stress, water stress, growth regulators, and pathogen attack. The most important post harvest factors are temperature, atmospheric gas composition, and physical stress. Temperature has a profound effect on the rate of biological reactions like metabolism and respiration. For the potential benefits during storage and packaging optimization, the effects of these gases at particular temperature on respiration must be quantified for the selection of packaging and storage conditions. Measurements of respiration provide an easy, non-destructive means of monitoring the metabolic and physiological state of tissues.

To retain the harvest quality of the vegetable and for extending the shelf life, the research on determination of respiration rates at different temperature is conducted with the following objectives:

***Corresponding author:** T. Sushma Rani, Indian Institute of Crop Processing Technology, Thanjavur, Tamilnadu, India, E-mail: sushmarani69@gmail.com

Received January 05, 2013; **Accepted** January 27, 2013; **Published** February 05, 2013

Citation: Sushma Rani T, Kavitha Abirami CV, Alagusundaram K (2013) Studies on Respiration Rates in *Coccinia grandis* (Ivy Gourd) at Different Temperatures. J Food Process Technol 4: 217. doi:10.4172/2157-7110.1000217

Copyright: © 2013 Sushma Rani T, et al. This is an open-access article distributed under the terms of the Creative Commons Attribution License, which permits unrestricted use, distribution, and reproduction in any medium, provided the original author and source are credited.

1. To determine the changes in the gas concentration for a particular time interval.
2. Determine the effect of temperature on the respiration rate of Ivy gourd.
3. To develop mathematical models to predict respiration rate of Ivy gourd.

Materials and Methods

Materials

The raw materials, ivy gourd are procured from the local farmer's field located at Vallam, Thanjavur. The ivy gourds are plucked from the plants after 120 to 140 days of planting. Ivy gourd samples were harvested in the morning at typical commercial maturity (dark green-colored firm fruit) and transported within one hour under ambient conditions to the laboratory. The physical dimensions like size, average weight and bulk density are measured for the samples selected for the respiration studies. The glass bottle of known (700 ml) volume is taken as container for filling with ivy gourds, along with closure lid. The closure lid has a small hole which is covered with an air tight rubber holder to draw the gas samples from the container. M-Type seal is used for sealing the container lid outside to make airtight.

Equipments

The environmental chamber (Model HTC-3003, LiBratherm Instrument Private Limited, temperature range-0.1 to 60°C with an accuracy of $\pm 1^\circ\text{C}$ and relative humidity range from 0 to 99%) for different selected temperatures is used for respiratory studies. The PBI dansensor gas analyzer of model TYP83090138, head space analyzer is used for measuring the oxygen and carbondioxide gas concentrations of the respiratory samples.

Experimental set up

A sample lot of 350 g selected with uniform size and color free from defects were filled in 700 ml glass containers. The glass containers were closed with the metal lid having airtight rubber septum for drawing gas samples using needles. The glazy type seal was used for sealing the bottle. The glass containers were placed in the environmental chamber for different selected temperatures of 40, 30, 20, 15 and 10°C for the respiratory studies. The gas samples were drawn from zeroth hour and at every 30min intervals till the O₂ concentration in the bottles fell

below 1%. All experiments were replicated for three times and the mean values were obtained (Figure 1).

Respiration rates: The respiration rate of fresh ivy gourds stored at different temperatures is calculated using the following formulae given by Susana C. Fonseca [8] in terms of the O₂ consumption rates and/or CO₂ production rates:

$$RO_2 = \frac{\Delta O_2 \times V}{M \times T} \quad (2)$$

$$RCO_2 = \frac{\Delta CO_2 \times V}{M \times T} \quad (3)$$

Where

V is the partial volume occupied by the ivy gourd sample inside the glass bottle pack (ml)

R is the respiration rate of ivy gourd sample, which expressed as volume of O₂ consumed/CO₂ produced (ml/kg-hr).

M is weight of the product (kg).

T is enclosed time of product in a container (hour).

Modeling: Considering the respiration rate as a function of the four factors influencing the respiratory kinetics (i=4) namely, O₂ and CO₂ gas concentrations and, time and temperature of storage, a model based on an exponential growth or decay function was proposed. A similar relation was also used to express the respiration rate in terms of CO₂ evolution. The values of gas concentrations collected from all temperatures were analyzed by multiple regression analysis using SYSTAT 10.0 for determining the value of the model coefficients.

Results and Discussion

Physical dimensions

The sizes of ivy gourd vegetables varied from 2.5 to 7 cm. The average weight of one ivy gourd fruit is 1.5 to 3 g. The bulk density per kg of fruit is about 0.02345 m³/kg.

Changes in the concentration of gases with respect to time and temperature

The ivy gourd in the airtight glass container undergoes the metabolic reaction due to the respiration, shows the variation in the O₂ concentration and CO₂ concentration. The O₂ concentration decreased and CO₂ concentration increased with time. The changes in O₂ and CO₂ concentrations with time in a jar at 40, 30, 20, 15 and 10°C are presented in the table 1.

CO₂ production rate

The CO₂ production rate increased significantly with increase in temperature. There was a gradual increased concentration of CO₂ with respect to increased time from 0 to 400min at same temperature due to the respiration of ivy gourd samples. The CO₂ production was high at elevated temperatures compared to the low temperature. From the figure 1 the increase in CO₂ production rate at 40°C compared with gradual reduction at 30, 20 and 10°C respectively was observed. According to R. Lakakul, [9] the rise in CO₂ content in the package or inside the jar will increase the heat where there will be a chance of enhancing the rate of respiration and ripening for further time. Similar observations were noted in the respiration studies with increase in the temperature for increase in the respiration rate of ivy guard fruit-let (Figure 2).

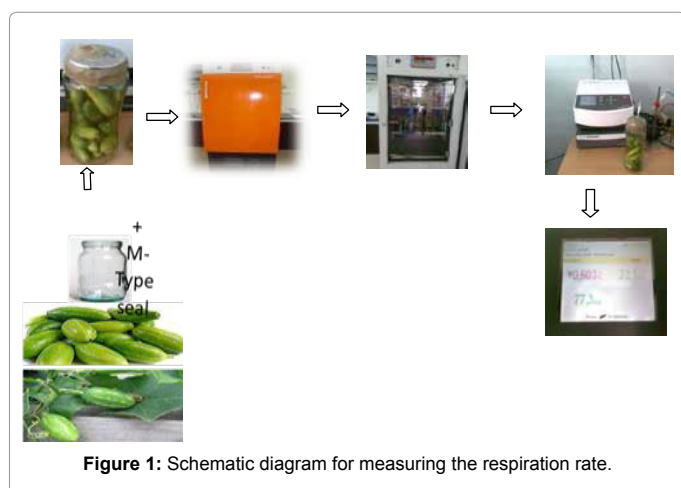


Figure 1: Schematic diagram for measuring the respiration rate.

O₂ Consumption rate

The O₂ consumption rate increased significantly with increase in the storage temperature inside the jar with ivy guard fruit let. As the time increased from 0 to 400 min of storage at same temperature, there was a gradual decrease in O₂ concentration inside the glass jar environment. The loss of O₂ and gain in the CO₂ will spoil the product quality due to the internal heat evolved from the tissues by the process of respiration [10]. From the figure 3 and the results obtained shows that the high O₂ consumption rate at 40°C and the gradual decrease of O₂ consumption rate at 30, 20 and 10°C respectively.

Modeling of respiration rate

The rate of decrease of O₂ was found to follow an exponential pattern and observed to fit to a following empirical equation:

$$f = a * \exp(-b*x)$$

where

f is the O₂ consumed by the ivy gourd

x is time measured for the O₂ gas concentrations inside the galas bottles

Time (min)	Gas Concentrations of ivy gourd inside the glass bottles									
	40°C		30°C		20°C		15°C		10°C	
	O ₂ (%)	CO ₂ (%)	O ₂ (%)	CO ₂ (%)	O ₂ (%)	CO ₂ (%)	O ₂ (%)	CO ₂ (%)	O ₂ (%)	CO ₂ (%)
0	19.97 ± 0.12	0.60 ± 0.26	19.93 ± 0.06	0.80±0.36	20.03 ± 0.12	0.90 ± 0.30	20.07 ± 0.06	0.70 ± 0.17	19.93 ± 0.15	0.70 ± 0.17
30	17.07 ± 0.15	3.07 ± 0.12	17.13 ± 0.12	3.33±0.12	17.27 ± 0.31	3.10 ± 0.10	17.57 ± 0.32	2.87 ± 0.29	18.57 ± 0.61	1.80 ± 0.10
60	13.63 ± 0.25	5.03 ± 0.35	14.13 ± 0.32	5.47±0.12	15.30 ± 0.36	4.50 ± 0.53	13.73 ± 0.40	5.97 ± 0.21	18.13 ± 0.25	2.43 ± 0.15
90	11.73 ± 0.42	6.40 ± 0.26	12.17 ± 0.47	6.77±0.15	13.53 ± 1.12	5.73 ± 0.92	11.53 ± 0.38	7.23 ± 0.15	17.47 ± 0.55	3.33 ± 0.25
120	9.99 ± 0.38	7.47 ± 0.31	10.12 ± 0.70	8.33±0.31	11.97 ± 1.10	7.00 ± 0.36	10.08 ± 0.29	8.10 ± 0.20	16.90 ± 0.66	4.20 ± 0.26
150	8.53 ± 0.22	8.33 ± 0.21	9.35 ± 0.72	9.03±0.42	10.32 ± 0.60	7.97 ± 0.32	8.92 ± 0.41	8.87 ± 0.23	16.04 ± 0.75	4.97 ± 0.32
180	7.52 ± 0.16	9.47 ± 0.29	8.92 ± 0.74	9.33±0.42	9.91 ± 0.51	8.53 ± 0.60	8.40 ± 0.62	9.33 ± 0.15	15.67 ± 0.74	5.37 ± 0.25
210	6.43 ± 0.31	10.87 ± 0.84	8.51 ± 0.74	9.90±0.62	9.29 ± 0.70	9.07 ± 0.46	8.10 ± 0.71	9.60 ± 0.10	15.24 ± 0.75	5.90 ± 0.10
240	5.40 ± 0.20	12.47 ± 1.12	7.35 ± 0.86	10.77±0.81	8.26 ± 0.56	9.97 ± 0.81	7.25 ± 0.54	9.93 ± 0.29	14.54 ± 1.02	6.60 ± 0.36
270	4.43 ± 0.21	14.00 ± 0.17	6.70 ± 0.67	11.53±0.40	7.13 ± 0.06	10.77 ± 0.72	6.67 ± 0.55	10.30±0.46	13.74 ± 1.02	7.47 ± 0.15
300	3.30 ± 0.10	15.77 ± 0.31	6.38 ± 0.53	11.97±0.35	6.48 ± 0.15	11.40 ± 0.72	6.15 ± 0.97	10.93 ± 0.65	13.01 ± 1.22	8.33 ± 0.21
330	1.97 ± 0.22	17.30 ± 0.40	5.92 ± 0.85	12.53±0.57	5.81 ± 0.37	12.20 ± 0.92	5.80 ± 0.90	11.27 ± 0.60	12.24 ± 1.28	9.20 ± 0.40
360	1.27 ± 0.40	18.33 ± 0.21	5.48 ± 0.76	13.23±0.64	5.11 ± 0.65	12.63 ± 0.90	5.36 ± 0.92	11.60 ± 0.50	11.30 ± 1.16	10.03 ± 0.40
390	0.67 ± 0.15	19.33 ± 0.38	5.06 ± 0.69	13.83±0.55	4.13 ± 0.83	13.00 ± 0.87	4.92 ± 0.74	11.90 ± 0.56	10.41 ± 0.98	10.83 ± 0.44

Table 1: Gas concentrations at different temperatures of 40, 30, 20, 15 and 10°C of ivy gourd.

Temperature (°C)	Gas Concentration (%)	R	R ²	a	b
40	O ₂	0.994	0.9882	20.1715	0.006
	CO ₂	0.9925	0.985	44.6029	0.0014
30	O ₂	0.9817	0.9637	18.5418	0.0039
	CO ₂	0.9888	0.9777	13.912	0.007
20	O ₂	0.997	0.9939	19.4437	0.0038
	CO ₂	0.9908	0.9818	14.444	0.0053
15	O ₂	0.9758	0.9521	18.6109	0.004
	CO ₂	0.9907	0.9815	11.4866	0.0101
10	O ₂	0.99	0.98	19.9635	0.0015
	CO ₂	0.9905	0.981	24.5055	0.0014

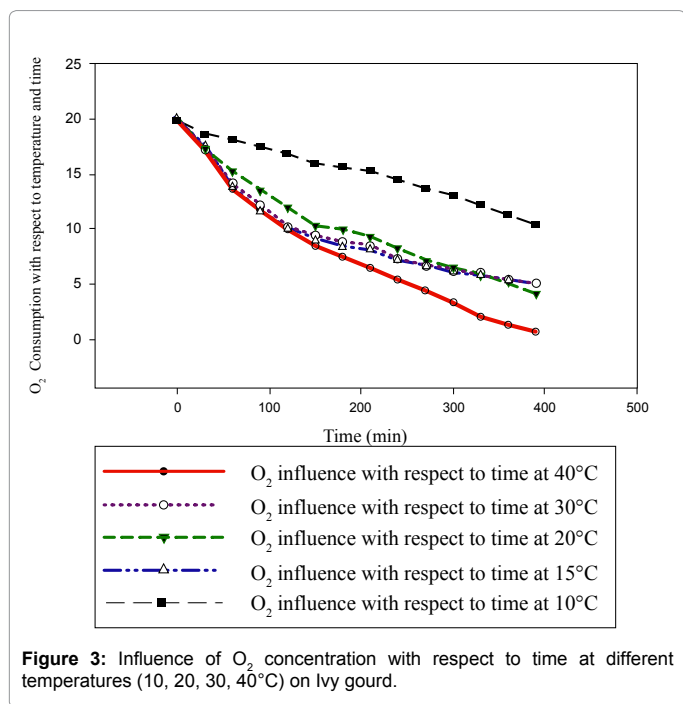
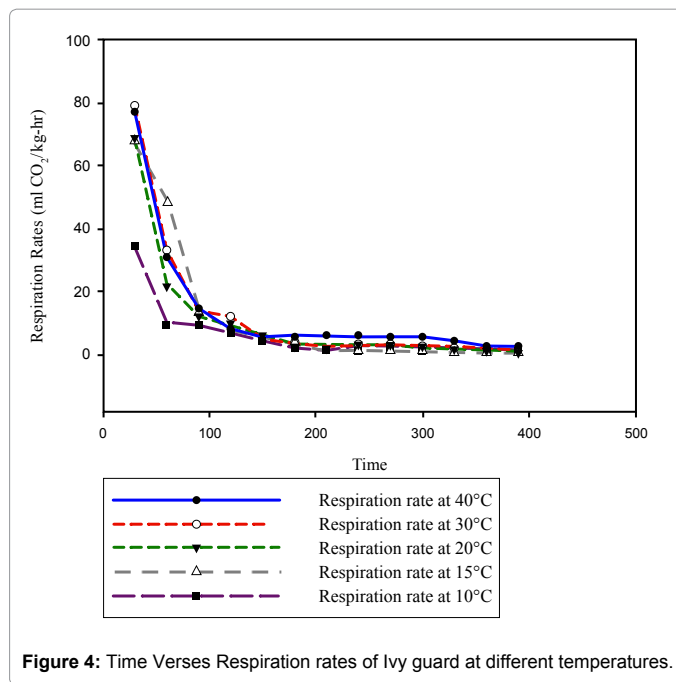
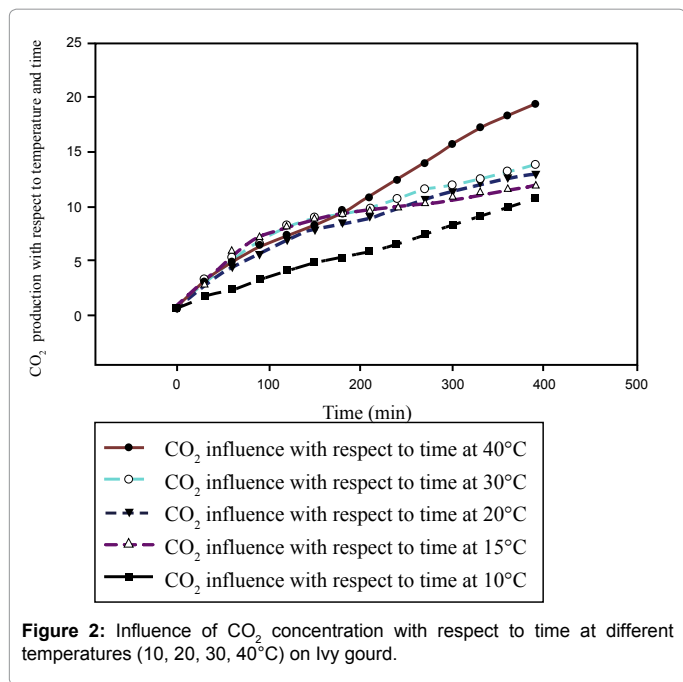
Where Goodness of fit is indicated by the R² value, R = the multiple correlation Coefficient and a and b are constants.

Table 2: Statistical fitness for change in O₂ and CO₂ gas concentrations of ivy gourd during storage at particular temperatures.

Time (min)	RCO ₂ at 40°C	RCO ₂ at 30°C	RCO ₂ at 20°C	RCO ₂ at 15°C	RCO ₂ at 10°C
30	77.03	79.11	68.70	67.66	34.35
60	30.71	33.31	21.86	48.41	9.89
90	14.23	13.53	12.84	13.19	9.37
120	8.33	12.23	9.89	6.77	6.77
150	5.41	4.37	6.04	4.79	4.79
180	5.90	3.56	2.95	2.43	2.38
210	6.25	2.53	2.38	1.19	2.08
240	6.25	3.38	3.51	1.30	2.73
270	5.32	2.66	2.78	1.27	3.01
300	5.52	1.35	1.98	1.98	2.71
330	4.35	1.61	2.27	0.95	2.46
360	2.69	1.82	1.13	0.87	2.17
390	2.40	1.44	0.88	0.72	1.91

RCO₂ - Rate of respiration, which is expressed as volume of CO₂ generated

Table 3: Respiration rates of Ivy guard for 30min time interval in ml kg⁻¹ h⁻¹.



a and *b* are constants.

The R² values of these equations were close to 0.9. The table shows the best fitting line for the O₂ and CO₂ concentration changes with time (Table 2).

Respiration rates

The O₂ and CO₂ concentrations were predicted from 0 to 360 min for all experimental combinations. Using the equations (2) and (3) the predicted rate of respiration for the obtained gas concentrations was calculated. From the values, it was observed that the respiration rates for CO₂ gas concentration at any temperature with increase in the time interval decreased. The CO₂ production rate was faster at 40°C than the other temperatures. The reduction of respiration rates was noted at 15°C and 10°C. At 15°C there was a significant decrease of CO₂ production rate and at 10°C there were fluctuations in the CO₂ values which may be due to the occurrence of chilling injury of tissues (Table 3, Figure 4).

Conclusion

From the results of this study the following major conclusions can be drawn:

1. The CO₂ release and O₂ consumption rates were faster during the initial hours of packing. The CO₂ release rate was influenced by the O₂ concentration prevailed inside the air-tight glass bottles.
2. The respiration rate was faster at higher temperatures (40°C) but remained stable at lower temperature (10°C). This shows that the respiration rate was less at lower temperature, which in turn increases the shelf life of the ivy gourd fruit.

References

1. Chun ME (2001) Biology and host specificity of *Melittia oedipus* (Lepidoptera: Sesiidae), a biological control agent of *Coccinia grandis* (Cucurbitaceae). Proceedings of the Hawaiian Entomological Society 35: 85-93.

a and *b* are constants.

Similarly the changes in the CO₂ concentration with time were found to fit to an following empirical model:

$$f = a * (1 - \exp(-b*x))$$

where

f is the CO₂ released by the ivy gourd

x is time measured for the CO₂ gas concentrations inside the galas bottles

2. Ramachandran K, Subramaniam B (1983) Scarlet Gourd, *Coccinia grandis*, Little-Known Tropical Drug Plant. Econ Bot 37: 380-383.
3. Kunkel G (1984) Plants for human consumption: an annotated checklist of the edible phanerogams and ferns. Koeltz Scientific Books, Koenigstein, Germany.
4. Manandhar NP, Manandhar S (2002) Plants and People of Nepal. Timber Press, Portland.
5. Kulkarni SG, Vijayanand P (2012) Effect of Pretreatments on Quality Characteristics of Dehydrated Ivy Gourd (*Coccinia indica* L.). Food and Bioprocess Technology 5: 593-600.
6. Goswami TK (2010) Modeling of Respiration Kinetics. ASABE Annual International Meeting. Pittsburgh, Pennsylvania.
7. Mikal ES, Respiratory Metabolism Mann Laboratory, Department of Vegetable Crops, University of California, Davis, CA.
8. Susana CF, Oliveira FAR, Brecht JK (2002) Modelling respiration rate of fresh fruits and vegetables for modified atmosphere packages: a review. J Food Eng 52: 99-119.
9. Lakakul R, Beaudry RM, Hernandez RJ (1999) Modeling Respiration of Apple Slices in Modified-Atmosphere Packages. J Food Sci 64: 105-110.
10. Yang CC, Chinnan MS (1988) Modeling the Effect of O₂ and CO₂ on Respiration and Quality of Stored Tomatoes. Transactions of the ASABE 31: 0920-0925.