Pertanika 11(3), 407-417 (1988)

Effect of Chemical Treatments on the Shelf Life of Rambutans (*Nephelium lappaceum*) – II

SUHAILA MOHAMED, ESHAH OTHMAN and FAUZIAH ABDULLAH
Department of Food Science
Faculty of Food Science and Biotechnology
Universiti Pertanian Malaysia
43400 Serdang, Selangor, Malaysia.

Key words: Rambutans; calcium chloride; sodium metabisulphite; benomyl dips and sulfur dioxide treatment.

ABSTRAK

Mencelup rambutan selama 5 minit dalam larutan sodium metabisulfit, calcium chloride dan metabisulfit atau calcium chloride dan asid askorbik dapat mengurangkan % buah-buah rosak sehingga 30%. Perlakuan sulfur dioxide didapati kurang berkesan untuk mengekalkan kesegaran rambutan bila dibandingkan dengan penyimpanan di bawah udara terubah suai. Teknik-teknik yang dapat menukar kadar pernafasan dan kadar kehilangan kelembapan adalah lebih berkesan dalam mengekalkan kesegaran rambutan dari cara-cara yang menghalang keperangan enzim. Buah-buah yang telah dicelup dengan sodium metabisulphite + calcium chloride selama 5–10 min, dalam bungkusan PE pada suhu simpanan 8 C, masih manis dan mantap pada hari yang ke 17. Buah-buah yang disimpan pada suhu bilik tidak menunjukkan perbezaan bererti antara yang telah dicelup dan yang tidak melalui perlakuan kimia.

ABSTRACT

Dipping rambutans for 5 minutes in sodium metabisulphite, calcium chloride and metabisulphite or calcium chloride and ascorbic acid solutions helped reduce % unacceptable fruits by up to 30% when fruits were stored packaged at 8 C. Chemical dipping of rambutans and sulfur dioxide treatments were found to be less effective in prolonging the shelf life compared to low temperature storage. Techniques which slow down respiration rate and dehydration rate were found to be more effective in prolonging the shelf life of rambutans than methods to inhibit enzymic browning. Fruits treated with sodium metabisulphite + calcium chloride in PE at 8 C with soaking time of 5–10 minutes, remained sweet and firm on the 17th day. Shelf life of treated fruits stored at room temperature is not significantly different from untreated fruits.

INTRODUCTION

Chemical control of post harvest wastage has become an integral part of the handling and successful marketing of fruit. A wide range of chemicals has been used for the control of post-harvest wastage of fruits.

Lieberman and Mapson (1962), Lieberman *et al.*, (1964) and Ayres *et al.*, (1964) reported that treatment on tomatoes with ethylene oxide showed a definite delay in ripening, developed attractive skin colours with firm texture. Whereas usage of potassium permanganate as ethylene absorbent (Scott *et al.*, 1970) in film bags package of bananas showed firmer texture than fruits sealed with calcium hydroxide to removed carbon dioxide.

Usage of mold fumigant, methyl bromide, gave the maximum inhibition of mango ripening throughout the storage period of 20 days at ambient temperature (Subramanyam *et al.*, 1969). Benomyl, a fungicide used to control spoilage during storage was observed to delay ripening of Alphonso mango (Shanta Krishnamurthy and Rao, 1983). Sulfur dioxide as a gas or in solution as the acid or salt has been in use for centuries especially in the preservation of dried fruit and wine to maintain their light, natural colour during extended storage. It is also being used for the extension of shelf-life of raw grape and preservation of raw crushed grapes or wine (USDA, 1977).

The objective of this research is to determine whether chemical treatments can be used to prolong the shelf life of fresh rambutans.

MATERIALS AND METHODS

Rambutans of the red variety (R7) were harvested in bulk from the University Orchards (Ladang 5). They were sorted, weighed and subjected to various treatment and storage conditions on the same day.

Each result is an average reading from analysis of 6 fruits.

Chemical Treatments

The rambutans were dipped for 5, 10, 15 and 20 mins. in the following solutions:

i) 1000 ppm sodium metabisulphite.
ii) 1000 ppm sodium metabisulphite+300 ppm calcium chloride.
iii) 500 ppm benomyl at 50 C.
iv) 1000 ppm calcium chloride + 1% ascorbic acid.

Results were compared to that of untreated fruits. The chemical treatments were also studied in combination with the following storage conditions:

a. Stored unwrapped at ambient temperature.
b. Sealed in low density polyethylene bags at ambient temperature.
c. Sealed in low density polyethylene bags at 8 ± 2^oC.
d. Packed in nitrogen gas, sealed in low density polyethylene bags at ambient temperature.

The effect of leaving the fruit stalks attached to the fruits, on shelf life of rambutans were observed. Fruit stalks of different lengths (0 cm, 15cm and 30cm) were left attached to the fruits. The colour and texture of the fruits were compared to that of the control (fruits with no stalks).

Treatments with Sulfur Dioxide

Fruits were exposed to dense sulfur dioxide fumes from burning sulphur in a closed dessicator for 1 min, 5 min, 10 min, 15 min, 120 min and 240 min respectively. Care was taken to ensure that neither the flame nor the hot crucible touched any part of the fruit. Fruits were weighed, packed and sealed in LDPE bags after exposure.

RESULTS AND DISCUSSION

Chemical Treatments

The effect of chemical dips on rambutan stored unwrapped at ambient temperatures and in LDPE bags at ambient and 8 ± 2 C are shown in *Figs. 1, 2* and *3* respectively.

For fruits kept unwrapped at ambeint temperatures, all the chemical treatments (except with benomyl) reduced the percentage unacceptable fruits by 20–30%. However, the storage

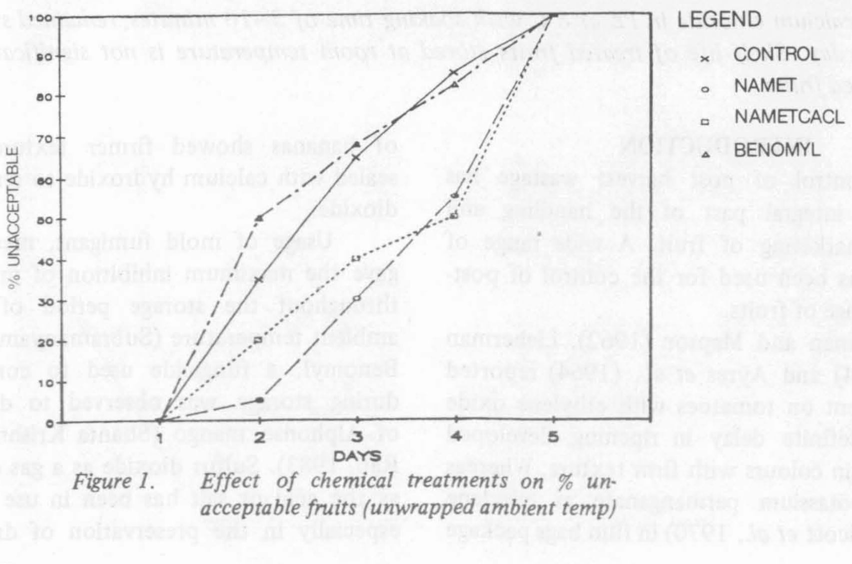

Figure 1. Effect of chemical treatments on % unacceptable fruits (unwrapped ambient temp)

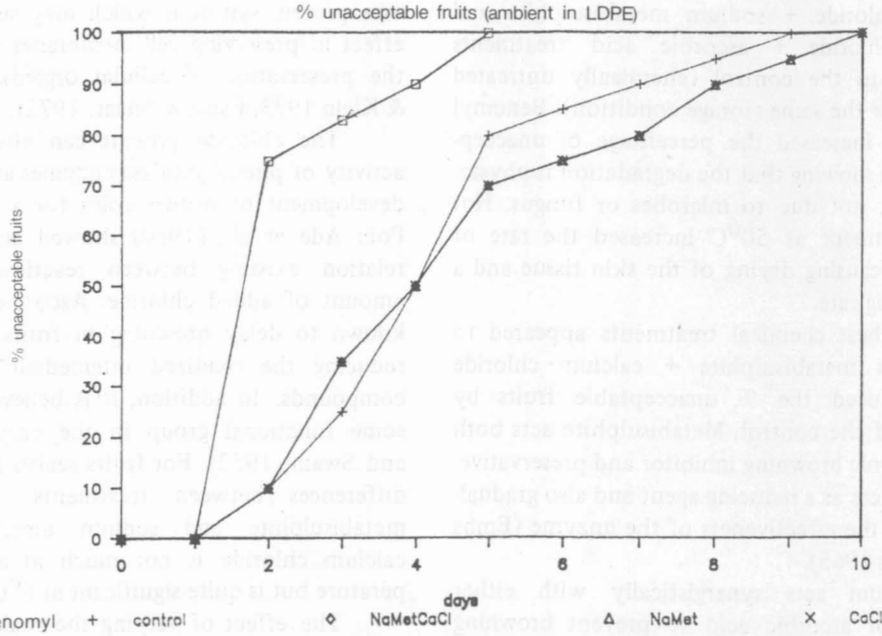

Figure 2. Effect of chemical treatments on % unacceptable fruits (ambient in LDPE).

life could not be extended beyond four days. By the 14th day all the samples have turned black accompanied by an unfavourable fermented smell and softening of the skin and flesh. At this stage discolouration of the flesh had occurred and the fruit was inedible. By the fifth day fungal growth was present in all except those treated with sodium metabisulphite. The skins was beginning to rot.

Rambutans sealed in LDPE, both at 8 C and ambient temperature, have reduced % unacceptable fruits only with sodium metabisulphite,

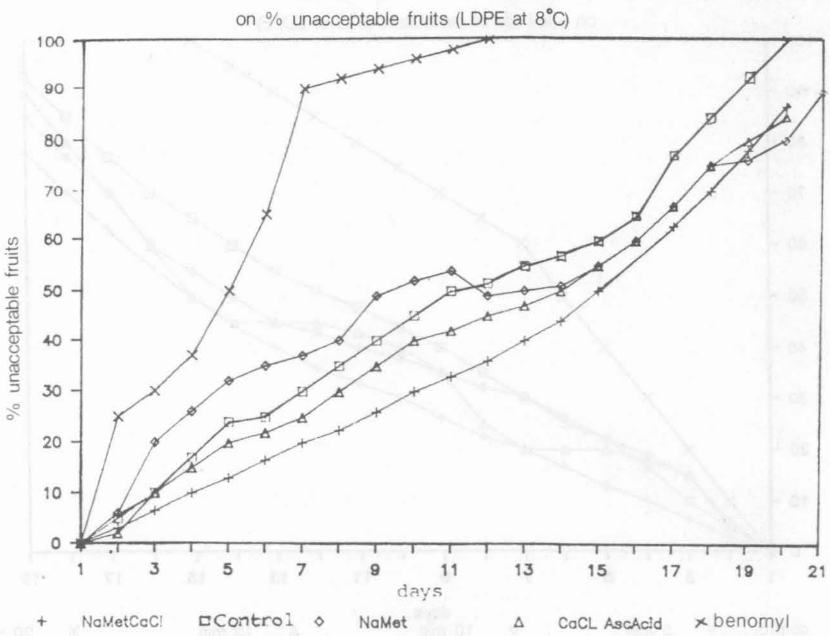

Figure 3. Effect of chemical treatments on % unacceptable fruits (LDPE at BC).

calcium chloride + sodium metabisulphite and calcium chloride + ascorbic acid treatments compared to the control (chemically untreated fruits under the same storage condition). Benomyl treatments increased the percentage of unacceptable fruits showing that the degradation is physiological, i.e. not due to microbes or fungus. Hot water treatment at 50^{o}C increased the rate of browning, causing drying of the skin tissue and a faster drying rate.

The best chemical treatments appeared to be sodium metabisulphite + calcium chloride which reduced the % unacceptable fruits by 10–20% of the control. Metabisulphite acts both as an enzymic browning inhibitor and preservative. Sulphites acts as a reducing agent and also gradually reduces the effectiveness of the enzyme (Embs & Markakis 1965).

Calcium acts synergistically with either sulphites or ascorbic acid to prevent browning in apple slices (Ponting *et al.*, 1972). Faust & Klein (1973) and Faust & Shear (1972) have shown an inverse relation between respiration and the Ca concentration in the flesh of fruit. In this experiment the Ca may have done the same to the pericarp. Calcium has been shown to be able to preserve cellular organisation and at deficiency levels, to induce disintegration of cytoplasmic membranes. One function of Ca may be to maintain protein synthesis which may supplement its effect in preserving cell membranes as a factor in the preservation of cellular organisation. (Faust & Klein 1973, Faust & Shear, 1972).

The chloride present can also inhibit the activity of phenol oxidase enzymes and will retard development of brown color for a limited time. Poix Ade et al., (1980) showed an exponential relation existing between reaction speed and amount of added chloride. Ascorbic acid is also known to delay browning in fruits, possibly by reducing the oxidized intemediate of phenolic compounds. In addition, it is believed to act on some functional group in the enzyme (Baruah and Swain, 1952). For fruits sealed in LDPE, the differences between treatments with sodium metabisulphite and sodium metabisulphite + calcium chloride is not much at ambient temperature but is quite significant at 8^{o}C.

The effect of varying the soaking time for the chemical treatments are seen in *Fig. 4.* The optimum time appears to be 5–10 minutes and soaking at 20 minutes adversely affects the storage quality of the fruits. The fruits became too moist and decayed faster. A similar trend is seen for all the chemical dipping treatments. By the 17th day, fruits treated with sodium metabisulphite + calcium chloride in LDPE at 8 C, remained sweet and firm at soaking time of 5 to 10 minutes.

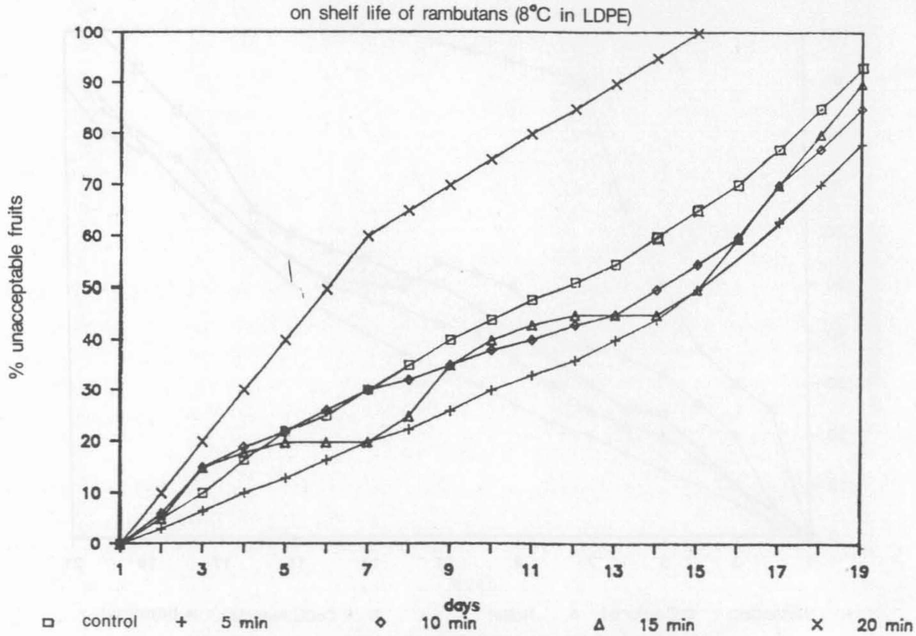

Figure 4. Effect of NaMetCaCl soaking time on shelf life of rambutans BC in LDPE).

Brown patches were observed in the inner layer of the skin for samples soaked at 15 and 20 minutes.

Mendoza *et al* (1972) study on Seematjan and Maharlika rambutans showed that storage decay could be controlled effectively by treatment with 1000 ppm benlate (1-butyl carbonyl-2-benzimidazol carbonic acid) but wax coating reduced moisture loss for 2 days only.

Sulfur Dioxide Treatments

Since sodium metabisulphite dips in the presence or absence of calcium ions were able to slightly extend the shelf life of wrapped rambutans at 8^{O}C, a further experiment was carried out using sulfur dioxide gas exposure. Sulfur dioxide gives better penetration into the skin, and like metabisulphite, it behaves both as a preservative, and anti browning agent. When fruits were exposed for different dutations, 15 minutes sulfur dioxide exposure extended the shelf by 2–3 days but had a higher % unacceptable fruit at anytime until the 16th

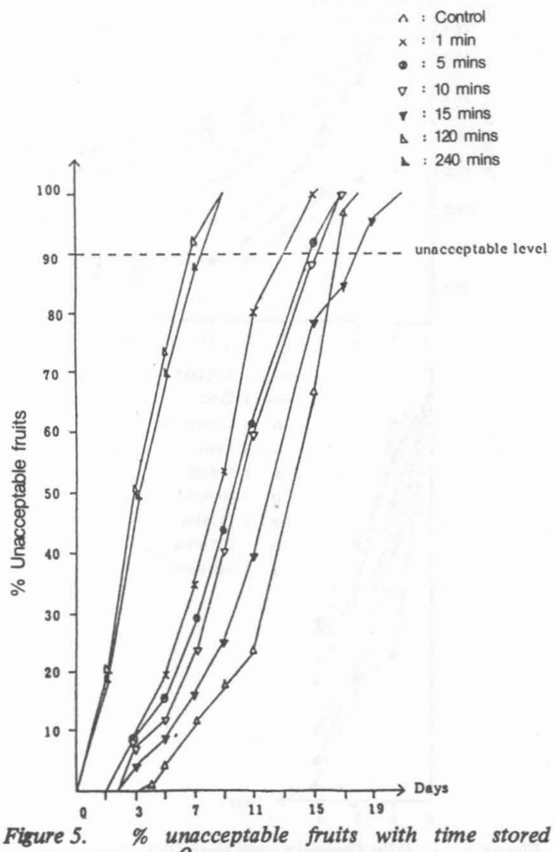

Figure 5. % unacceptable fruits with time stored at 10^{O}C (SO_2 treatments).

day compared to that of the control at 8 C (wrapped in LDPE), (*Fig. 5*). For ambeint temperature storage, sulfur dioxide treatment was detrimental to the fruits (*Fig. 6*).

Although sulfur dioxide inhibits enzymic browning it does not slow down the respiration rate, hence the physiological deterioration that occurs in the fruits during storage. Fruits treated with excess sulfur dioxide for 120 minutes and 240 minutes have the lowest shelf life. The fruits

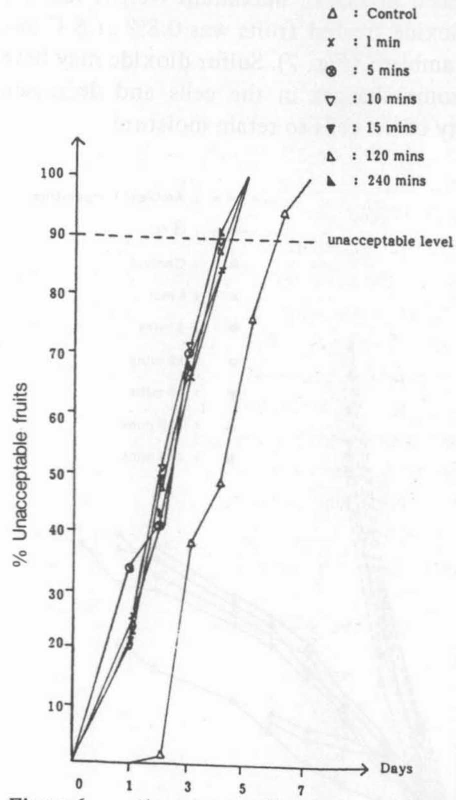

Figure 6. % unacceptable fruits with time stored at ambient temperature (SO_2 treatments).

suffered from excessive bleaching and injury, with the skin turning bright pink and browning occurring on the inner side of the skin. The flesh also suffered injury – had turned slightly brown and gave off a strong acidic, sulfurous odour thus making it inedible.

Treatment with sulfur dioxide gas can provide satisfactory quality maintenance for other fruits. However, the limiting parameter is usually the acid-sulfurous odour and taste, and also its corrosivity. It is necessary to promptly and vigorously sweep out excess sulfur dioxide to avoid a sulfurous off-flavour. A recent comprehensive review of sulfur dioxide application to food revealed no deleterious effects with the exception of a reduction in thiamine (Post, 1979a). Any condition that accelerates sulfur dioxide loss will in turn accelerate the darkening of the product (Schrader and Thompson, 1947; Bolin and Boyle, 1972).

Weight Loss

Sulfur dioxide treated fruits showed a slight increase in dehydration compared to untreated fruits sealed in LDPE. Maximum weight loss for sulfur dioxide treated fruits was 0.8% at 8 C and 1.3% at ambient (*Fig. 7*). Sulfur dioxide may have caused some changes in the cells and decreased the ability of the cells to retain moisture.

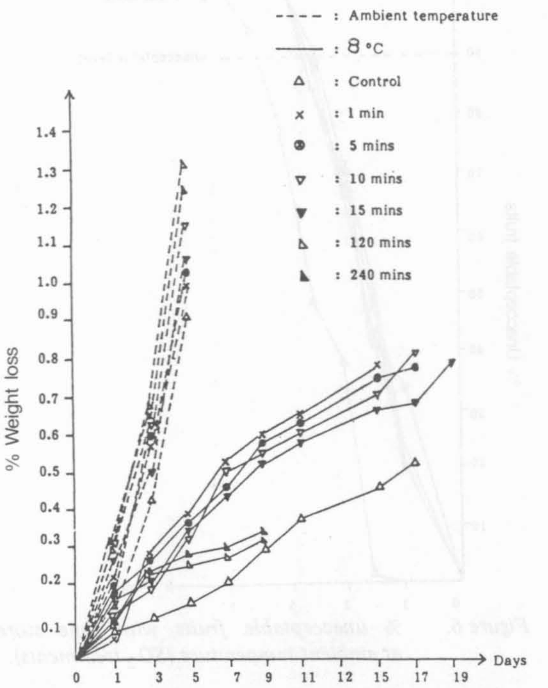

Figure 7. *% weight loss with time (SO_2 treatments).*

Colour

Sulfur dioxide treatments helped retain the highest L values (lightness) and b values (yellowness) but gave the lowest a values (redness) (Table 1). This showed that sulfur dioxide preserved the colour by a bleaching effect i.e. sulfur dioxide inhibits browning, but is detrimental to the natural red pigment present in the fruit skin. Discolouration to yellowish brown could be seen in fruits which were exposed for short durations (1–15 mins) while a pink discolouration was seen in fruits which underwent longer exposure (120–240 mins).

Texture

Fruits stored at 8 C, and which had undergone 15 mins of exposure to sulfur dioxide gas, showed firmer skin texture than those of the control fruits at the end of its shelf life *(Fig. 8).* Fruits exposed to sulfur dioxide for 10 and 15 mins showed significantly firmer skin texture, compered to the control up till the 9th day of storage. Exposure of fruits to sulfur dioxide for 1 min, 120 mins and 240 mins decreased the skin firmness. Too long an exposure to sulfur dioxide may have caused injury to the fruits. Storage at ambient temperature showed a similar trend, but with a shorter storage life of 4 days, hence a steeper slope of decline is obtained. Sulfur dioxide treatments for any duration adversely affect the pulp firmness (*Fig. 9*).

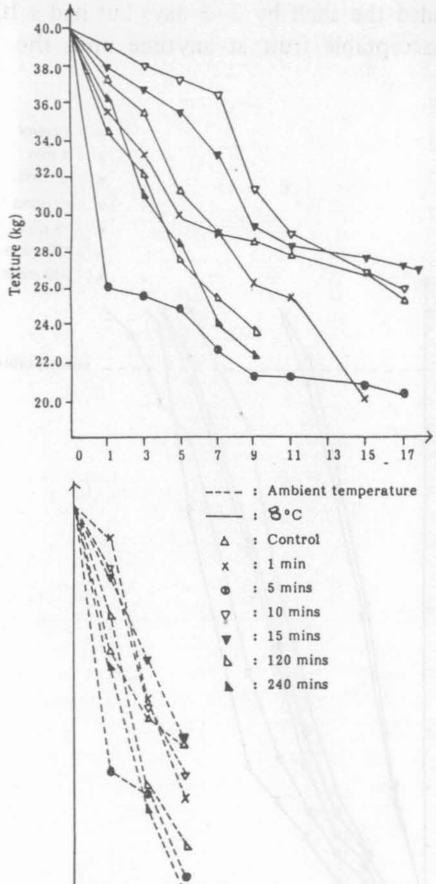

Figure 8. *Pulp firmness with time (SO_2 treatments).*

TABLE 1
Effect of various SO_2 treatment on colour of the skin for rambutans stored in LDPE BAGS (0.05 mm thickness)

	Control			1 min			5 mins			10 mins			15 mins			120 mins			240 mins		
Day	L	a	b	L	a	b	L	a	b	L	a	b	L	a	b	L	a	b	L	a	b
(8^{o} C)																					
1	19.9	13.0	6.9	27.4	1.6	3.4	27.3	2.3	4.1	25.7	4.3	5.4	26.4	1.2	2.5	28.5	6.3	10.0	29.0	4.9	11.8
3	18.2	10.9	6.4	26.9	4.9	5.6	20.7	3.7	4.6	24.5	5.9	5.6	25.7	3.9	5.2	26.1	5.4	9.7	25.6	3.6	10.4
5	18.5	10.4	6.0	24.7	6.3	6.6	25.0	4.6	5.9	23.6	7.7	6.9	24.3	4.5	6.0	24.3	5.3	9.1	23.8	2.1	10.1
7	17.7	9.0	5.7	21.3	7.5	7.8	20.5	5.9	6.4	22.3	8.4	7.5	23.9	5.2	6.8	21.0	5.2	8.0	24.6	5.1	8.0
9	16.7	8.5	5.4	20.0	8.0	7.9	19.9	6.7	6.9	21.7	3.6	9.5	22.6	5.3	6.9	19.8	4.9	6.8	20.4	4.4	7.6
11	15.9	7.8	5.2	16.1	7.6	5.9	16.4	4.6	5.8	17.4	7.4	6.3	19.9	5.6	7.0						
15	15.0	7.0	4.1	16.4	3.9	5.8	15.1	5.8	4.9	16.6	4.0	5.7	17.8	6.2	6.7						
17	13.5	6.2	3.9				14.3	4.9	4.5	14.5	4.0	5.3	16.7	5.4	6.3						
19													15.3	4.5	5.2						
(Ambient)																					
1	20.1	11.9	7.0	25.4	3.7	4.1	26.1	1.7	4.0	26.2	2.1	1.5	28.3	1.9	3.8	24.0	4,0	8.6	22.9	3.7	9.8
3	18.6	11.3	5.8	20.1	4.5	6.3	21.8	4.0	5.6	21.8	4.9	5.9	25.0	4.8	5.6	19.3	5.4	7.9	20.9	2.8	8.1
5	15.5	9.7	3.9	18.2	3.5	5.4	17.4	3.0	3.7	18.7	2.9	4.0	21.5	3.4	4.0	16.9	3.5	7.5	18.7	2.0	6.2

*SD values ranges from 0.1 – 0.3

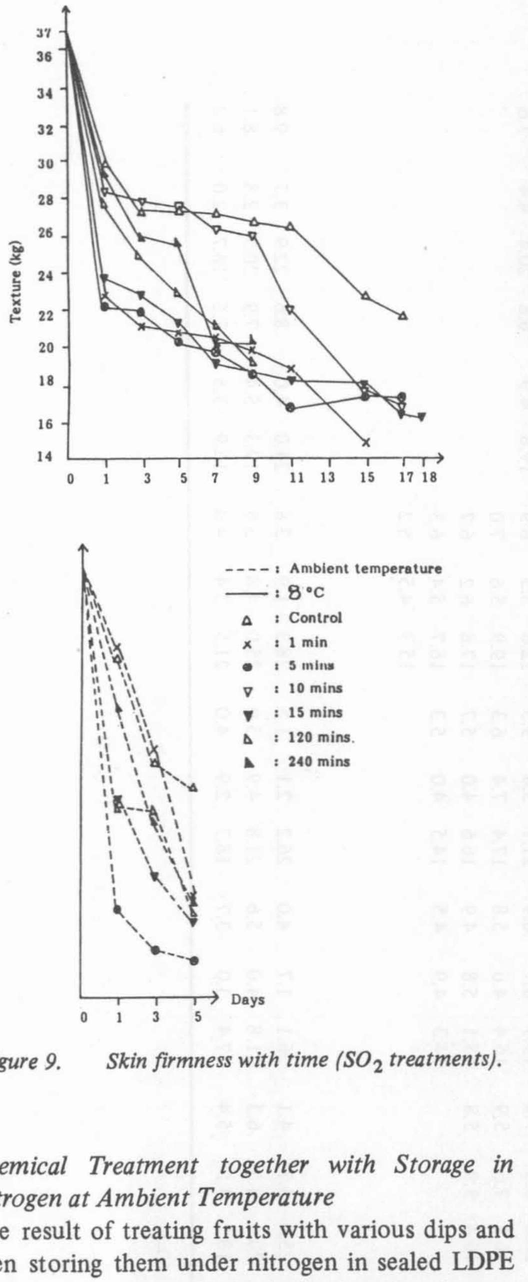

Figure 9. *Skin firmness with time (SO_2 treatments).*

Norman and Craft (1971) found that oranges held in nitrogen produced increasing amounts of ethanol, acetaldehyde and methanol as the duration of the anaerobic treatment was prolonged. Volatile emission fell upon transfer of fruits to normal air. Rind injury, however developed in air preceeding an exposure period of 3 or more days in N. The high oxygen uptake or carbon dioxide production as a result of exposure to nitrogen may be reversed if low oxygen levels are used. Craft *et al* (1968) observed that the anaerobic carbon dioxide output initiated by lemon fruits in the nitrogen atmosphere was suppressed by adding 2 or 5% oxygen. Oranges and lemons were compared to rambutans because they all fall under the category of non-climateric fruits (Mendoza *et al.*, 1972).

Chemical Treatment together with Storage in Nitrogen at Ambient Temperature

The result of treating fruits with various dips and then storing them under nitrogen in sealed LDPE bags are shown in Table 2. Storage in nitrogen show some potential in prolonging the shelf life of rambutans treated with calcium and a reducing agent which reduced the respiration and oxidation rate of the fruit. The effect of storing rambutans treated with calcium chloride and Na met under nitrogen at 8 C could very well prolong the shelf life of the fruit further but this was not investigated because it would mean a costly post-harvest handling of the fruit.

Effect of Leaving Fruit Stalks Attached to the Fruit

Leaving the fruits stalks on the fruit, did not significantly prolong the shelf life of the fruits when compared to the control. (Table 2) This is contrary to the general belief that the presence of fruit stalk can prolong the shelf life of the fresh fruits but is in agreement with the fact that the major moisture loss occured through the soft spines (hairs) of the pericarp (Mendoza *et al* 1972).

Correlations between Weight Loss, Texture and Colour

There appears to be a good correlation between skin firmness and L value for all the treatments both at 8 C and ambient temperature (Table 3). However, the correlation of a and b values to texture is poor with sulfur dioxide treatments. There is a good correlation between firmness of the skin and pulp with weight loss in sulfur dioxide treated fruits.

ACKNOWLEDGEMENT

The authors thank the Universiti farm personnel for making available the fruits for research (especially Wan Jaharah Wan Ngah and Haji Mahmood Jaafar), Encik Abdullah Hassan (BTM, MARDI) for useful suggestions at the start of the research, and Norhayati Salamuddin for typing the manuscript.

TABLE 2
Effect of varying stalk length and storage in Nitrogen on % unacceptable fruits

	% Unacceptable fruits						
Stalk length/days	0	2	4	6	8	10	12
Unwrapped/RT							
0	0	40	90	100			
15	0	50	90	100			
30	0	50	90	100			
LDPE/RT							
0	0	20	65	95	100		
15	0	20	65	95	100		
30	0	20	65	95	100		
LDPE/RT Namet + Cacl2							
0	0	20	60	90	100		
15	0	20	60	90	100		
30	0	20	60	90	100		
LDPE/RT (Namet + Asc. Acid)							
0	0	30	75	90	100		
15	0	30	75	90	100		
30	0	30	75	90	100		
Unwrapped/8 C							
0	0	15	30	60	80	90	100
15	0	15	30	60	80	90	100
30	0	15	30	60	80	90	100
LDPE/8 C							
0	0	5	15	20	35	45	50
15	0	5	15	20	35	45	50
30	0	5	15	20	35	45	50
LDPE/8 C (Namet + Cacl2)							
0	0	5	15	20	30	40	50
15	0	5	15	20	30	40	55
30	0	5	15	20	30	40	55
LDPE/8 C (Namet + Asc. Acid)							
0	0	5	20	30	35	40	50
15	0	5	20	30	35	40	45
30	0	5	20	30	35	40	45
Chemically treated fruits stored in nitrogen/RT							
LDPE	0	33	57	90	100		
Na Benz/sorbate	0	37	93	100			
Hot benomyl	0	63	93	100			
NaMet + CaCl2	0	27	40	50	73	90	100
CaCl2 + Asc. Acid	0	23	60	73	100		

TABLE 3

Correlation between skin and pulp firmness with weight loss and between skin firmness with colour

TREATMENTS	N	Correlation Coefficient: Skin Texture vs Wt. Loss	Correlation Coefficient: Pulp Texture vs Wt. Loss	Best Fitted Line: Skin Texture vs Wt. Loss	Best Fitted Line: Pulp Texture vs Wt. Loss
1. SO_2: (8°C)					
a) Control	16	−0.903	−0.918	y = −23.261 x +36.502	y = −15.137 x +30.149
b) 1 min	14	−0.969	−0.907	y = −20.740 x +38.257	y = −7.968 x +23.428
c) 5 mins	16	−0.976	−0.967	y = −10.310 x +28.022	y = −8.507 x +23.986
d) 10 mins	16	−0.931	−0.895	y = −20.537 x +42.746	y = −15.536 x +30.609
e) 15 mins	18	−0.972	−0.981	y = −20.041 x +41.304	y = −12.338 x +25.437
f) 120 mins	10	−0.942	−0.961	y = −51.517 x +40.455	y = −3[illegible].096 x +32.156
g) 240 mins	10	−0.965	−0.896	y = −60.567 x +43.261	y = −40.155 x +34.126
2. (Ambient)					
a) Control	6	−0.943	−0.880	y = − 6.097 x +32.433	y = − 8.396 x +32.070
b) 1 min	6	−0.983	−0.998	y = −17.777 x +41.135	y = −17.276 x +36.693
c) 5 mins	6	−0.945	−0.918	y = − 6.723 x +27.594	y = − 3.224 x +19.068
d) 10 mins	6	−0.955	−9.995	y = −12.735 x +39.370	y = −10.919 x +31.271
e) 15 mins	6	−0.981	−0.932	y = −10.890 x +38.227	y = − 7.057 x +25.474
f) 120 mins	6	−0.909	−0.945	y = −11.334 x +35.436	y = − 5.972 x +26.839
g) 240 mins	6	−0.948	−0.988	y = −11.501 x +33.358	y = −10.543 x +31.538

TREATMENTS	N	Correlation Coefficient Texture vs Colour: L	a	b	Best Fitted Line Texture vs Colour: L	a	b
1. SO_2 (Ambient)							
a) Control	6	0.919	0.894	0.944	y = 0.997 x +11.502	y = 2.001 x +7.568	y = 1.536 x +20.956
b) 1 min	6	0.992	0.051	−0.694	y = 1.876 x −9.189	y = 0.686 x +27.972	y = 4.428 x +53.966
c) 5 mins	6	0.940	−0.243	0.480	y = 0.638 x +9.666	y = −0.622 x +25.363	y = 1.388 x +17.407
d) 10 mins	6	0.997	−0.439	−0.700	y = 1.513 x −3.089	y = − 1.740 x +36.283	y = −1.814 x +37.432
e) 15 mins	6	0.990	−0.500	−0.081	y = 1.335 x −1.602	y = −1.564 x +36.960	y = −0.373 x +33.361
f) 120 mins	6	0.995	−0.027	0.992	y = 1.771 x −8.558	y = −0.173 x +27.718	y = 11.448 x −64.614
g) 240 mins	6	0.997	0.989	0.976	y = 2.708 x −31.310	y = 6.765 x +5.934	y = 3.155 x −0.248
2. (8°C)							
a) Control	16	0.893	0.948	0.922	y = 1.815 x −0.422	y = 1.778 x +13.925	y = 3.716 x +10.025
b) 1 min	12	−0.938	0.930	0.994	y = 0.850 x +10.642	y = −1.525 x +39.097	y = 5.710 x −3.821
c) 5 mins	16	0.962	−0.817	−0.587	y = 0.441 x +13.749	y = −1.225 x +29.128	y = −1.299 x +30.412
d) 10 mins	16	0.970	0.402	0.075	y = 1.275 x +6.445	y = 1.117 x +26.617	y = 0.283 x +31.093
e) 15 mins	18	0.928	−0.750	−0.614	y = 1.017 x 9.621	y = −2.302 x +42.078	y = −1.928 x +42.653
f) 120 mins	10	0.984	0.893	0.943	y = 1.264 x −1.449	y = 7.808 x −13.505	y = 3.219 x +0.872
g) 240 mins	10	0.985	−0.059	0.987	y = 1.691 x 12.447	y = −0.271 x +29.694	y = 3.137 x −1.445

REFERENCES

AYRES. J.C., A.A. KRAFT, and L.C. PIERCE. (1964): Delaying spoilage of tomatoes. *Food Tech.* **18(8)**: 1210.

BARUAH, P. and T. SWAIN. (1925): The effect of 1-ascorbic acid on the in vitro of polyphenoloxidase from potato. *Biochem. J.* **55**: 392-399.

BOLIN, H.P and F.P. BOYLE. (1972): Effect of storage and processing on sulfur dioxide in preserved fruits. *Food Prod. Dev.* **6(7)**: 82.

EMBS, R.J. and P. MARKIKIS. (1965): The mechanism of sulfite inhibition of browning caused by polyphenol oxidase. *J. Food Sci.* **30**: 753-758.

FAUST, M. and J.D. KLEIN. (1973): Levels and sites of metabolically active Ca in apple fruit. *J. Am. Soc. Hort. Sci.* **99**: 93-94.

FAUST, M. and C.B. SHEAR. (1972): The effect of calcium on respiration of apples. *J. Am. Soc. Hort. Sci.,* **97**: 437-439.

LIEBERMAN, H. and L.W. MAPSON. (1962): Inhibition of the evolution of ethylene and the ripening of fruit by ethylene oxide. *Nature* 196 (4855): 660.

LIEBERMAN, M., S. ASEN, and L.W. MAPSON. (1964): Ethylene oxide an antagonist of ethylene in metabolism. *Nature* **204** (4960): 756.

MENDOZA, D. BJ. E.B. PANTASTICO, and F.B. JAVIER. (1972): Storage and Handling of rambutan. *Phillipines agriculturist* **55**: 322.

POIX ADE, M.A. ROVET MAYER and J. PHILIPPON. (1980): Combined action of chlorides and ascorbic acid on inhibition of enzymic browning in apple puree. *Lebensmittel-Wissenschaft und-Technologie* **13(2)**, 105-110.

PONTING, J., D.R. JACKSON and G. WATERS. (1972): Refrigerated apple slices. Preservative effects of ascorbic acid, calcium and sulfite. *J. Food Sci.* **37**: 434-436.

POST, R. (1979): Sulfur dioxide kinetics. In quarterly report from University of Maryland. DOE, contract EC77-S-01-5073:13.

SCHRADER, A.C. and A.H. THOMPSON. (1947): Factors influencing the keeping quality of dehydrated apples. *Proc. Am. Soc. Hortic. Sci.* **49**: 125.

SCOTT, K.J., W.B. MCGLASSON and E.A. ROBERTS. (1970): Potassium permanganate as an ethylene absorbent in PE bags to delay ripening of bananas during storage. *Austr. J. Exp. Agric. Anim. Husb.* **10**: 237-240.

SHANTAKRISHNA MURTHY G. and K.P. GOPALAKRISHNA RAO. (1983): Post harvest control of spoilage in Mango (*Mangifera Indica* L.) with hot water and fungicides. *J. Fd. Sc. & Tech. India.* **20(2)**: 74-77.

SUBRAMANYAM, H., N.V.N. MOORTHY, N.V. SUBHADRA and M. MATHU. (1969): Control of spoilage and inhibition of ripening in 'alfonso' mangoes by fumigation. *Trop. Sci.* **11(2)**: 120.

USDA (1977): Freezing grapes for wine. Press release. Western Utiliz. Res. Lab., US Dept. Agric. Albany, Calif.

(Received 19 June 1987)