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RESPIRATION RATES, ETHYLENE PRODUCTIONS AND CHEMICAL COMPOSITIONS OF DIFFERENT MATURITY OF SOURSOP (*ANNONA MURICATA* L.) AT VARIOUS TEMPERATURES

P.F. LAM* and M.Z. ZAIPUN*

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RINGKASAN

Durian belanda (*Annona muricata* L.) berumur 10, 11 dan 12 minggu selepas berputik disimpan pada suhu 10°C, 15°C dan 20°Celsius. Puncak etilena tidak berlaku pada 10°C sedangkan pada 15°C dan 20°C puncak etilena adalah sama dengan puncak klimakterik pernafasan. Buah yang telah dirawat dengan 500 dan 1 000 μlitres/litre eterel menunjukkan kenaikan puncak klimakterik pernafasan yang lebih awal berbanding dengan buah kawalan. Puncak klimakterik pernafasan dalam buah yang dirawat dengan eterel berlaku serentak, sehari lebih awal daripada buah kawalan. Nilai pH dan kandungan kanji menurun bagi buah yang lebih matang dan sedang masak manakala keasidan, pepejal terlarut dan kandungan gula meningkat. Buah durian belanda yang matang boleh disimpan pada suhu 15°C dan 20°C, tetapi suhu 20°C adalah lebih sesuai untuk kemasakan biasa. Jangka masa simpanan buah durian belanda ialah selama tiga minggu pada suhu 15°C dan dua minggu pada suhu 20°Celsius.

INTRODUCTION

Soursop is an aggregate fruit which does not ripen evenly. It shows the diffuse type of respiratory climacteric with more than one peak (BIALE and BARCUS, 1970). PAULL, DEPUTY and CHEN (1983) found that the optimum eating quality of soursop coincided with the ethylene peak which occurred about four days after harvest. They also showed that half of the organic acids was present as salts with malic acid as the predominant acid. The ripe fruit is also processed into juice. This paper reports the respiration rates, ethylene productions and changes in chemical contents at different stages of maturity of soursop, which would provide the criteria for its storage and processing.

MATERIALS AND METHODS

Soursop (*Annona muricata*) fruit, MARDI No. 1 and Local 2 No. 4 varieties, of 10, 11 and 12 weeks after fruit-set were obtained from MARDI orchard at Serdang. Studies were carried out from 1983 to 1985. Observations made earlier showed that soursop ripened on the tree at approximately 13 weeks after fruit-set. The fruit were washed with potable water. Each fruit was kept in a low density polyethylene respiratory bag of thickness 0.08 mm with an inlet-and-outlet tube. The inlet tube carried humidified air with a flow rate of approximately 1 litre/h/100 g of fruit weight. Four replicates of individual fruit made up a treatment and the fruit were stored at 10°C, 15°C and 20°Celsius.

In another experiment, the fruit were dipped in 500 and 1 000 μlitres/litre ethrel for five minutes. Control fruit were dipped in water. The fruit were kept at 20°C for determining the respiration rate and ethylene production.

The respiration rate was determined by measuring the carbon dioxide produced from the fruit. One millilitre of respired air was taken from the outlet tube and determined in a Varian 1420 thermal conductivity gas chromatograph with a 1 800 x 3 mm stainless steel column packed with 80–100 mesh Porapak R. The flow rate of the helium carrier gas was 30 ml/min and the column oven was 35°Celsius. For ethylene determination, 1 ml of respired air was injected into a Varian 1440 flame ionization gas chromatograph fitted with a

*Food Technology Division, MARDI, Serdang, Selangor, Malaysia.

1 800 x 3 mm stainless steel column packed with Porapak T of 100–120 mesh. The flow rate of the nitrogen carrier gas was 30 ml/min and the column oven was operated at 100°Celsius.

The chemical composition of soursop was determined at harvest and again after ripening. The fruit was considered ripe when it became soft. The pH, total titratable acidity (TTA) in terms of malic acid (PAULL *et al.*, 1983), total soluble solid (TSS), total sugars and starch were determined according to the methods in the AOAC (1975).

Sensory evaluation on texture, sweetness, sourness, flavour and general acceptability of the tree-ripened fruit of the two varieties was conducted to determine the variety preferred for fresh consumption. The skin was removed and the mesocarp was cut into 4 cm x 5 cm slices. Ten trained panel members scored for the attributes with a score of 1 to 5 with 1 = dislike extremely, 3 = neither like nor dislike and 5 = like extremely.

RESULTS

All fruit showed the respiratory climacterics *(Figures 1–3)*. The peaks at 10°C, 15°C and 20°C were respectively 120, 130 and 180 ml CO_2/kg/hour. This showed that the fruit had a higher respiration rate at higher temperature.

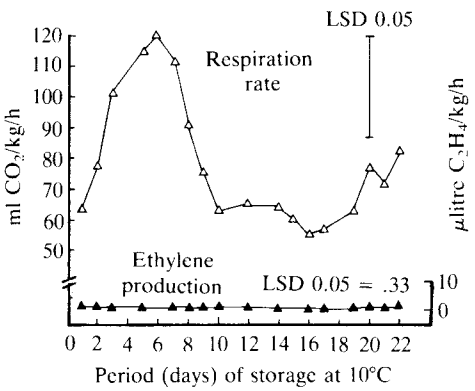

Figure 1. Respiration rate and ethylene production of 11-week-old soursop stored at 10°C.

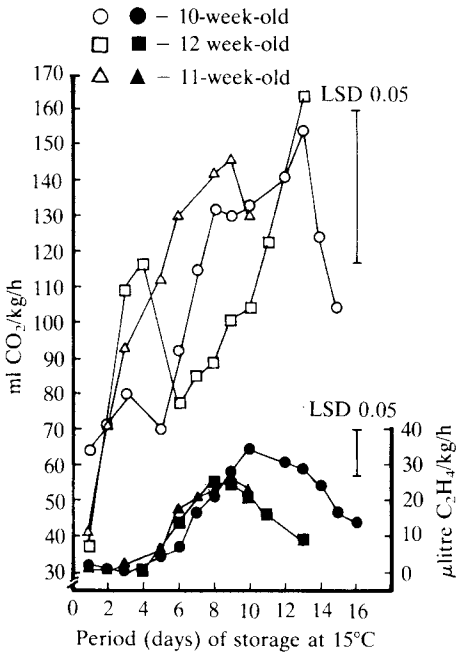

Figure 2. Respiration rate and ethylene production of different maturities of soursop at 15°C.

The ethylene production by soursop at 10°C was low, *i.e.*, less than 2 µlitres/kh/h *(Figure 1)*. Ethylene production was suppressed at this temperature although the respiratory peak was present. However, ethylene peaks were present in fruit stored at 15°C and 20°C *(Figures 2* and *3)*. No multiple ethylene peaks were observed. The ethylene peaks were similar at these two temperatures, *i.e.*, 25 µlitres/kg/hour. The peaks at 15°C and 20°C occurred at the ninth and sixth day respectively. This indicated that the rise in ethylene at 15°C was later than that at 20°Celsius. The base for the ethylene peak was also broader at 15°C than at 20°Celsius.

Generally, the ethylene peaks and respiratory peaks occurred at the same time for each storage temperature. The bases of the ethylene peaks and respiratory peaks were broadest at 10°C and narrowest at 20°Celsius. This showed that the storage life of soursop increased as the storage temperature lowered. The fruit kept at 10°C had dark skin after storage as a result of chilling

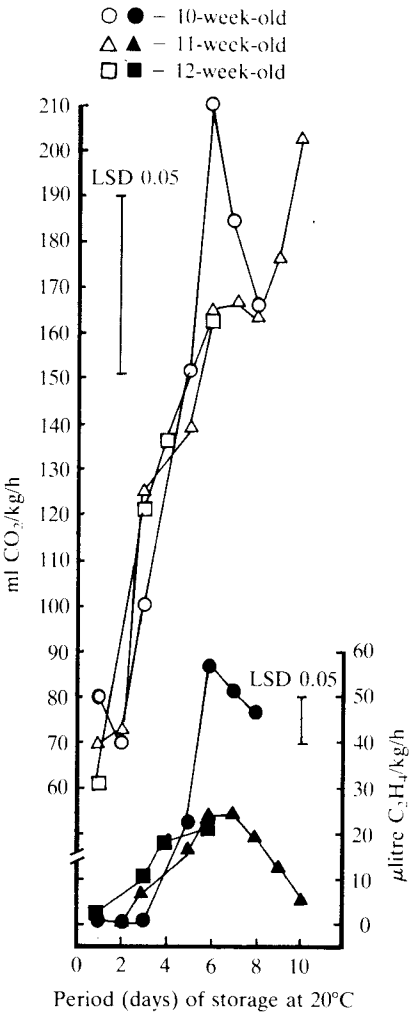

Figure 3. Respiration rate and ethylene production of different maturities of soursops at 20°C.

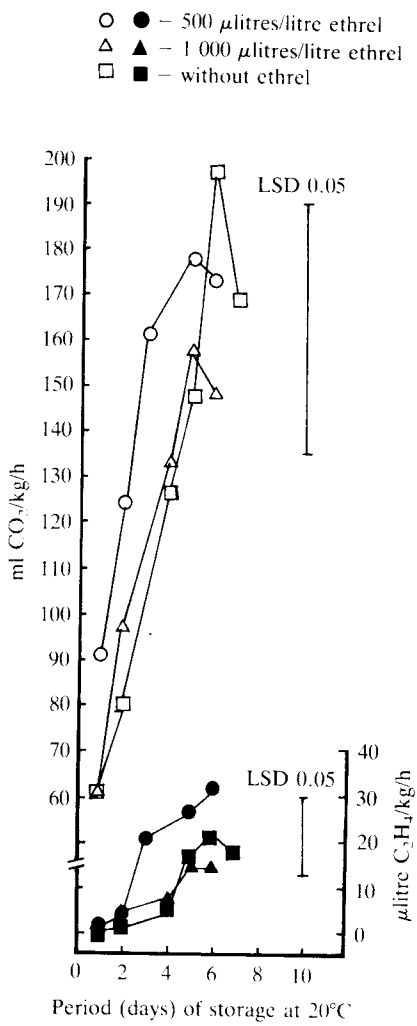

Figure 4. Respiration rate and ethylene production of 11-week-old soursop dipped in 2 concentrations of ethrel.

injury. The fruit kept at 15°C ripened but the skin showed an increased tendency to darken. Thus, it can be seen that 20°C is a suitable temperature for storing unripe soursop fruit. The fruit which normally ripened at this temperature, developed a sweet, aromatic flavour while retaining its normal green skin. Thus, a temperature range of 15°C–20°C is suitable for storing unripe soursop. The storage life at 15°C and 20°C was respectively three and two weeks.

Soursop dipped in 500 and 1 000 µlitres/litre ethrel for five minutes had the respiratory climacteric at the fifth day, one day earlier than the control fruit *(Figure 4)*. The ethylene peak of the control fruit occurred also at the sixth day. The peaks for the treated fruit seemed to have occurred earlier than the control because after the sixth day the fruit were senescing. It appeared that ethrel at 500 and 1 000 µlitres/litre was effective in hastening ripening.

The pH and starch content of soursop decreased during fruit ripening *(Table 1)* and also in more mature fruit. Fruit at 10 and 12 weeks after fruit-set had values of 6.5 and 5.5 respectively. Ripened fruit had a pH

Table 1. Chemical composition of different maturities of soursop at various temperatures

Storage temp. (°C)	Maturity (weeks)	Ripening time (days)	pH	TTA (% malic acid)	TSS (%)	Total sugars (%)	Starch (%)
10	10	At harvest	6.5a	0.12dc	5.8c	3.0d	9.2a
	11	At harvest	6.3a	0.08e	5.4e	3.0d	9.2a
	12	At harvest	5.5b	0.30cde	9.1d	5.5cd	6.2b
15	10	16	4.7c	0.45bcd	12.0c	8.0bc	N.A.
	11	10	4.0de	1.13a	16.4a	11.2a	2.3c
	12	13	3.9e	0.72b	15.4a	8.8ab	2.0c
20	10	8	4.8c	0.50bc	13.5bc	8.8ab	N.A.
	11	7	4.2de	0.61bc	16.1a	10.5ab	2.3c
		6;500 μlitres/ litre ethrel	4.4cd	0.82ab	16.1a	9.0ab	2.0c
		6;1 000 μlitres/ litres ethrel	4.1de	0.64bc	16.1a	9.8ab	2.1c
	12	6	4.0de	0.81ab	14.8ab	10.8a	1.3c

N.A.: Not available
Means with the same subscripts in each column are not significantly different at 5% level with the LSD Test.

of approximately 4.0. These values showed that soursop was more acidic in the more mature fruit and also ripened fruit. The 10 and 12-week-old fruit had a starch content of approximately 2% (w/w) when the fruit ripened. The values for the TTA, TSS and total sugars increased in more mature fruit and also in the ripened fruit. The TTA increased from approximately 0.1% to 0.3% (w/w) in the 10 and 12-week-old fruit respectively. The ripened fruit had approximately 1% total titratable acid. The increase in TTA also showed that there was an increase in acidity of the more mature fruit and also in ripened fruit. The TSS increased from approximately 6% to 9% (w/w) in the 10 and 12-week-old fruit respectively. The total sugars increased to approximately 3% to 5% (w/w) respectively. The total sugars was approximately 10% (w/w) in the ripened fruit.

The members of the sensory evaluation panel preferred the Local 2 No. 4 variety in the attributes of sweetness, sourness, flavour and acceptability. There was no significant difference in preference on the texture of the fruit *(Table 2)*. Sensory evaluation was conducted to determine the preferred variety because it is difficult to differentiate between the two varieties based on the external and internal appearance of the fruit.

Table 2. Score for sensory evaluation of tree-ripe soursop fruit

Variable	Variety	
	MARDI No. 1	Local 2 No. 4
Texture	3.9a	3.9a
Sweetness	2.6b	3.8a
Sourness	2.4b	3.4a
Flavour	3.4b	4.1a
Acceptability	2.6b	3.6a

Means with the same subscripts in each row are not significantly different at 5% level with the t-test.

DISCUSSION

The respiration rates of soursop increased with a rise in storage temperature. Similar observation was recorded by BROUGHTON and TAN (1979) who showed that custard apple (*Annona squamosa* L.) had higher respiration rates and ethylene productions at 20°C than at 15°Celsius. The fruit stored at 10°C showed an early respiratory climacteric, which was earlier than that stored at 15°C and 20°Celsius. The fruit stored at lower temperature seemed to exhibit further respiratory climacteric. For example, BIALE and BARCUS (1970) showed a multiple respiratory climacteric for this fruit. On the other hand, the pattern of ethylene production showed only one peak.

The respiratory climacteric peak corresponded to the ethylene peak. PAULL *et al.* (1983) also found a distinct ethylene peak, but a diffused respiratory climacteric in soursop.

The increasing trends in the TSS and total sugars content and the decreasing trend in the starch content were similar to other fruits such as banana (VON LOESECKE, 1949) and mango (LAKSHMINARAYANA, 1973). However, the increasing trends in TTA and the decreasing trends in pH were different from those of the banana and mango but were similar to atemoya (*Annona atemoya* L.) (WILLS' POI and GREENFIELD, 1984). PAULL (1982) and PAULL *et al.* (1983) found similar trends in the chemical composition of soursop. In soursop, the fruit is likely to taste both sweet and sour when riped, but not very sour in unriped fruit (not soft). The low pH, high total sugars and high TSS of the ripen fruit make it suitable for processing into juice, nectar or puree. These advantages reduce the addition of acid and sugar which saves cost in the processing of this fruit.

Soursop does not soften evenly within the same fruit. It is recommended that 'ripeness' for processing purpose be taken as being three-quarter soft or when the surface of the fruit is soft. Over-ripeness occurs when the surface is black and soft, and fermentation has set in. It is also noted that a tree-ripen fruit with three-quarter soft surface is optimum for processing.

ABSTRACT

Soursops (*Annona muricata* L.) of 10, 11 and 12 weeks after fruit-set were stored at 10°C, 15°C and 20°Celsius. There was no ethylene peak at 10°C while those at 15°C and 20°C coincided with the respiratory climacteric peaks. Fruit dipped in 500 and 1 000 μlitres/litre ethrel respectively had an earlier respiratory climacteric rise than the control by one day. The respiratory climacteric peaks of the fruit dipped in ethrel occurred at the same time. The pH values and starch content of the more mature fruit and ripening fruit decreased while the total titratable acidity, total soluble solids and total sugar of these fruit increased. Unripe soursops could be stored between 15°C and 20°C but 20°C is preferred for normal ripening. The storage life at 15°C and 20°C is respectively three and two weeks.

REFERENCES

AOAC (1975). *Methods of Analysis* 12th ed. Washington D.C. : Association of Agricultural Chemists.

BIALE, J.B. and BARCUS, D.E. (1970). Respiratory patterns in tropical fruits of the Amazon Basin. *Trop. Sci.* ***12***, 93–104.

BROUGHTON, W.J. and TAN, G. (1979). Storage conditions and ripening of the custard apple *Annona squamosa* L. *Scientia Horticulturae* ***10***, 73–82.

LAKSHMINARAYANA, S. (1973). Respiration and ripening patterns in the life cycle of the mango fruit. *J. hort. Sci.* ***48***, 227–33.

PAULL, R.E. (1982). Postharvest variation in composition of soursop (*Annona muricata* L.) fruit in relation to respiration and ethylene production. *J. Amer. Soc. Hort. Sci.* ***107***, 582–5.

PAULL, R.E., DEPUTY, J. and CHEN, N.J. (1983). Changes in organic acids, sugars, and headspace volatiles during fruit ripening of soursop (*Annona muricata* L.). *J. Amer. Soc. Hort. Sci.* ***108***, 931–4.

VON LOESECKE, H.W. (1949). *Bananas-Chemistry, Physiology, Technology* 189 pp. New York : Interscience Publ. Inc.

WILLS, R.B.H., POI, A. and GREENFIELD, H. (1984). Postharvest changes in fruit composition of *Annona atemoya* during ripening and effects of storage temperature on ripening. *Hort. Sci.* ***19***, 96–7.

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