

## CHAPTER IV

## RESULTS

4.1 Qualities of Fresh Lime Juice

Qualities of fresh lime juice were presented in Table 1. The pH values of all samples were equal to 2.4 with a little variability in °Brix and % acidity. Citrus juices have maximum buffering capacity so that juices of various titratable acidity may have identical pH value (Agr. Hand Book No.98). The amount of vitamin C in fresh lime juice was in the range of 28-38 mg per 100 cm<sup>3</sup> of juice. Fresh lime juice had limonin content of 4.55-6.00 ppm. The extent of limonin content depends upon the variety of fruits, rootstock, methods of extractions and stage of maturity. Fresh lime juice had a yellowish green color which was expressed as percentage of color shown in Table 1.

4.2 Effect of Potassium Metabisulfite in Full Bottle Sample

The effect of potassium metabisulfite on limonin in full bottle lime juice stored at refrigerator temperature and room temperature was investigated, the results obtained were shown in Table 2 that the concentrations of potassium metabisulfite had little effects on limonin content in all samples. It should be noted that the limonin content in samples that were treated with 200, 300 ppm of potassium metabisulfite decreased clearly as compared with the controlled lime juice during 6 weeks of storage time at both tempera-

Table 1 Qualities of fresh lime juice

Sample No.	Limonin Content ppm	Vit.C mg/100cm <sup>3</sup>	pH	°Brix	% Acidity	% Color				
						Green	Grey	Yellow	White	Orange
1	4.55	38.89	2.4	9.00	7.76	38.0	8.0	40.0	5.0	8.0
2	5.03	32.50	2.4	8.50	7.49	43.5	10.0	33.0	5.5	8.0
3	4.93	34.90	2.4	8.50	7.74	42.0	10.8	33.2	5.5	8.5
4	6.00	30.50	2.4	8.40	7.50	43.5	10.0	32.0	6.5	8.0
5	5.41	28.59	2.4	8.20	7.22	41.0	10.8	33.2	6.5	8.5
av.	5.184	33.08	2.4	8.52	7.54					

tures. The limonin contents developed more slowly in samples treated with 200, 300 ppm of potassium metabisulfite stored at both temperatures compared to the controlled sample during the first 4 weeks, later it developed more quickly until the end of the sixth week. Limonin content of all samples varied irregularly with a tendency of increasing during 6 weeks of storage test after that it varied irregularly with a tendency of constant value. A drop in limonin content after 6 weeks of storage could not be accounted for (Figure 2)

The chemical and physical qualities of all treated lime juice during 4 months of storage time at refrigerator and room temperature are summarized in Tables 3-5. In view of chemical qualities, the pH values of all samples were constant at 2.4. The data indicated that total acidity of lime juice varied very slightly. The findings of Shaker et al (1966) on lime juice, confirmed these results.

Measurement of °Brix which was related to total soluble solid including sugar, acid, soluble pectin and other compounds had shown that all samples had a little variable value between 8.2-8.8°Brix or they were nearly constant.

The Vitamin C retention during the storage test at refrigerator temperature and room temperature was shown in Figures 3,4. The vitamin C retention in all samples varied irregularly during the storage test with a tendency of decreasing. For samples stored at both refrigerator temperature and room temperature, treated with 200, 300 ppm of potassium metabisulfite retained more ascorbic acid than the controlled lime juice. The sudden decrease in vitamin C occurred in the sample treated with heat and kept at room temperature. The best retention of vitamin C was in the sample treated with 300 ppm

Table 2 Effect of potassium metabisulfite on limonin content in lime juice during 4 months of storage time.

Week	Limonin content (ppm)					
	A Refrigerator temperature			B Room temperature		
	I <sub>1</sub>	I <sub>3</sub>	I <sub>4</sub>	I <sub>1</sub>	I <sub>3</sub>	I <sub>4</sub>
0	14.411	15.373	14.581	15.448	14.602	13.677
2	17.425	17.000	14.581	17.859	16.729	14.807
4	19.404	16.103	15.240	19.724	16.691	15.900
6	19.668	18.602	18.103	21.552	19.894	19.103
8	19.706	21.602	21.156	20.836	21.602	20.158
10	19.932	18.602	17.746	20.045	18.000	18.914
12	20.120	19.480	19.701	21.100	20.602	19.442
14	19.819	20.572	19.101	21.364	18.602	20.801
16	19.781	20.001	20.602	21.853	21.550	20.987



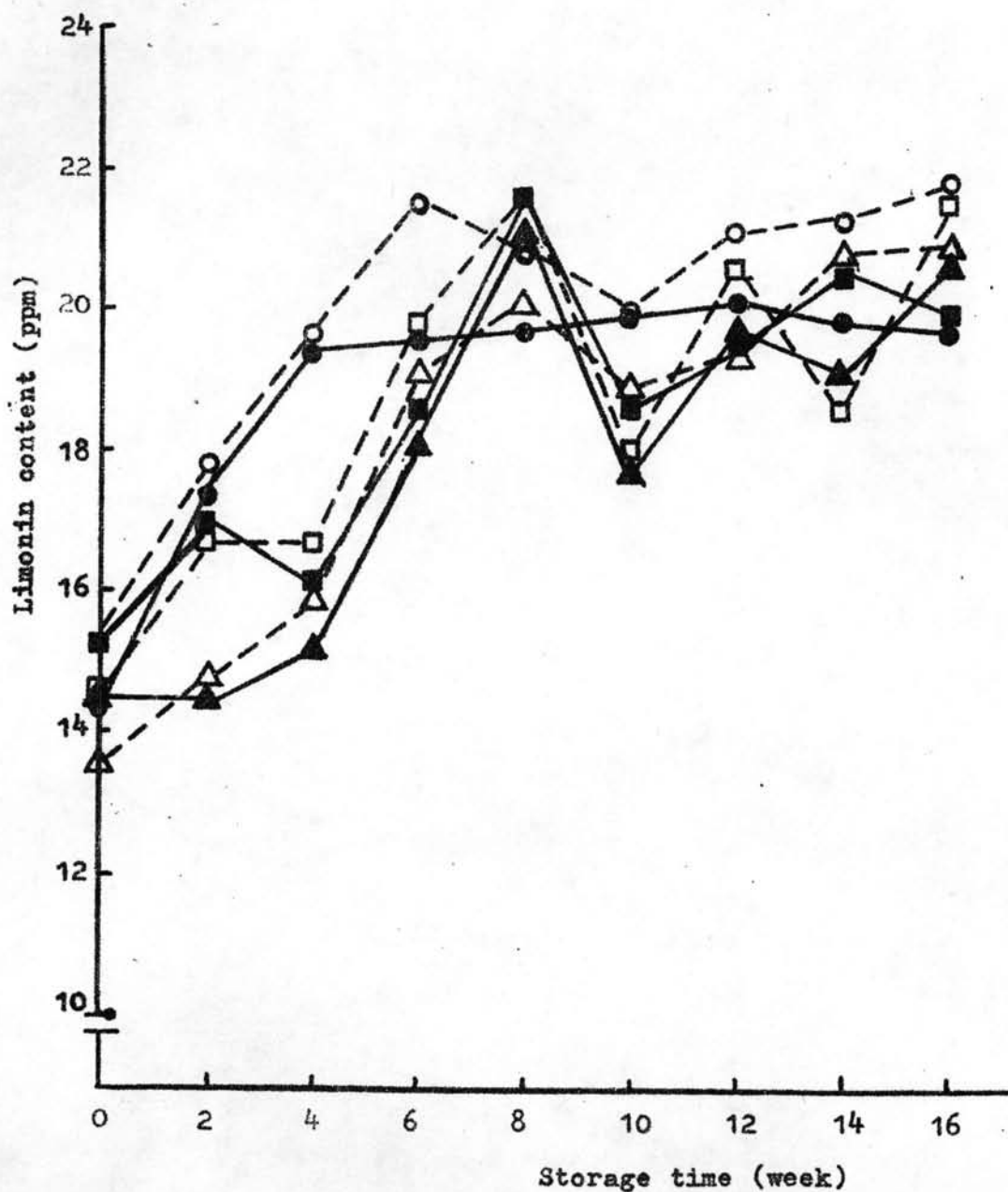


Figure 2 Effect of potassium metabisulfite on the variation of limonin content with time.

- control, ■ 200 ppm, ▲ 300 ppm, at refrigerator temperature,
- control, □ 200 ppm, △ 300 ppm, at room temperature.

Table 3 a Chemical qualities of full-bottle-lime juice (controlled) during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	29.44	100.00	2.4	8.5	7.46
2	27.23	92.46	2.4	8.5	7.53
4	21.14	71.80	2.4	8.6	7.32
6	16.44	55.84	2.4	8.8	7.67
8	19.48	66.16	2.4	8.5	7.34
10	18.15	61.63	2.4	8.6	7.07
12	17.04	57.87	2.4	8.6	7.21
14	15.97	54.25	2.4	8.5	7.33
16	16.15	54.86	2.4	8.5	7.22
B Room Temperature					
0	28.45	100.00	2.4	8.5	7.36
2	23.94	84.15	2.4	8.6	7.53
4	20.99	73.79	2.4	8.5	7.49
6	15.80	55.52	2.4	8.5	7.56
8	17.18	60.40	2.4	8.6	7.33
10	14.72	51.73	2.4	8.5	7.11
12	15.22	53.49	2.4	8.6	7.09
14	14.67	51.58	2.4	8.6	7.16
16	12.31	43.26	2.4	8.5	7.09

Table 3 b Physical qualities of full-bottle-lime juice (controlled) during 4 months of storage time.(early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.8	32.5	7.5	9.5	0
4	39.0	10.0	34.5	8.5	8.0	0
6	37.0	10.0	36.0	8.5	8.5	0
8	39.0	10.0	34.5	9.0	8.5	0
10	38.0	9.0	35.5	9.5	8.0	0
12	38.0	9.0	40.0	6.0	7.0	0
14	36.0	9.0	36.0	9.0	10.0	++
16	34.0	9.0	40.5	7.0	9.5	++
B Room Temperature						
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	36.5	7.0	38.5	9.0	8.0	0
6	34.0	12.5	39.5	7.0	8.0	+
8	32.0	11.0	42.0	7.0	8.0	++++
10	28.5	7.0	46.5	9.0	9.0	++++
12	24.0	6.0	48.0	10.0	12.0	+++++
14	24.0	10.0	40.0	7.0	19.0	+++++
16	24.0	11.0	41.0	5.0	19.0	+++++

Table 4 a Chemical qualities of full-bottle lime juice treated with 200 ppm of potassium metabisulfite during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	33.69	100.00	2.4	8.5	7.33
2	31.71	94.13	2.4	8.5	7.26
4	31.08	92.26	2.4	8.6	7.25
6	22.17	65.81	2.4	8.5	7.51
8	25.42	75.45	2.4	8.5	7.23
10	22.81	67.70	2.4	8.6	7.02
12	21.90	65.0	2.4	8.4	7.27
14	18.83	55.91	2.4	8.2	6.96
16	18.07	53.65	2.4	8.5	6.96
B Room Temperature					
0	33.54	100.00	2.4	8.5	7.37
2	27.01	80.53	2.4	8.5	7.40
4	25.42	75.79	2.4	8.5	7.25
6	18.62	55.53	2.4	8.5	7.51
8	22.78	67.91	2.4	8.6	7.37
10	19.88	59.27	2.4	8.5	7.09
12	20.62	61.47	2.4	8.4	7.02
14	17.53	52.28	2.4	8.6	7.06
16	12.31	43.26	2.4	8.5	7.09



Table 4 b Physical qualities of full-bottle lime juice treated with 200 ppm of potassium metabisulfite during 4 months of storage time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	39.0	10.0	34.5	8.5	8.0	0
6	37.0	10.0	36.0	8.5	8.5	0
8	39.0	10.0	34.5	9.0	8.5	0
10	38.0	9.0	35.5	9.5	8.0	0
12	38.0	9.0	40.0	6.0	7.0	0
14	36.0	8.0	36.0	10.0	10.0	0
16	34.0	9.0	40.5	7.0	9.5	0
B Room Temperature						
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	36.5	7.0	38.5	9.0	8.0	0
6	34.0	12.5	39.5	7.0	8.0	+
8	32.0	11.0	42.0	7.0	8.0	+++
10	28.5	7.0	46.5	9.0	9.0	+++
12	31.0	7.0	44.5	9.0	6.5	++++
14	24.0	12.0	38.0	8.0	18.0	++++
16	24.0	11.0	41.0	5.0	19.0	+++++

Table 5 a Chemical qualities of full-bottle lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C %retention	pH	°Brix	% Acidity
0	34.57	100.00	2.4	8.5	7.81
2	32.30	93.43	2.4	8.6	7.63
4	29.38	84.98	2.4	8.7	7.81
6	27.35	79.12	2.4	8.8	7.84
8	29.04	83.99	2.4	8.0	7.65
10	24.73	71.53	2.4	8.8	7.38
12	22.03	63.74	2.4	8.5	7.33
14	25.32	73.26	2.4	8.5	7.13
16	22.76	65.83	2.4	8.5	7.22
B Room Temperature					
0	34.84	100.00	2.4	8.5	7.28
2	32.19	92.40	2.4	8.4	7.39
4	28.26	81.13	2.4	8.5	7.32
6	23.84	68.43	2.4	8.5	7.46
8	23.70	68.04	2.4	8.4	7.51
10	23.27	66.80	2.4	8.4	7.06
12	21.46	61.61	2.4	8.4	7.09
14	17.66	50.70	2.4	8.2	7.09
16	14.80	60.35	2.4	8.6	7.06

Table 5 b Physical qualities of full-bottle lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	39.0	10.0	34.5	8.5	8.0	0
6	37.0	10.0	36.0	8.5	8.5	0
8	39.0	10.0	34.5	9.0	8.5	0
10	38.0	9.0	35.5	9.5	8.0	0
12	38.0	9.0	40.0	6.0	7.0	0
14	38.0	8.0	36.0	10.0	8.0	0
16	34.0	9.0	40.5	7.0	9.5	0
B Room Temperature						
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	33.0	10.5	7.0	0
4	36.5	7.0	38.5	9.0	8.0	0
6	34.0	12.5	39.5	7.0	8.0	+
8	32.0	11.0	42.7	7.0	8.0	+++
10	28.5	8.5	45.0	9.0	9.0	+++
12	31.0	7.0	44.5	9.0	6.5	++++
14	32.0	11.0	38.0	8.0	11.0	++++
16	24.0	11.0	41.0	5.0	19.0	+++++

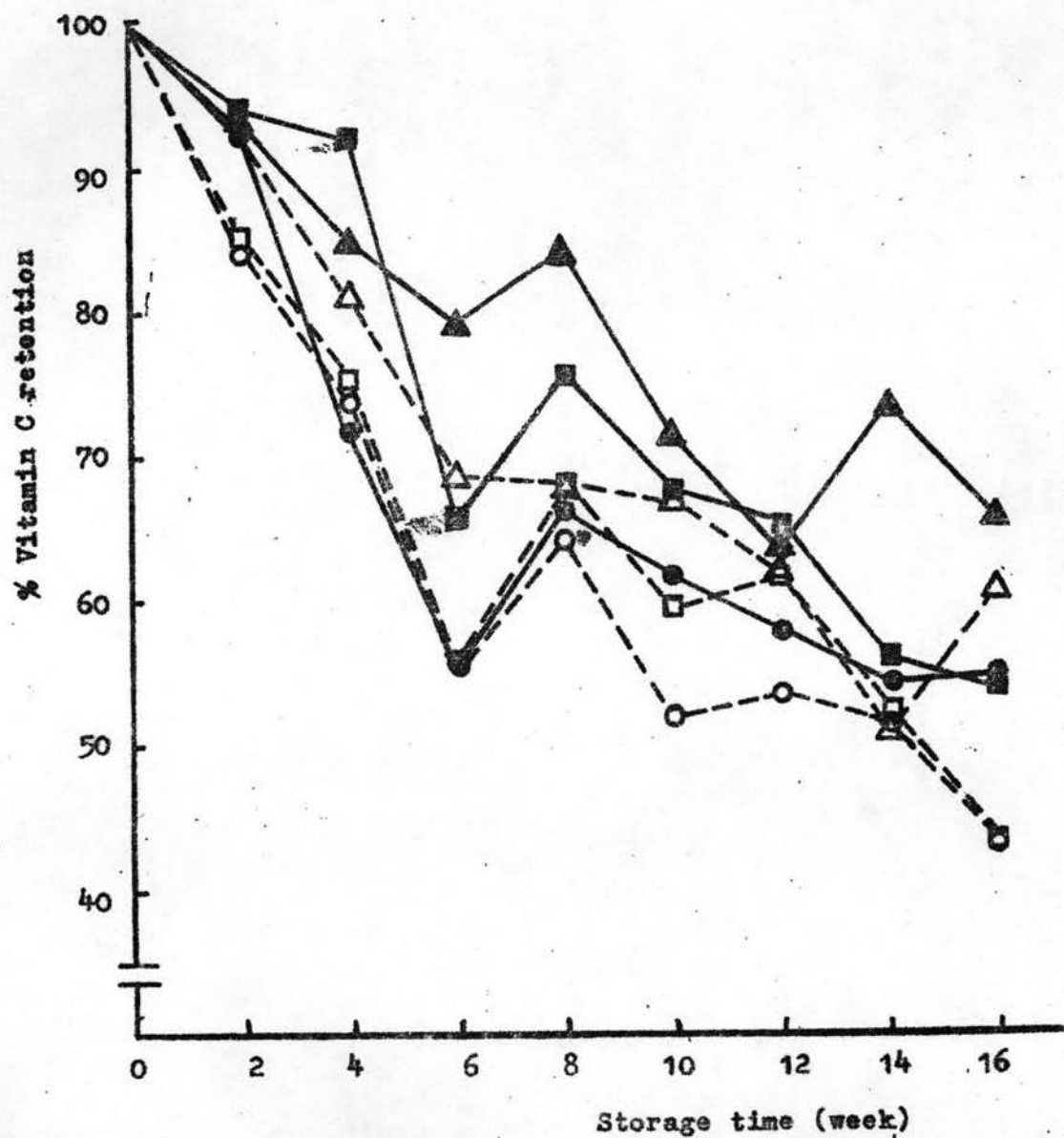


Figure 3 Effect of potassium Metabisulfite on Vitamin C retention in full-bottle-lime juice (early season)

- control, ■ 200 ppm, ▲ 300 ppm, at refrigerator temperature,
- control, □ 200 ppm, △ 300 ppm, at room temperature.



Table 6 a Chemical qualities of full-bottle-lime juice (controlled) during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	32.50	100.00	2.4	8.0	7.09
2	-	-	-	-	-
4	25.83	79.50	2.4	7.30	
6	21.12	64.98	2.4	8.4	7.30
8	21.10	64.62	2.4	8.4	7.28
10	19.50	60.00	2.4	8.2	7.30
12	18.15	55.84	2.4	8.0	7.29
14	19.98	61.47	2.4	8.4	7.58
16	17.06	52.50	2.4	8.5	7.45
B Room Temperature					
0	32.50	100.00	2.4	8.0	7.09
2	-	-	-	-	-
4	23.72	72.98	2.4	9.0	7.62
6	17.71	54.51	2.4	8.6	7.60
8	16.27	50.06	2.4	8.6	7.39
10	18.13	55.80	2.4	8.0	7.17
12	19.28	59.32	2.4	8.0	7.37
14	14.67	45.15	2.4	8.0	7.79
16	12.84	39.00	2.4	8.5	7.40

Table 6 b Chemical qualities of full-bottle-lime juice  
(controlled) during 4 months of storage time.  
(late season)

A Refrigerator temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	42.0	13.5	28.0	6.5	10.0	0
6	42.0	13.5	29.5	6.5	8.5	0
8	37.0	9.0	32.0	12.5	9.5	0
10	37.5	9.0	32.5	12.0	9.0	0
12	37.0	8.0	34.5	8.5	12.0	0
14	36.0	8.0	36.0	10.0	10.0	0
16	35.0	11.0	37.5	8.0	8.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	37.0	9.0	32.0	12.5	9.5	0
6	36.5	13.5	28.0	7.5	14.5	++
8	38.0	7.0	38.0	7.0	10.0	++
10	32.5	9.0	36.5	9.5	12.5	+++
12	31.0	10.0	44.0	8.0	7.0	+++++
14	17.0	14.0	40.0	7.0	22.0	+++++
16	-	-	-	-	-	+++++++

Table 7 a Chemical qualities of full-bottle-lime juice treated with 200 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	35.74	100.00	2.4	8.0	7.42
2	-	-	-	-	-
4	33.95	95.00	2.4	8.5	7.30
6	26.27	80.85	2.4	8.5	7.29
8	26.19	80.00	2.4	8.2	7.16
10	22.96	70.13	2.4	8.2	7.21
12	27.23	76.18	2.4	8.0	7.20
14	21.45	60.01	2.4	8.0	7.34
16	20.46	57.25	2.4	8.0	7.20
B Room Temperature					
0	35.74	100.00	2.4	8.0	7.42
2	-	-	-	-	-
4	25.02	70.01	2.4	8.7	7.28
6	20.01	55.99	2.4	8.8	7.26
8	17.00	60.78	2.4	8.6	7.32
10	18.58	52.01	2.4	8.0	7.26
12	21.08	59.00	2.4	8.0	7.31
14	11.64	32.58	2.4	8.0	7.30
16	13.56	37.95	2.4	8.0	7.17

Table 7b Physical qualities of full-bottle-lime juice treated with 200 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	41.0	15.0	27.0	6.5	10.5	0
6	42.0	13.5	29.5	6.5	8.5	0
8	39.5	9.0	31.0	13.0	7.5	0
10	37.5	9.0	32.5	12.0	9.0	0
12	37.0	8.0	34.5	8.5	12.0	+
14	36.0	8.0	36.0	10.0	10.0	0
16	35.0	11.0	37.5	8.5	8.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	39.5	9.0	31.0	13.0	7.5	0
6	32.5	15.0	24.5	9.5	18.5	0
8	36.0	10.0	32.0	8.0	11.0	++
10	25.0	11.0	42.5	7.0	14.5	+++
12	27.0	10.0	44.0	8.0	11.0	++++
14	24.0	12.0	38.0	8.0	18.0	++++
16	-	-	-	-	-	++++++



Table 8 a Chemical qualities of full-bottle-lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100cm <sup>3</sup>	Vit.C % Retention	pH	°Brix	% Acidity
0	34.24	100.00	2.4	8.0	7.45
2	-	-	-	-	-
4	32.69	95.50	2.4	8.5	7.53
6	32.00	93.44	2.4	8.5	7.51
8	28.85	84.25	2.4	8.8	7.42
10	27.74	81.01	2.4	8.2	7.30
12	22.76	66.47	2.4	8.0	7.40
14	21.25	62.08	2.4	8.4	7.47
16	18.59	54.29	2.4	8.8	7.22
B Room Temperature					
0	34.24	100.00	2.4	8.0	7.45
2	-	-	-	-	-
4	25.68	75.00	2.4	8.7	7.44
6	23.97	70.00	2.4	8.8	7.44
8	19.22	56.13	2.4	8.4	7.30
10	19.34	56.50	2.4	8.0	7.39
12	21.06	61.50	2.4	8.0	7.43
14	14.00	40.91	2.4	8.0	7.40
16	11.98	34.99	2.4	8.8	7.27

Table 8 b Physical qualities of full-bottle-lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	41.0	15.0	28.0	7.0	9.0	0
6	42.0	13.5	29.5	6.5	8.5	0
8	39.5	9.0	31.0	13.0	7.5	0
10	37.5	9.0	32.5	12.0	9.0	0
12	37.5	8.5	34.0	8.0	12.0	0
14	36.0	8.0	36.0	10.0	10.0	0
16	35.0	11.0	37.5	8.0	8.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	39.5	9.0	31.0	13.0	7.5	0
6	32.5	15.0	32.5	9.5	18.5	0
8	36.0	10.0	32.0	8.0	11.0	++
10	25.0	11.0	42.5	7.0	14.5	+++
12	27.0	10.0	44.0	8.0	11.0	++++
14	24.0	12.0	38.0	8.0	18.0	++++
16	-	-	-	-	-	++++++

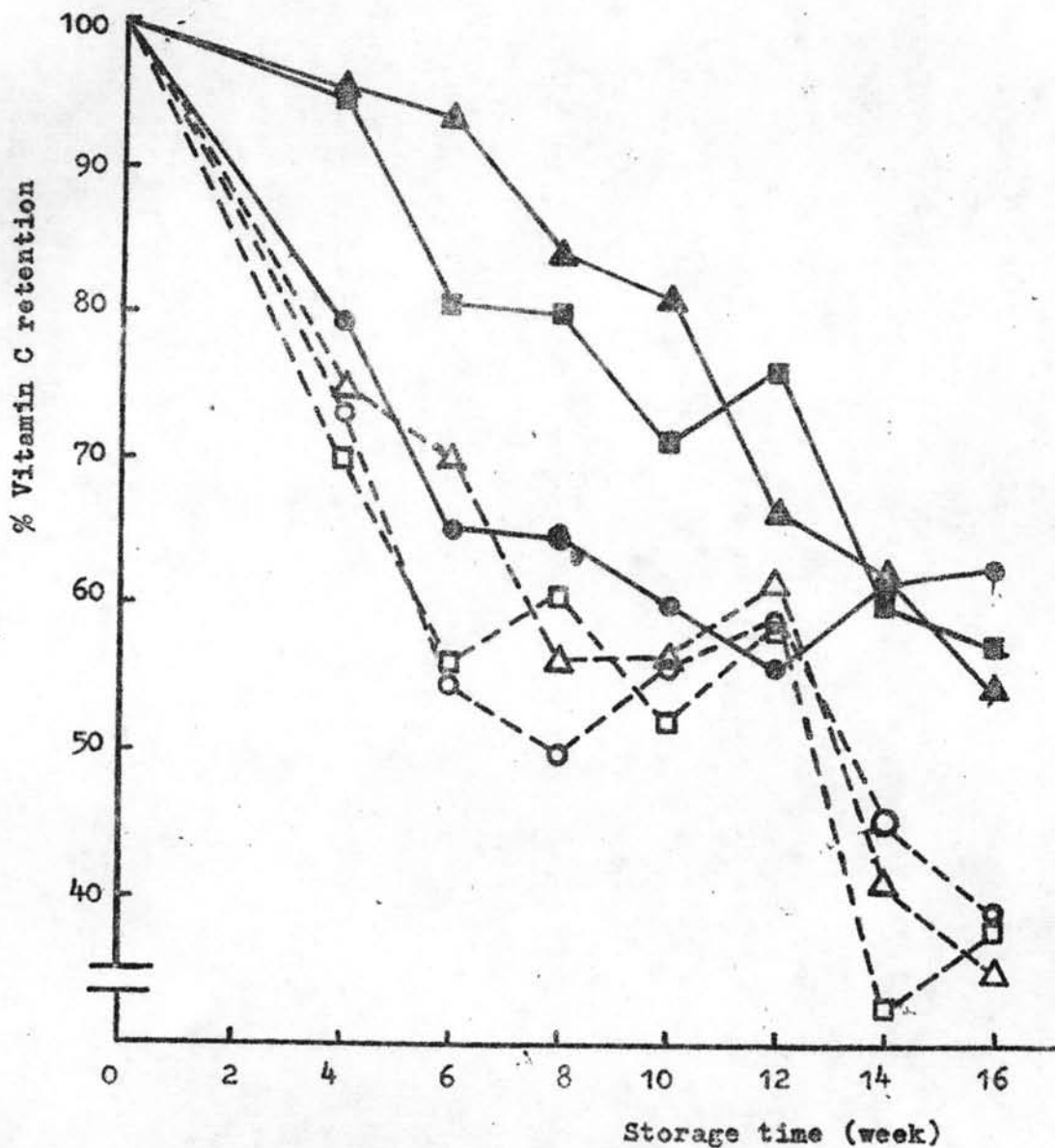


Figure 4 Effect of potassium metabisulfite on Vitamin C retention in full-bottle-lime juice (late season)

- control, ■ 200 ppm, ▲ 300 ppm, at refrigerator temperature.
- control, □ 200 ppm, △ 300 ppm, at room temperature.

of potassium metabisulfite at refrigerator temperature.

Color of all samples stored at refrigerator temperature was still acceptable after the end of the fourth month. At room temperature samples treated with 200, 300 ppm potassium metabisulfite were acceptable at the end of the fourteenth week with a little appearance of browning. But the controlled lime juice at room temperature could be acceptable up to ten weeks only. Finally, all the samples at room temperature were not acceptable and turned to brown color at the end of 4 months of storage time. Sample treated with 200, 300 ppm of potassium metabisulfite had better color than the controlled one. In view of color, browning developed more quickly in samples stored at room temperature than the samples stored at refrigerator temperature.

#### 4.3 Effect of Potassium Sorbate in Full Bottle Sample

The effect of potassium sorbate on limonin in full bottle of preserved lime juice stored at refrigerator and room temperature was investigated. The results obtained were shown in Table 9 that the concentrations of potassium sorbate had no effect on limonin contents in all samples. During the storage test at both temperatures the limonin contents in all samples varied with a tendency of increasing after 4 weeks the limonin contents were nearly constant. Samples treated with 200, 300 ppm of potassium sorbate as well as controlled sample at room temperature had little higher value in limonin content than the sample stored at refrigerator temperature (1-2 ppm). Changes of limonin content in all samples at both tempera-

turs were not significant at whatever concentration of potassium sorbate added. The rate of increasing of limonin content in the samples treated with potassium metabisulfite was more slowly than in the samples treated with potassium sorbate. (Figure 5)

The chemical and physical qualities of all treated lime juice during 4 months of storage at refrigerator temperature and room temperature had been summarized in Tables 10-12. In view of chemical qualities, the pH values of all samples were also 2.4 without any change during the storage test. There was a little variability or no significant change in both °Brix and percentage of acidity in all samples.

The vitamin C retention in all samples during the storage test at room temperature and refrigerator temperature were shown in Figure 6. In all samples at both temperatures percentage vitamin C retention varied irregularly during the storage test with a tendency of decreasing as in the case of potassium metabisulfite. The samples treated with 200, 300 ppm of potassium sorbate at refrigerator temperature retained more ascorbic acid than the sample treated with heat (controlled lime juice). The latter had the worst vitamin C retention compared to others. The treated lime juice with 200, 300 ppm of potassium sorbate retained less ascorbic acid than the lime juice treated with potassium metabisulfite at the same concentration.

Color of all samples stored at refrigerator temperature was still acceptable without significant change with various concentration of potassium sorbate added.

Table 9 Effect of potassium sorbate on limonin content of lime juice during 4 months of storage time.

Week	Limonin content (ppm)					
	A Refrigerator temperature			B Room temperature		
	II <sub>1</sub>	II <sub>3</sub>	II <sub>4</sub>	II <sub>1</sub>	II <sub>3</sub>	II <sub>4</sub>
0	-	-	-	-	-	-
2	13.941	17.181	13.338	15.071	14.581	18.978
4	18.274	17.897	15.260	21.100	21.213	21.138
6	19.593	19.555	19.668	22.042	21.401	21.853
8	19.630	19.027	20.612	21.439	21.703	22.300
10	20.346	19.701	19.202	21.707	19.894	20.045
12	19.802	20.105	19.902	21.100	20.309	21.138
14	20.902	20.623	19.440	21.929	21.853	21.100
16	21.700	21.552	21.103	22.117	21.853	23.059

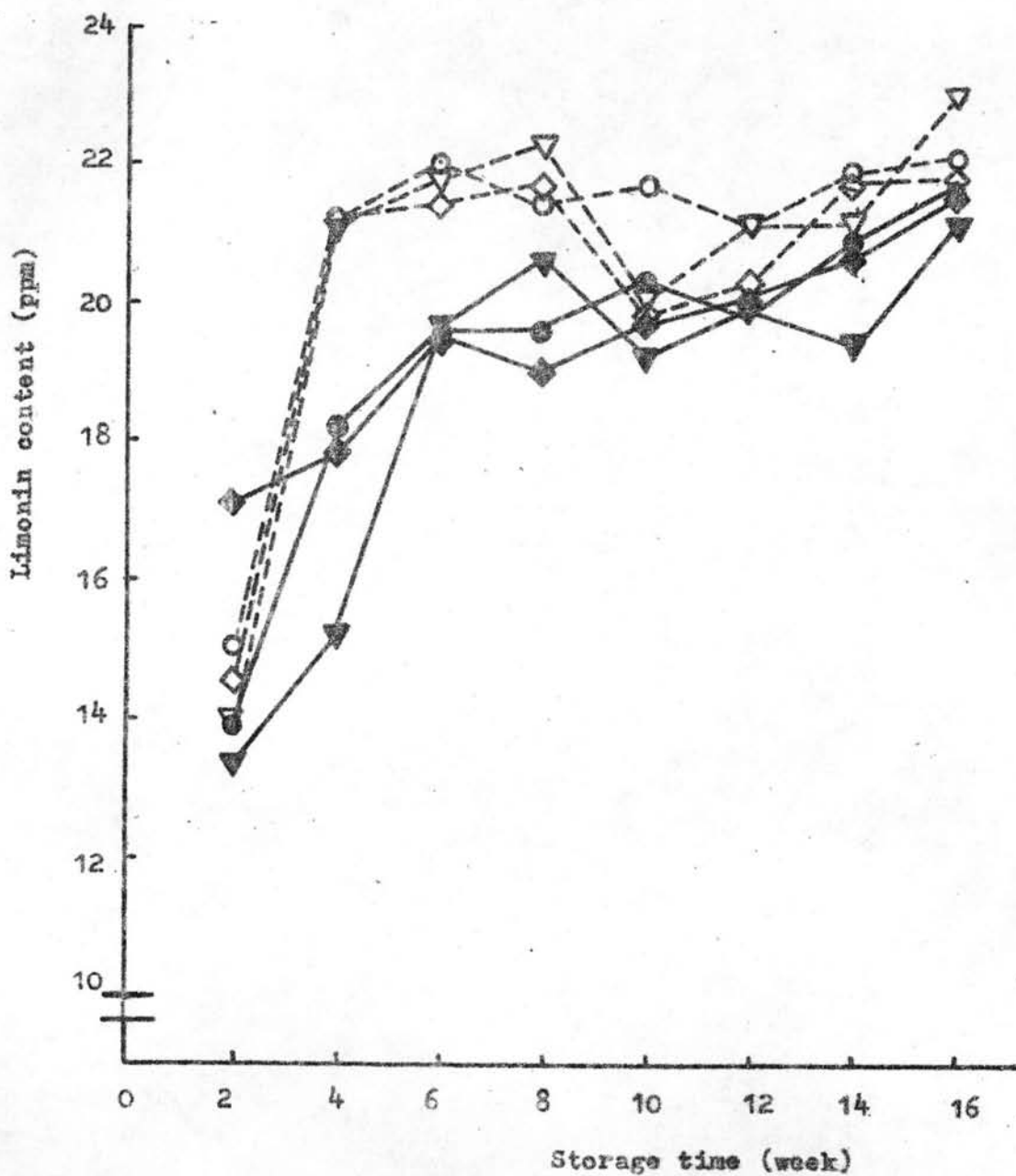


Figure 5 Effect of potassium sorbate on the variation of limonin content with time.

- control, ◆ 200 ppm, ▼ 300 ppm, at refrigerator temperature,
- control, ◇ 200 ppm, ▽ 300 ppm, at room temperature.

Table 10 a Chemical qualities of full-bottle-lime juice (controlled) during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 ml	Vit.C % retention	pH	°Brix	% Acidity
0	32.50	100.00	2.4	8.0	7.09
2	-	-	-	-	-
4	24.74	76.12	2.4	9.5	7.44
6	23.89	73.50	2.4	9.0	7.68
8	19.59	60.28	2.4	8.5	7.51
10	20.55	63.23	2.4	8.6	7.68
12	21.40	65.86	2.4	8.3	7.70
14	15.37	47.28	2.4	8.0	7.47
16	17.87	55.00	2.4	8.0	7.38
B Room Temperature					
0	32.50	100.00	2.4	8.0	7.09
2	-	-	-	-	-
4	24.82	76.37	2.4	9.5	7.58
6	20.70	63.70	2.4	8.4	7.47
8	15.30	47.08	2.4	8.2	7.58
10	16.97	52.21	2.4	8.6	7.72
12	16.97	52.21	2.4	8.4	7.61
14	13.29	40.90	2.4	8.1	7.51
16	11.48	35.32	2.4	8.2	7.61



Table 10 b Physical qualities of full-bottle-lime juice  
(controlled) during 4 months of storage  
time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	40.0	13.0	27.5	7.5	12.0	0
6	39.0	7.5	33.5	8.2	12.8	0
8	39.0	8.0	35.0	7.5	10.5	0
10	36.0	9.0	37.0	7.0	11.0	0
12	37.0	11.0	37.5	6.0	8.5	0
14	37.0	8.0	36.0	8.0	12.0	0
16	38.5	7.5	34.0	7.5	12.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	38.0	13.0	30.0	10.0	9.0	0
6	34.5	11.0	30.5	4.0	20.0	0
8	34.0	10.0	36.0	7.0	14.0	++
10	30.0	9.0	39.5	7.0	14.5	++++
12	28.0	10.5	40.0	6.5	15.0	+++++
14	26.0	10.0	46.0	9.0	9.0	++++++
16	23.0	12.0	44.0	7.5	14.5	++++++

Table 11 a Chemical qualities of full-bottle lime juice treated 200 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refriterator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	34.88	100.00	2.4	8.0	7.45
2	-	-	-	-	-
4	27.39	78.53	2.4	9.0	7.26
6	25.29	72.51	2.4	8.6	7.44
8	19.50	55.91	2.4	8.5	7.44
10	25.63	73.48	2.4	8.8	7.58
12	23.49	67.35	2.4	8.3	7.52
14	22.89	65.62	2.4	8.0	7.40
16	20.93	60.00	2.4	8.0	7.47
B Room Temperature					
0	34.88	100.00	2.4	8.0	7.45
2	-	-	-	-	-
4	25.29	72.50	2.4	9.5	7.39
6	23.04	66.07	2.4	9.0	7.33
8	19.16	54.93	2.4	8.0	7.58
10	15.83	45.39	2.4	8.6	7.47
12	19.39	55.61	2.4	8.4	7.38
14	14.82	42.50	2.4	8.0	7.33
16	13.08	37.50	2.4	8.2	7.37

Table 11 b Physical qualities of full-bottle-lime juice treated with 200 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	38.5	12.5	29.0	10.0	10.0	0
6	39.0	7.5	33.5	8.2	12.8	0
8	39.0	8.0	35.0	7.5	10.5	0
10	36.0	9.0	37.0	7.0	11.0	0
12	37.0	11.0	37.5	6.0	8.5	0
14	37.0	8.0	36.0	8.0	12.0	0
16	38.5	7.5	34.0	7.5	12.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	39.0	15.0	29.0	10.0	7.0	0
6	34.5	11.0	30.5	4.0	20.0	0
8	34.0	10.0	36.0	7.0	14.0	++
10	30.0	9.0	39.0	7.5	14.5	++++
12	30.5	10.5	38.5	6.5	14.0	++++
14	27.0	12.0	45.0	7.0	9.0	+++++
16	23.0	12.0	44.0	7.5	14.5	+++++

Table 12 a Chemical qualities of full-bottle-lime juice treated with 300 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	34.56	100.00	2.4	8.0	7.45
2	-	-	-	-	-
4	29.42	85.12	2.4	8.2	7.31
6	29.89	86.50	2.4	8.2	7.52
8	24.19	70.16	2.4	8.6	7.42
10	21.26	61.52	2.4	8.5	7.43
12	23.87	69.07	2.4	8.2	7.47
14	22.65	65.53	2.4	8.0	7.54
16	21.20	60.78	2.4	8.2	7.40
B Room Temperature					
0	34.56	100.00	2.4	8.0	7.45
2	-	-	-	-	-
4	23.84	68.99	2.4	9.5	7.44
6	22.11	63.97	2.4	9.0	7.30
8	17.39	50.32	2.4	8.2	7.44
10	17.61	50.96	2.4	8.6	7.68
12	15.68	45.37	2.4	8.4	7.49
14	6.28	18.10	2.4	8.0	7.36
16	11.94	34.50	2.4	8.2	7.44

Table 12 b Physical qualities of full-bottle-lime juice treated with 300 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	39.0	11.5	29.5	10.0	10.0	0
6	39.0	7.5	33.5	8.2	12.8	0
8	39.0	8.0	35.0	7.5	10.5	0
10	36.0	9.0	37.0	7.0	11.0	0
12	37.0	11.0	37.5	6.0	8.5	0
14	37.0	8.0	36.0	8.0	12.5	0
16	38.5	7.5	34.0	7.5	12.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	-	-	-	-	-	-
4	38.5	15.5	30.0	9.0	7.0	0
6	33.0	11.0	31.5	4.5	20.0	0
8	34.0	10.0	36.0	7.0	14.0	++
10	30.0	9.0	39.0	7.5	14.5	++++
12	30.5	10.5	38.5	6.5	14.0	++++
14	27.0	12.0	44.0	8.5	8.5	+++++
16	23.0	12.0	44.0	7.5	14.5	+++++

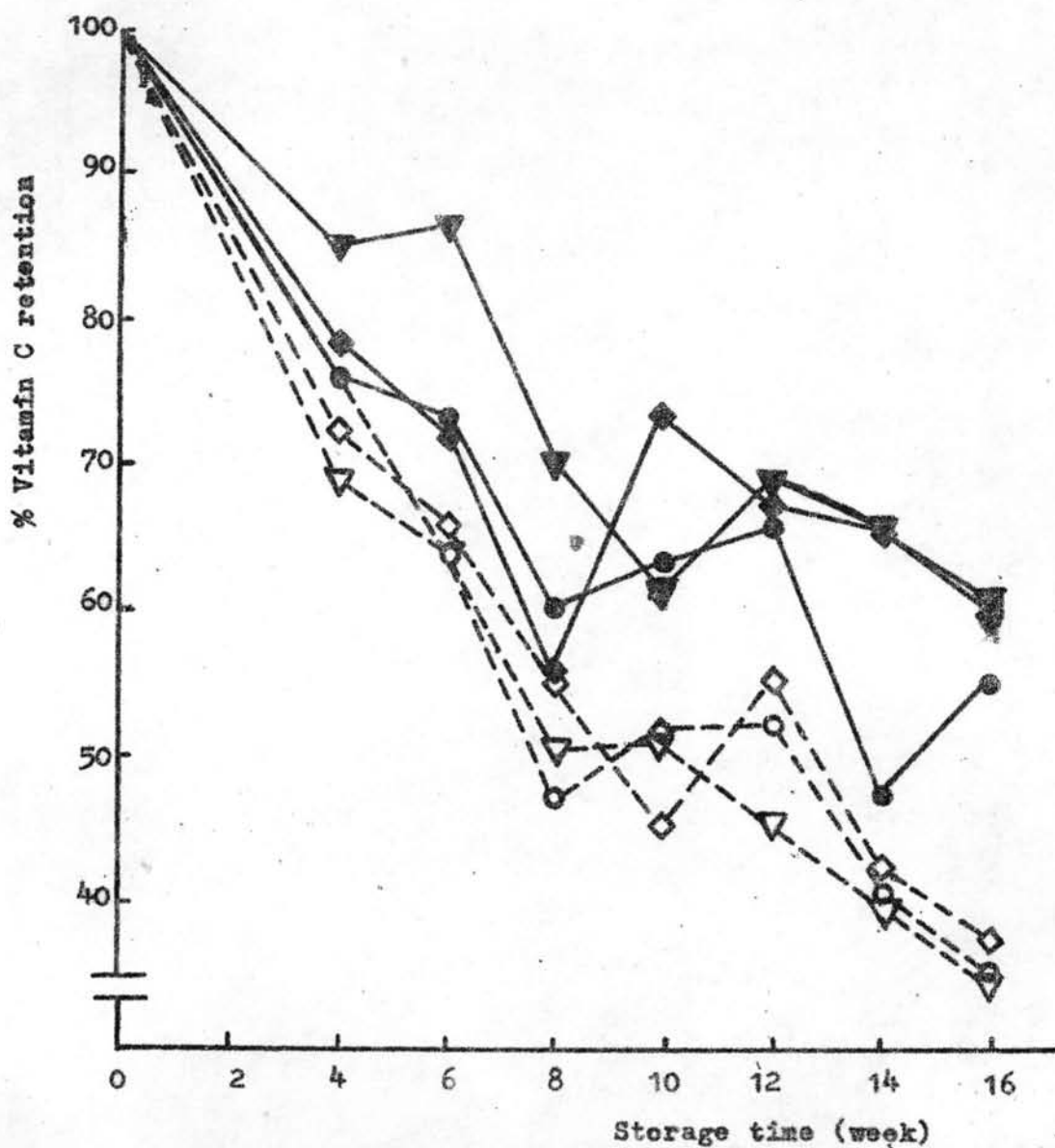


Figure 6 Effect of potassium sorbate on vitamin C retention in full-bottle-lime juice

● control, ◆ 200 ppm, ▼ 300 ppm, at refrigerator temperature

○ control, ◇ 200 ppm, ▽ 300 ppm, at room temperature.

At room temperature all samples were still acceptable after 3 months of storage, but at the end of four months, all samples developed browning and became unacceptable.

#### 4.4 Effect of Incorporated Air

##### 4.4.1 Effect of Potassium Metabisulfite and Potassium Sorbate

The effect of incorporated air of preserved lime juice treated with 200, 300 ppm of potassium metabisulfite, 200, 300 ppm of potassium sorbate at refrigerator and room temperature was studied. It was found that all treated samples at refrigerator temperature had a light brown color, still acceptable at the end of the fourth month, whilst at room temperature all treated samples were still acceptable up to one month only. Browning developed more quickly at high temperature. At the end of the third month all treated samples turned to deep brown color.

The chemical and physical qualities of all treated samples during 4 months of storage at both temperatures had been summarized in Tables 13-17. In view of chemical qualities the pH values of all samples in this experiment were constant at 2.4. It is evident that °Brix of all samples had a little variable °Brix between 8.4-9.0 and percentage of acidity of lime juice had also a little variable change in the range of 7-8 percent of citric acid.

The vitamin C retention in all samples during the storage test at room temperature and refrigerator temperature were presented in Figure 7. Vitamin C retention in treated lime juice at refrigerator

temperature gradually decreased during 6 weeks after that it remained constant (2-4 %). Samples treated with 200, 300 ppm of potassium metabisulfite had higher vitamin C retention than the others. Lime juice treated with 300 ppm of potassium metabisulfite had the lowest tendency of decreasing in vitamin C during the first 8 weeks, after that vitamin content remained constant. Lime juice treated with 200, 300 ppm of potassium sorbate had similar rate of decreasing in vitamin C as the controlled lime juice.

It is evident that the loss of vitamin C at room temperature was greater than at refrigerator temperature. At the end of the second week vitamin C retention was about 30-40 % in samples kept at room temperature. The vitamin C retention in all treated samples at room temperature dropped to half of the value of that retained at refrigerator temperature during the first two weeks.

Incorporated air enhances the rates of vitamin C destruction. Percent vitamin C retention decreased very quickly to the value below 5%. The decreasing of vitamin C was very great compared to samples stored for four months at room and refrigerator temperatures without any incorporated air.

During the storage test the qualities of the treated samples at refrigerator temperature were better than the sample stored at room temperature. It is due to the fact that high storage temperature would accelerate the loss of sulfite by reduction to sulfate and also accelerate reaction of sulfite with some of constituents of fruit, notably aldehydes, ketones and sugar, to form compound lacking in preserving power (Agr. Handbook No. 98, 1962).





Table 13 a Chemical qualities of half-bottle-lime juice during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	25.66	100.00	2.4	8.50	7.43
2	15.33	59.40	2.4	8.65	7.49
4	9.86	38.40	2.4	8.60	7.56
6	0.87	3.39	2.4	8.60	7.84
8	1.04	4.04	2.4	8.60	7.62
10	1.04	4.04	2.4	8.40	7.24
12	0.85	3.29	2.4	8.80	7.58
14	0.78	3.04	2.4	8.50	7.19
16	0.77	2.99	2.4	8.80	7.19
B Room Temperature					
0	22.13	100.00	2.4	8.5	7.53
2	7.11	32.13	2.4	8.5	7.40
4	1.11	5.00	2.4	8.5	7.56
6	0.87	3.93	2.4	8.7	7.71
8	1.04	4.68	2.4	8.4	7.53
10	0.76	3.44	2.4	8.5	7.21
12	0.75	3.37	2.4	8.8	7.24
14	0.72	3.24	2.4	8.5	7.27
16	0.77	3.47	2.4	8.8	7.24

Table 13 b Physical qualities of half-bottle lime juice during 4 months of storage time.  
(early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.5	33.5	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	36.5	12.0	33.0	8.5	10.0	0
6	34.0	12.5	39.5	7.0	8.0	0
8	33.0	9.5	41.0	8.5	8.0	+
10	29.5	9.0	45.5	9.0	7.0	+++
12	31.0	7.0	44.5	9.0	6.5	++++
14	32.0	11.0	38.0	8.0	11.0	++++
16	28.0	12.5	39.0	5.0	14.5	++++
B Room Temperature						
0	41.0	10.5	33.5	6.5	8.5	0
2	31.0	8.0	44.0	8.0	9.0	0
4	29.0	10.5	43.0	7.0	10.5	++
6	8.0	32.5	45.5	4.0	10.0	+++++
8	6.0	36.0	44.0	4.0	10.0	++++++
10	3.0	44.0	46.0	3.0	4.0	+++++++
12	-	-	-	-	-	+++++++
14	-	-	-	-	-	+++++++
16	-	-	-	-	-	+++++++

Table 14 a Chemical qualities of half-bottle lime juice treated with 200 ppm of potassium metabisulfite during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	32.65	100.00	2.4	8.56	7.55
2	28.22	86.44	2.4	8.50	7.46
4	10.65	32.63	2.4	8.60	7.62
6	1.16	3.55	2.4	8.60	7.66
8	1.18	3.63	2.4	8.60	7.56
10	1.04	4.04	2.4	8.40	7.24
12	0.72	2.19	2.4	8.70	7.28
14	0.91	2.79	2.4	8.60	7.19
16	0.77	2.36	2.4	8.70	7.19
B Room Temperature					
0	26.69	100.00	2.4	8.50	7.60
2	12.22	45.79	2.4	8.50	7.33
4	0.92	3.44	2.4	8.50	7.58
6	0.87	3.25	2.4	8.50	7.69
8	0.74	2.77	2.4	8.40	7.53
10	0.83	3.11	2.4	8.40	7.24
12	0.81	3.04	2.4	8.50	7.24
14	0.78	2.93	2.4	8.60	7.24
16	0.77	2.88	2.4	8.50	7.26

Table 14b Physical qualities of half-bottle-lime juice  
treated with 200 ppm of potassium metabisulfite  
during 4 months of storage time.  
(early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	36.5	12.0	33.0	8.5	10.0	0
6	37.5	11.0	40.0	8.5	9.0	+
8	33.0	9.5	41.0	6.5	8.0	+
10	29.5	9.0	45.5	9.0	7.0	+++
12	31.0	7.0	44.5	9.0	6.5	++++
14	32.0	11.0	38.0	8.0	11.0	++++
16	28.0	12.5	39.0	5.0	14.5	++++
B Room Temperature						
0	41.0	10.8	33.2	6.5	8.5	0
2	31.0	8.0	44.0	8.0	9.0	0
4	26.5	12.0	42.5	6.5	12.5	+++
6	8.0	32.5	45.5	4.0	10.0	+++++
8	6.0	36.0	44.0	4.0	10.0	++++++
10	3.0	44.0	46.0	3.0	4.0	+++++++
12	-	-	-	-	-	+++++++
14	-	-	-	-	-	+++++++
16	-	-	-	-	-	+++++++

Table 15 a Chemical qualities of half-bottle-lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (early season)

A. Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	32.94	100.00	2.4	8.88	7.82
2	31.04	94.22	2.4	8.90	7.91
4	30.36	92.17	2.4	8.90	7.91
6	11.59	35.19	2.4	8.60	8.02
8	1.18	3.60	2.4	8.60	8.04
10	4.02	12.19	2.4	8.90	7.53
12	0.78	2.37	2.4	8.90	7.72
14	0.78	2.37	2.4	8.90	7.56
16	0.77	2.33	2.4	8.90	7.59
B Room Temperature					
0	31.54	100.00	2.4	8.88	7.96
2	12.22	38.74	2.4	8.90	7.84
4	6.47	20.51	2.4	9.00	7.97
6	1.01	3.21	2.4	9.00	8.15
8	1.04	3.29	2.4	8.60	7.76
10	1.18	3.73	2.4	9.00	7.58
12	0.65	2.06	2.4	9.10	7.73
14	0.91	2.89	2.4	9.00	7.70
16	0.71	2.44	2.4	8.90	7.86

Table 15 b Physical qualities of half-bottle-lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	8.5	0
4	36.5	12.0	33.0	8.5	10.0	0
6	36.5	13.0	36.0	6.5	8.0	0
8	33.0	9.5	41.0	8.5	8.0	+
10	29.5	9.0	45.5	9.0	7.0	+++
12	31.0	7.0	44.0	9.0	6.5	++++
14	32.0	11.0	38.0	8.0	11.0	++++
16	28.0	12.5	39.0	5.0	14.5	++++
B Room Temperature						
0	41.0	10.8	33.2	6.5	8.5	0
2	31.0	8.0	44.0	8.0	9.0	0
4	29.0	10.5	43.0	7.0	10.5	++
6	8.0	32.5	45.5	4.0	10.0	+++++
8	6.0	36.0	44.0	4.0	10.0	+++++
10	3.0	44.0	46.0	3.0	4.0	+++++
12	-	-	-	-	-	+++++
14	-	-	-	-	-	+++++
16	-	-	-	-	-	+++++

Table 15 a Chemical qualities of half-bottle lime juice treated with 200 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % Retention	pH	°Brix	% Acidity
0	28.97	100.00	2.4	8.5	7.78
2	17.70	61.11	2.4	9.0	7.72
4	7.83	27.01	2.4	8.75	7.80
6	1.45	5.00	2.4	8.60	7.91
8	1.04	3.58	2.4	8.70	8.03
10	1.04	3.58	2.4	9.00	7.49
12	0.72	2.47	2.4	8.80	7.54
14	0.78	2.70	2.4	9.0	7.53
16	0.77	2.65	2.4	8.8	7.53
B Room Temperature					
0	26.98	100.00	2.4	8.5	7.70
27	8.59	31.84	2.4	8.8	7.74
4	1.30	4.83	2.4	8.7	7.83
6	0.87	3.22	2.4	9.0	7.21
8	0.89	3.29	2.4	9.0	7.76
10	0.69	2.56	2.4	9.0	7.53
127	0.84	3.13	2.4	9.0	7.71
14	0.78	2.89	2.4	8.8	7.56
16	0.77	2.85	2.4	9.0	7.56

Table 16 b Physical qualities of half-bottle-lime juice treated with 200 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	36.5	12.0	33.0	8.5	10.0	0
6	36.5	13.0	36.0	6.5	8.0	0
8	33.0	9.5	41.0	8.5	8.0	+
10	29.5	9.0	45.5	9.0	7.0	+++
12	32.0	7.0	44.5	9.0	6.5	++++
14	32.0	11.0	38.0	8.0	11.0	++++
16	28.0	12.5	39.0	5.0	14.5	++++
B Room Temperature						
0	41.0	10.8	33.2	6.5	8.5	0
2	34.0	10.0	38.5	7.0	9.5	0
4	36.5	12.0	33.0	8.5	10.0	0
6	8.0	32.5	45.5	4.0	10.0	+++++
8	6.0	36.0	44.0	4.0	10.0	+++++
10	3.0	44.0	46.0	3.0	4.0	+++++
12	-	-	-	-	-	+++++
14	-	-	-	-	-	+++++
16	-	-	-	-	-	+++++



Table 17 a Chemical qualities of half-bottle-lime juice treated with 300 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	29.85	100.00	2.4	8.5	7.80
2	17.48	58.56	2.4	8.8	7.63
4	7.39	24.76	2.4	8.6	7.80
6	1.59	5.34	2.4	8.6	7.91
8	0.74	2.48	2.4	8.6	7.95
10	0.83	2.78	2.4	8.8	7.48
12	0.91	3.05	2.4	8.7	7.58
14	0.91	3.06	2.4	8.8	7.56
16	0.77	2.58	2.4	8.7	7.53
B Room Temperature					
0	25.66	100.00	2.4	8.65	7.86
2	7.18	27.99	2.4	8.88	8.02
4	0.87	3.39	2.4	8.60	8.06
6	1.01	3.35	2.4	9.00	8.31
8	1.18	4.62	2.4	9.00	8.00
10	0.76	2.96	2.4	9.20	7.49
12	0.84	3.29	2.4	9.0	7.46
14	0.78	3.04	2.4	8.9	7.59
16	0.77	3.00	2.4	9.0	7.59

Table 17 b Physical qualities of half-bottle-lime juice treated with 300 ppm of potassium sorbate during 4 months of storage time. (early season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	10.8	33.2	6.5	8.5	0
2	40.0	10.5	32.5	7.5	9.5	0
4	36.5	12.0	33.0	8.5	10.0	0
6	36.5	13.0	36.0	6.5	8.0	0
8	33.0	9.5	41.0	8.5	8.0	+
10	29.5	9.0	45.5	9.0	7.0	+++
12	32.5	7.0	44.5	9.0	6.5	++++
14	32.0	11.0	38.0	8.0	11.0	++++
16	28.0	12.5	39.0	5.0	14.5	++++
B Room Temperature						
0	41.0	10.8	33.2	6.5	8.5	0
2	34.0	10.0	38.5	7.0	9.5	0
4	36.5	12.0	33.0	8.5	10.0	0
6	8.0	32.5	45.5	4.0	10.0	+++++
8	6.0	36.0	44.0	4.0	10.0	+++++
10	3.0	44.0	46.0	3.0	4.0	+++++
12	-	-	-	-	-	+++++
14	-	-	-	-	-	+++++
16	-	-	-	-	-	+++++

Physical and chemical qualities of full bottle lime juice and half-bottle lime juice treated with 200 ppm of potassium metabisulfite were indicated in Tables 4, 7, 14, 19 and Figure 9. The result was that all treated samples at refrigerator temperature were still acceptable, but the color of light brown were present in the half-bottle-lime juice treated with 200 ppm of potassium metabisulfite at the end of 4 months of storage thus, the incorporated air enhanced the browning development. The vitamin C retention in the half-bottle-lime juice decreased very rapidly during the first 2 months down to 3-4% while the full bottle lime juice had retained more vitamin C, about 53-57% even at the end of the fourth month of storage. After four weeks the lime juice with incorporated air had no nutrition value in term of vitamin C any more. However the physical qualities were still acceptable.

Physical and chemical qualities of full-bottle-lime juice and half-bottle-lime juice treated with 300 ppm of potassium metabisulfite had been summarized in Tables 5, 8, 15, 20. The result was that all samples at refrigerator temperature were acceptable in view of color at the end of the fourth month of storage. In view of vitamin C, the full-bottle-lime juice retained most vitamin C during storage test (54.29-65.83 %) at refrigerator temperature. The half-bottle-lime juice with incorporated air had vitamin C retention with a tendency of decreasing (Figure 10). At the end of the eighth week vitamin C retention dropped rapidly then remained constant. Hence storage at refrigerator temperature was no use once the air was incorporated in the juice.

Physical and chemical qualities of full-bottle lime juice and half-bottle lime juice treated with 200 ppm of potassium sorbate had been summarized in Tables 11, 16, 22 and Figure 11. The result was that at refrigerator temperature all samples were still acceptable in terms of color and appearance but vitamin C retention was different. Samples in full bottle had vitamin C retention (60%) greater than the half-bottle-lime juice at the end of the fourth month. The half-bottle-lime juice had vitamin C retention of 27.01% at the end of the fourth week.

Physical and chemical qualities of full-bottle-lime juice treated with 300 ppm of potassium sorbate at refrigerator temperature has been summarized in Tables 12, 17, 23 and Figure 12. The result was that all samples were acceptable in terms of color and appearance. The vitamin C destruction in the half-bottle lime juice treated with 200, 300 ppm of potassium sorbate were nearly the same with 27.01 and 24.76% at the end of the fourth week, after that the vitamin C retention remained at 2-4% until the end of the fourth month. Treated sample with 300 ppm of potassium sorbate in full bottle had better vitamin C retention (60.78%). Incorporated air had the effect on vitamin C retention and browning development. Potassium sorbate cannot prevent the loss of vitamin C.

Physical and chemical qualities of full bottle lime juice and half-bottle lime juice treated with heat (controlled) are summarized in Tables 3, 6, 10, 13, 21 and Figure 8. The result was that at refrigerator temperature the vitamin C retention in half-bottle sample with incorporated air had a great tendency of

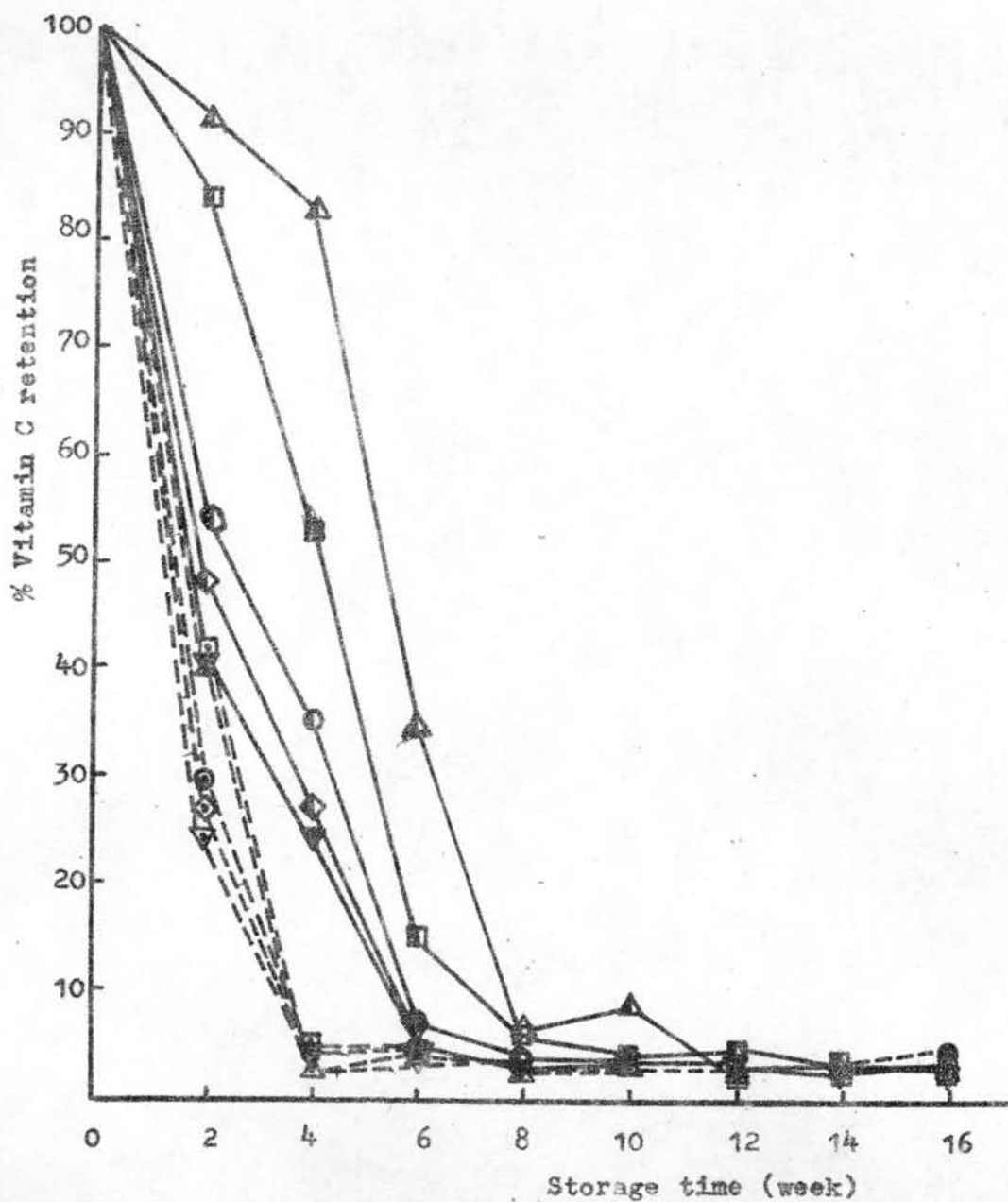


Figure 7 Effect of food additive on average vitamin C retention in half-bottle-lime juice

○ control, ■ 200 ppm, ▲ 300 ppm of potassium metabisulfite,  
 ◆ 200 ppm, ▼ 300 ppm of potassium sorbate at refrigerator temperature.

○ control, ■ 200 ppm, ▲ 300 ppm of potassium metabisulfite,  
 ◆ 200 ppm, ▼ 300 ppm of potassium sorbate at room temperature.

— at refrigerator temperature, --- at room temperature

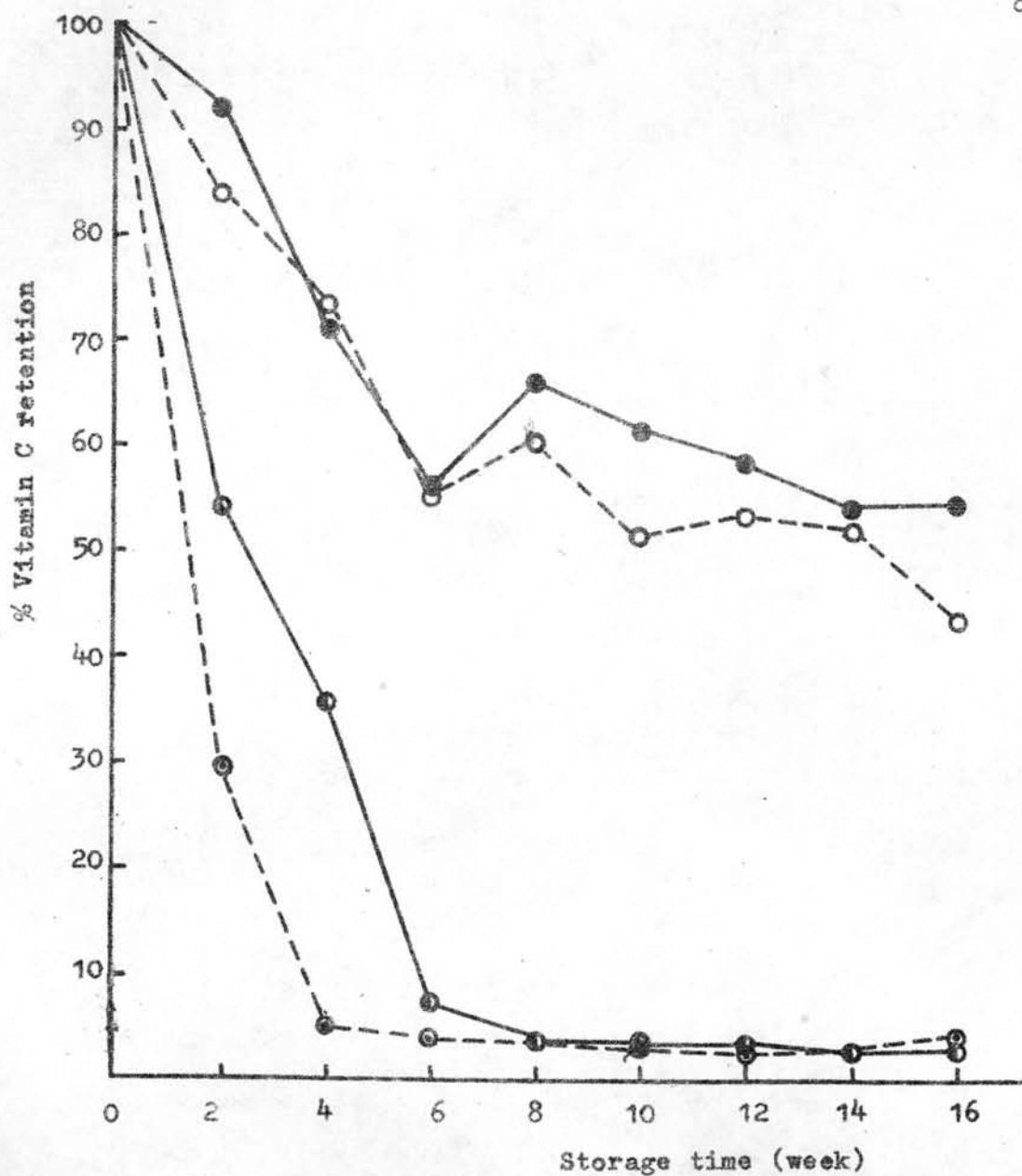


Figure 8 Percentage of vitamin C retention in half and full-bottle-lime juice (control)

- full, ○ half at refrigerator temperature,
- full, ● half at room temperature.

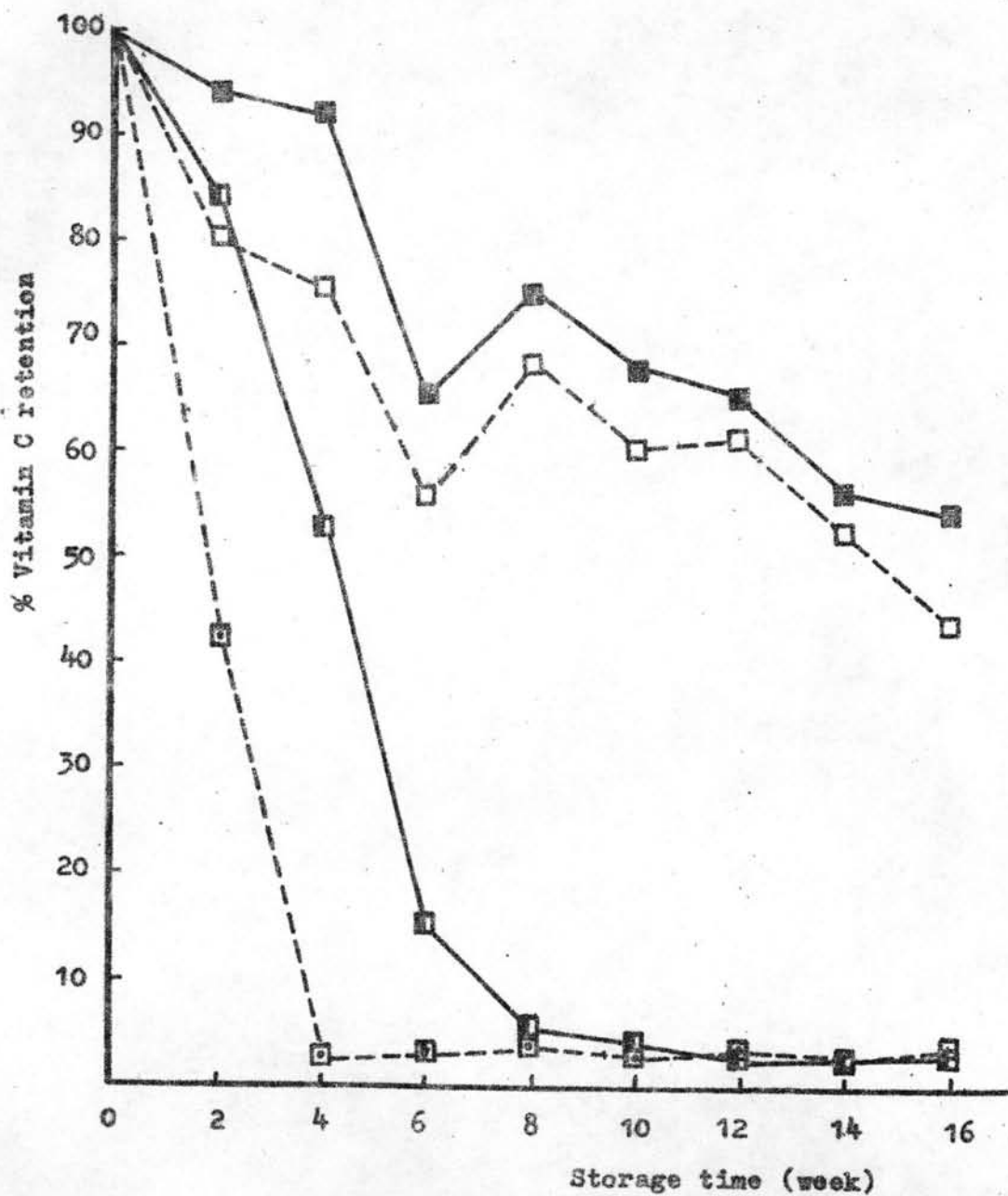


Figure 9 Effect of 200 ppm of potassium metabisulfite on vitamin C retention in half- and full-bottle-line juice

■ full, □ half at refrigerator temperature,

■ full, □ half at room temperature.

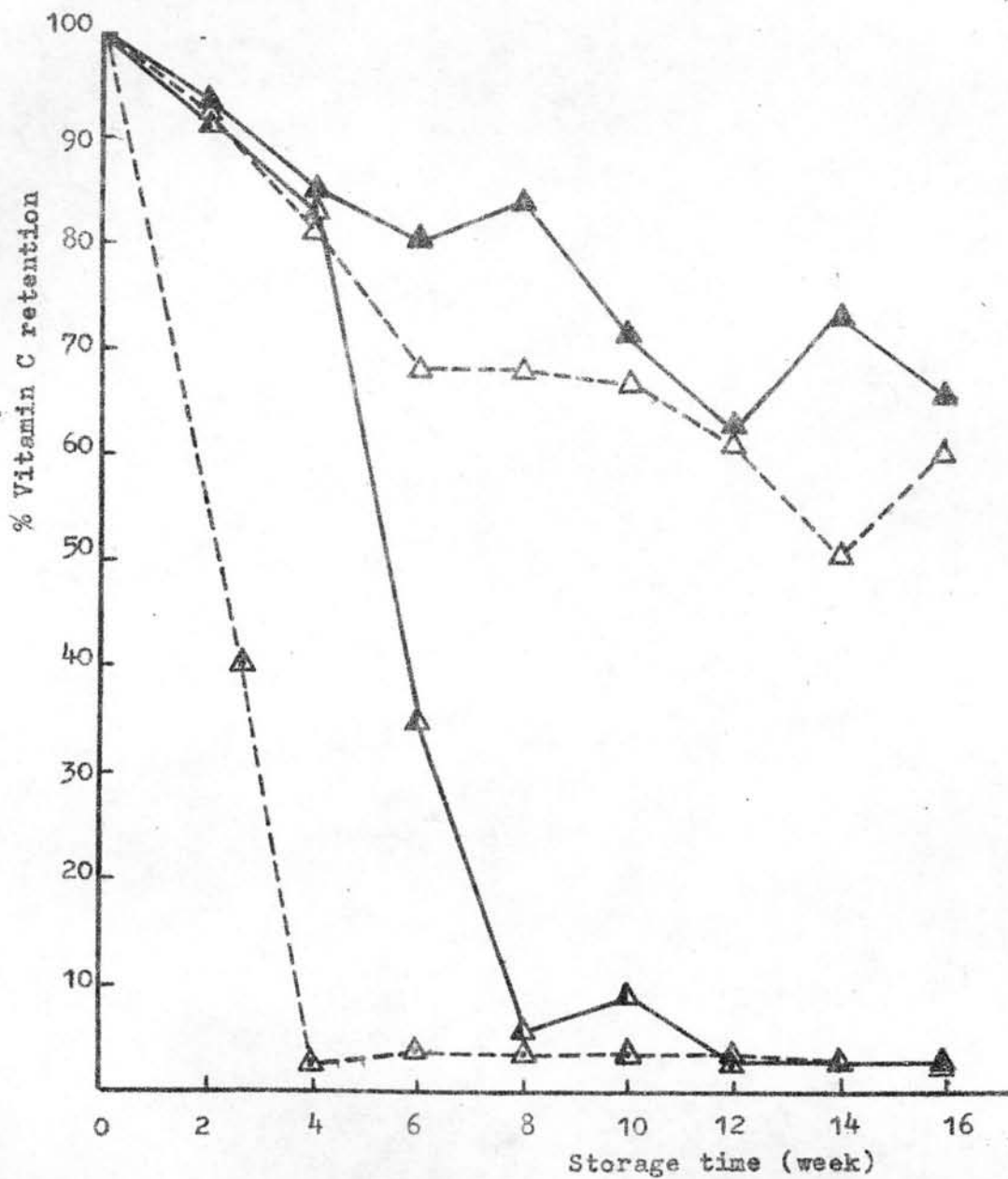


Figure 10 Effect of 300 ppm of potassium metabisulfite on vitamin C retention in half and full-bottle-line juice

▲ full, ▲ half at refrigerator temperature,  
 △ full, △ half at room temperature.



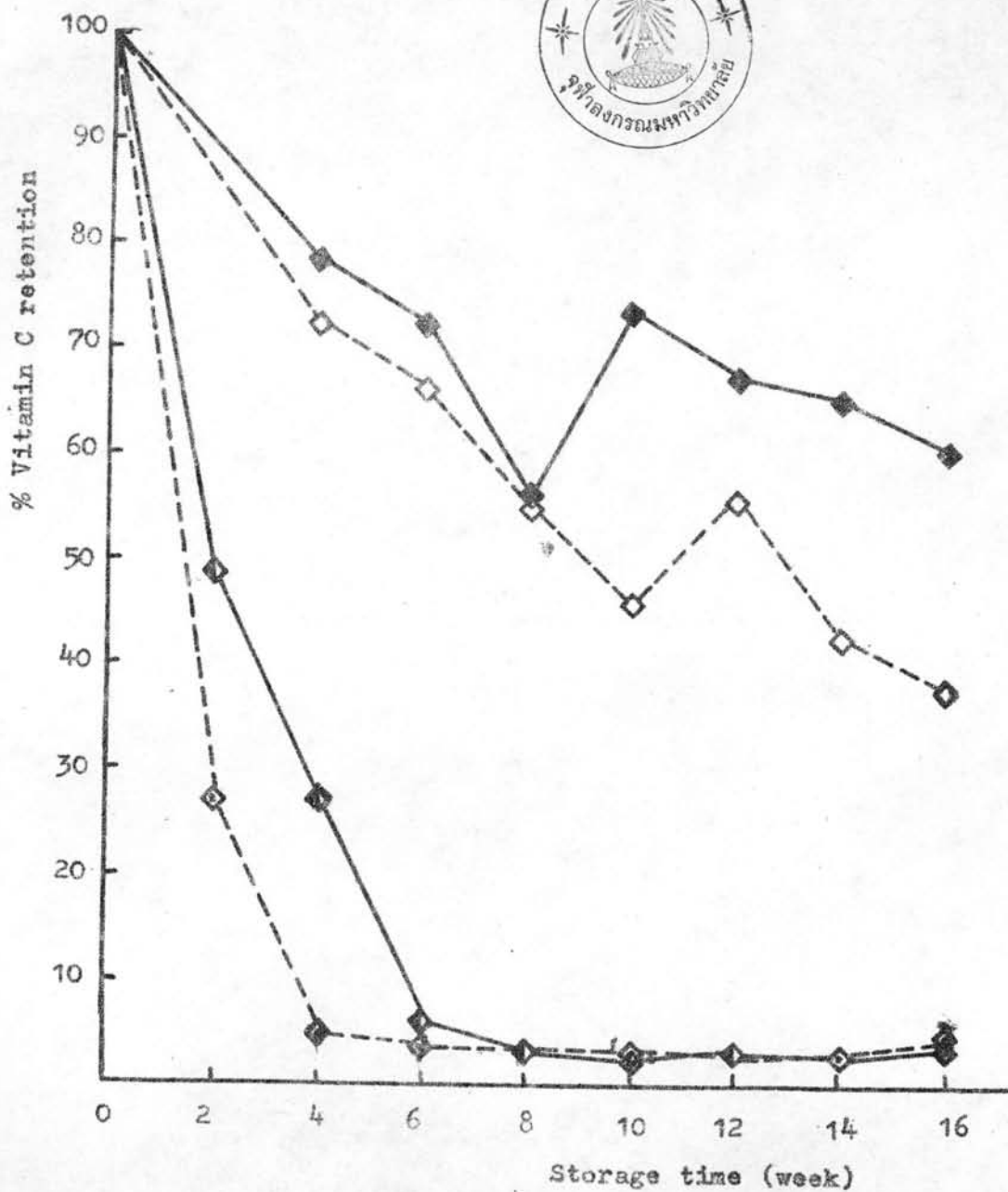


Figure 11 Effect of 200 ppm of potassium sorbate on vitamin C retention in half and full-bottle-lime juice

- ◆ full, ◆ half at refrigerator temperature,
- ◇ full, ◇ half at room temperature.

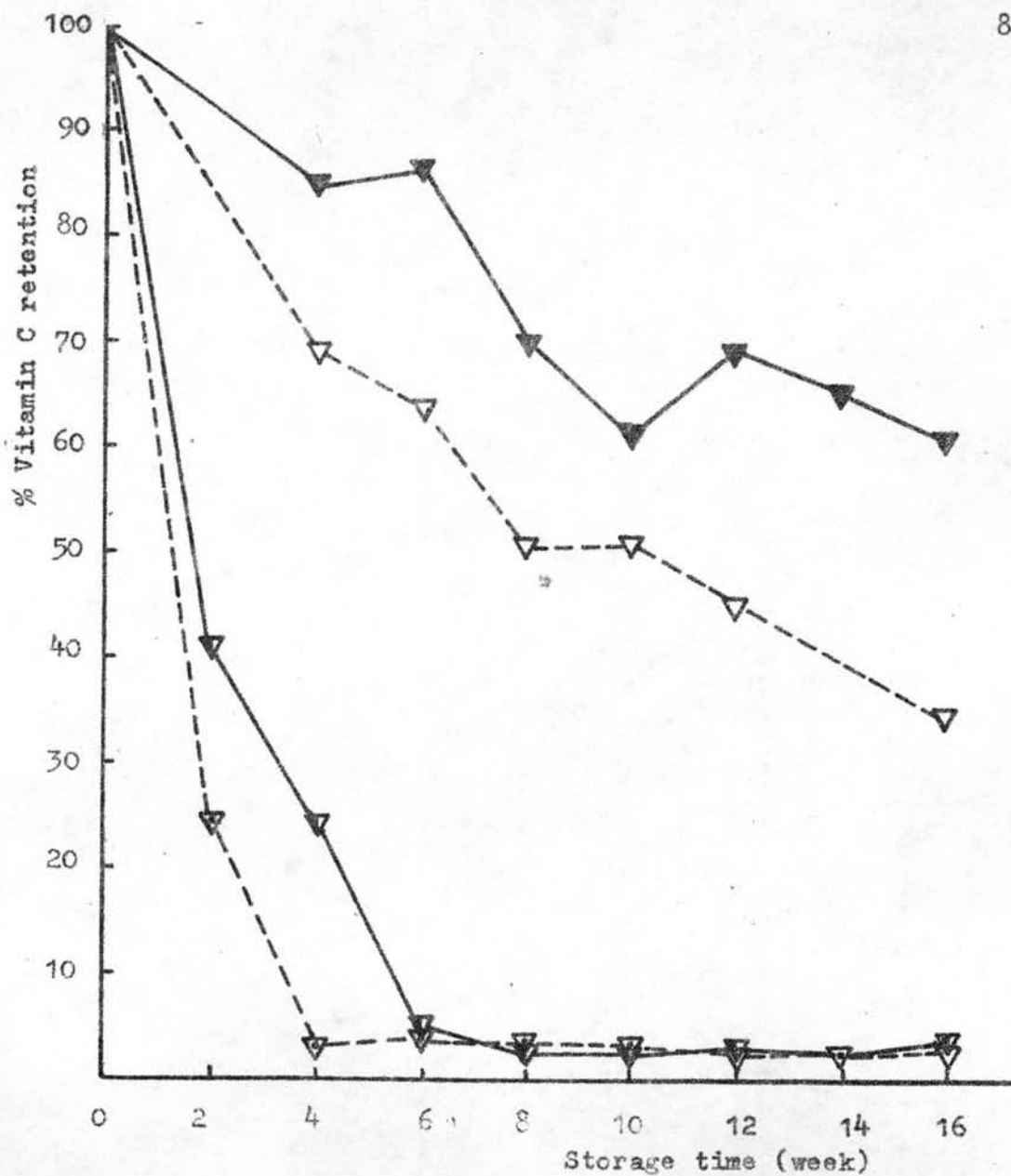


Figure 12. Effect of 300 ppm of potassium sorbate on vitamin C retention in half and full-bottle lime juice.

- ▼ full, ▽ half at refrigerator temperature,
- ▼ full, ▽ half at room temperature.

Table 18 a Chemical qualities of half-bottle lime juice (controlled) during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	32.50	100.00	2.4	8.0	7.09
2	16.09	49.50	2.4	9.0	7.08
4	4.09	12.57	2.4	9.0	7.95
6	2.13	6.54	2.4	9.6	8.07
8	1.53	4.71	2.4	8.8	7.16
10	1.53	4.71	2.4	8.2	7.16
12	1.17	3.60	2.4	8.8	7.73
14	0.99	3.05	2.4	8.5	8.15
168	1.53	4.71	2.4	8.6	8.26
B Room Temperature					
0	32.50	100.00	2.4	8.0	7.09
2	9.13	28.10	2.4	9.0	7.51
4	0.61	1.87	2.4	9.0	7.08
6	1.19	3.66	2.4	9.1	7.53
8	1.19	3.66	2.4	8.5	7.05
10	1.44	4.43	2.4	8.2	7.33
12	1.00	3.09	2.4	8.8	7.79
14	0.99	3.05	2.4	8.0	7.36
16	1.05	3.24	2.4	8.0	7.34

Table 18 b Physical qualities of half-bottle-lime juice (controlled) during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	41.0	15.0	28.6	6.0	10.4	0
4	39.5	8.0	33.5	10.5	8.5	0
6	35.5	11.0	27.0	7.5	19.0	0
8	38.0	9.5	34.0	10.0	8.5	0
10	38.0	12.0	32.0	6.0	12.0	0
12	38.0	10.0	34.5	6.0	11.5	0
14	33.5	9.5	39.0	7.0	11.0	++++
16	32.0	11.0	38.0	8.0	11.0	++++
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	34.0	10.0	36.0	7.0	13.0	++
4	36.5	13.5	28.0	7.5	14.5	+
6	20.0	19.5	28.5	5.0	27.0	++++++
8	19.0	15.0	35.0	7.5	23.5	++++++
10	-	-	-	-	-	+++++++
12	-	-	-	-	-	+++++++
14	-	-	-	-	-	+++++++
16	-	-	-	-	-	+++++++

Table 19 a Chemical qualities of half-bottle lime juice treated with 200 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	35.77	100.00	2.4	8.0	7.42
2	29.56	82.64	2.4	9.0	7.51
4	26.35	73.65	2.4	9.0	7.06
6	9.53	26.64	2.4	9.0	7.35
8	2.81	7.85	2.4	8.8	7.51
10	1.45	4.04	2.4	8.2	7.26
12	2.61	7.31	2.4	8.8	7.73
14	0.99	2.77	2.4	8.2	7.61
16	1.15	3.21	2.4	8.4	7.58
B Room Temperature					
0	35.77	100.00	2.4	8.0	7.42
2	13.78	38.50	2.4	9.0	7.48
4	0.52	1.46	2.4	9.0	7.06
6	1.19	3.33	2.4	9.0	7.38
8	1.45	4.04	2.4	8.5	7.37
10	0.94	2.62	2.4	8.2	7.24
12	1.26	3.51	2.4	8.8	7.92
14	0.99	2.77	2.4	8.2	7.43
16	1.15	3.21	2.4	8.0	7.34

Table 19<sup>b</sup> Physical qualities of half-bottle-lime juice treated with 200 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	41.0	15.0	28.5	5.5	11.0	0
4	39.0	8.5	33.0	11.0	8.5	0
6	40.5	10.5	27.0	7.0	15.0	0
8	37.0	9.5	35.8	10.0	8.5	0
10	38.0	12.0	32.0	6.0	12.0	0
12	29.0	12.0	39.0	7.5	12.5	++
14	27.0	13.0	38.0	16.0	6.0	++++
16	32.0	11.0	38.0	8.0	11.0	++++
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	36.0	10.0	32.0	8.0	11.0	++
4	34.5	15.5	22.0	3.5	24.5	+
6	16.0	25.0	24.5	7.0	29.5	++++++
8	7.0	29.0	44.0	3.0	17.0	++++++
10	-	-	-	-	-	++++++
12	-	-	-	-	-	++++++
14	-	-	-	-	-	++++++
16	-	-	-	-	-	++++++

Table 20 a Chemical qualities of half-bottle lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	34.24	100.00	2.4	8.0	7.45
2	30.61	89.39	2.4	9.0	7.51
4	25.39	74.15	2.4	9.0	7.16
6	11.98	35.00	2.4	8.45	7.65
8	3.23	9.44	2.4	8.50	7.76
10	1.77	5.17	2.4	8.20	7.49
12	1.00	2.93	2.4	8.00	7.11
14	0.99	2.89	2.4	8.20	7.81
16	1.24	3.63	2.4	8.40	7.76
B Room Temperature					
0	34.24	100.00	2.4	8.0	7.45
2	14.09	41.14	2.4	9.0	7.39
4	0.87	2.45	2.4	9.0	7.22
6	1.62	4.72	2.4	9.2	7.85
8	1.19	3.48	2.4	8.5	7.54
10	1.19	3.48	2.4	8.2	7.39
12	1.17	3.42	2.4	8.8	7.99
14	0.66	1.93	2.4	8.2	7.63
16	1.15	3.35	2.4	8.2	7.34

Table 20b Physical qualities of half-bottle-lime juice treated with 300 ppm of potassium metabisulfite during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	41.0	15.0	28.5	5.5	11.0	0
4	39.0	8.5	33.0	11.0	8.5	0
6	40.5	9.5	32.5	8.0	9.0	0
8	37.0	9.5	35.8	10.0	8.5	0
10	38.0	12.0	32.0	6.0	12.0	+
12	38.0	10.0	34.5	6.0	11.5	0
14	27.0	13.0	38.0	16.0	6.0	++++
16	32.0	11.0	38.0	8.0	11.0	++++
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	38.5	12.0	32.0	6.0	12.0	+
4	34.0	10.0	36.0	7.0	13.0	++
6	5.5	20.0	18.5	11.0	45.5	++++++
8	7.0	29.0	44.0	3.0	17.0	++++++
10	-	-	-	-	-	++++++
12	-	-	-	-	-	++++++
14	-	-	-	-	-	++++++
16	-	-	-	-	-	++++++



Table 21 a Chemical qualities of heated half-bottle line juice during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	32.50	100.00	2.4	8.0	7.09
2	17.53	53.94	2.4	8.5	7.36
4	10.58	32.55	2.4	9.5	7.65
6	4.05	12.46	2.4	8.5	7.76
8	1.15	3.53	2.4	8.5	7.47
10	0.99	3.05	2.4	9.0	7.97
12	1.32	4.07	2.4	8.2	7.79
14	0.70	2.14	2.4	8.5	7.81
16	1.52	4.69	2.4	8.4	7.75
B Room Temperature					
0	32.50	100.00	2.4	8.0	7.09
2	9.19	28.28	2.4	8.0	7.22
4	1.65	5.07	2.4	9.5	7.76
6	1.52	4.68	2.4	8.5	7.45
8	1.15	3.53	2.4	8.4	7.61
10	1.16	3.56	2.4	8.8	7.79
12	0.99	3.05	2.4	8.2	7.76
14	0.93	2.86	2.4	8.5	7.61
16	2.44	7.50	2.4	8.4	7.71

Table 21<sup>b</sup> Physical qualities of half-bottle-lime juice during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	10.0	10.0	0
2	41.0	15.0	27.5	5.5	11.0	0
4	40.0	13.0	27.5	7.5	12.0	0
6	39.5	8.0	33.5	10.5	8.5	0
8	38.5	9.5	35.0	7.0	10.0	0
10	36.0	9.0	36.5	7.5	11.0	0
12	37.0	7.0	38.0	6.0	12.0	0
14	35.5	9.5	36.0	7.5	12.5	0
16	35.0	10.5	39.0	7.0	8.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	34.5	15.5	15.5	3.5	24.5	+
4	34.0	17.0	17.0	13.0	8.0	++++
6	24.5	10.0	10.0	5.0	23.5	+++++++
8	-	-	-	-	-	+++++++
10	-	-	-	-	-	+++++++
12	-	-	-	-	-	+++++++
14	-	-	-	-	-	+++++++
16	-	-	-	-	-	+++++++

Table 22 a Chemical qualities of half-bottle-lime juice treated with 200 ppm of potassium sorbate during 4 months of storage time (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	34.88	100.00	2.4	8.0	7.45
2	12.59	36.11	2.4	8.5	7.24
4	1.72	4.95	2.4	8.2	7.97
6	2.53	7.26	2.4	8.7	7.54
8	1.15	3.29	2.4	8.5	7.58
10	0.83	2.37	2.4	8.8	7.86
12	1.24	3.55	2.4	8.2	7.63
14	0.70	2.00	2.4	8.4	7.74
16	1.52	4.37	2.4	8.4	7.54
B Room Temperature					
0	34.88	100.00	2.4	8.0	7.45
2	7.74	22.20	2.4	8.5	7.09
4	1.72	4.95	2.4	8.5	7.44
6	2.02	5.79	2.4	8.5	7.47
8	1.15	3.29	2.4	8.4	7.51
10	0.99	2.84	2.4	8.8	7.68
12	1.32	3.79	2.4	8.2	7.76
14	0.93	2.67	2.4	8.5	7.56
16	1.83	5.24	2.4	8.4	7.33

Table 22 **b** Physical qualities of half-bottle-lime juice treated with 200 ppm of potassium sorbate during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	41.0	15.0	28.5	6.0	10.5	0
4	40.0	13.0	27.5	7.5	12.0	0
6	39.5	8.0	33.5	10.5	8.5	0
8	38.0	9.0	36.0	7.0	9.0	0
10	36.0	9.0	37.0	7.0	11.0	0
12	37.0	7.0	38.0	6.0	12.0	0
14	35.5	7.0	37.5	7.5	12.5	0
16	35.0	10.5	39.0	7.0	8.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	33.0	12.0	25.0	4.0	26.0	+
4	30.0	12.5	30.0	16.5	16.0	++++
6	6.0	28.5	35.5	5.0	15.0	+++++++
8	-	-	-	-	-	+++++++
10	-	-	-	-	-	+++++++
12	-	-	-	-	-	+++++++
14	-	-	-	-	-	+++++++
16	-	-	-	-	-	+++++++

Table 23 a Chemical qualities of half-bottle lime juice treated with 300 ppm of potassium sorbate during 4 months of storage time. (late season)

A Refrigerator Temperature					
Storage time (week)	Vit.C mg/100cm <sup>3</sup>	Vit.C % retention	pH	°Brix	% Acidity
0	34.56	100.00	2.4	9.0	7.45
2	8.17	23.64	2.4	8.5	7.35
4	2.35	6.81	2.4	8.2	7.21
6	1.35	3.91	2.4	8.7	7.65
8	0.98	2.85	2.4	8.5	7.35
10	0.83	2.39	2.4	8.5	7.58
12	1.32	3.82	2.4	8.2	7.63
14	0.69	2.02	2.4	8.4	7.74
16	1.52	4.41	2.4	8.0	7.30
B Room Temperature					
0	34.56	100.00	2.4	9.0	7.45
2	7.10	20.56	2.4	8.5	7.05
4	1.41	4.08	2.4	8.5	7.42
6	1.52	4.39	2.4	8.7	7.31
8	0.98	2.85	2.4	8.4	7.28
10	0.82	2.39	2.4	8.5	7.58
12	1.16	3.35	2.4	8.0	7.36
14	0.85	2.47	2.4	8.3	7.48
16	1.68	4.85	2.4	8.0	7.37

Table 23 b Physical qualities of half-bottle-lime juice treated with 300 ppm of potassium sorbate during 4 months of storage time. (late season)

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
0	41.0	16.0	26.0	7.0	10.0	0
2	45.5	11.0	27.0	6.0	10.5	0
4	40.0	13.0	27.5	7.5	12.0	0
6	39.5	8.0	33.0	10.5	8.5	0
8	39.0	9.0	36.0	7.0	9.0	0
10	36.0	9.0	37.0	7.0	11.0	0
12	37.0	7.0	38.0	6.0	12.0	0
14	35.5	7.0	37.5	7.5	12.5	0
16	35.0	10.5	39.0	7.0	8.5	0
B Room Temperature						
0	41.0	16.0	26.0	7.0	10.0	0
2	32.0	10.0	28.0	4.0	26.0	+
4	30.0	12.5	30.0	15.5	11.0	++++
6	6.0	28.5	35.5	5.0	15.0	++++++
8	-	-	-	-	-	+++++++
10	-	-	-	-	-	+++++++
12	-	-	-	-	-	+++++++
14	-	-	-	-	-	+++++++
16	-	-	-	-	-	+++++++

Table 24 Average percentage vitamin retention of half-bottle-lime juice treated with potassium metabisulfite and potassium sorbate during 4 months of storage time.

A Refrigerator Temperature					
Week	I <sub>1</sub>	I <sub>3</sub>	I <sub>4</sub>	II <sub>3</sub>	II <sub>4</sub>
0	100.00	100.00	100.00	100.00	100.00
2	54.28	84.54	91.80	48.61	41.10
4	35.48	53.14	83.16	27.01	24.76
6	7.46	15.09	35.09	6.13	5.83
8	4.09	5.74	6.52	3.43	2.66
10	3.93	4.04	8.68	2.97	2.58
12	3.65	4.75	2.65	3.01	3.44
14	2.74	2.78	2.63	2.35	2.54
16	4.13	2.78	2.98	3.51	3.49
B Room Temperature					
0	100.00	100.00	100.00	100.00	100.00
2	29.50	42.14	39.94	27.02	24.28
4	5.03	2.45	2.54	4.89	3.73
6	4.09	3.29	3.97	4.50	4.17
8	3.96	3.41	3.38	3.29	3.73
10	3.81	2.86	3.60	2.70	2.68
12	3.17	3.28	2.74	3.46	3.32
14	3.05	2.85	2.41	2.78	2.76
16	4.74	3.04	2.89	4.04	3.92

decreasing, having the value of 32-38% at the end of the fourth week and remained constant afterwards. For the sample (controlled) in full bottle the average vitamin C retention was 54% at the end of the fourth month.

Effect of incorporated air on samples at room temperature was investigated. Comparing the physical and chemical qualities of treated lime juice in full bottle and half bottle, the results obtained are shown in Tables 3-12. Samples treated with heat in full bottle at room temperature were acceptable in appearance and color with a little of browning at the end of ten weeks. But the samples treated with various concentration of potassium metabisulfite, potassium sorbate were acceptable 2 weeks longer, after that they turned brown and became unacceptable at the end of the fourth month. Final percentage of vitamin C retention of all samples in full bottle was nearly the same (35-43%).

The treated samples in half bottle at room temperature were acceptable in appearance and color at the end of the fourth week and after that browning developed more intensely and the samples were no longer acceptable.

#### 4.4.2 Effect of Incorporated Air and Changes of Storage Temperature

Effect of incorporated air which was introduced into treated samples during storage test on the preservation of lime juice was investigated (Sinchumpasak, 1976). Halves of the samples were poured out after 6, 8, 10 weeks of storage time and were continued storing at the same condition or different condition for 4 weeks.



The results are shown in Table 25-28.

From the data tabulated in Table 25 and Figure 13. It is noted that the percentage vitamin C retention in the samples treated with combined 200 ppm of potassium metabisulfite and 300 ppm of potassium sorbate kept at room temperature and halves of samples were poured out after 6, 8, 10 weeks of storage time and were continued storing under the same condition for 4 weeks, were 5.18, 4.46, 4.99% respectively. Starting with full bottle before pouring out vitamin C retention were 84.64, 78.65, 72.52% at the end of 6, 8, 10 weeks respectively. The half-bottle lime juice treated with 200 ppm of potassium metabisulfite had vitamin C retention of 2.45% at the end of 4 weeks. After pouring at 6, 8, 10 weeks the percentage vitamin C retention was calculated from the initial values (84.64, 78.15, 72.52%) to be 6.12, 5.67, 6.88%. The rate of percentage of vitamin C destruction of both samples were the same since both had incorporated air.

Similarly, starting with full bottle of lime juice treated with combined additives (300 ppm of potassium metabisulfite+200 ppm of potassium sorbate) before pouring out, vitamin C retention were 83.38, 68.16, 49.87% at the end of 6, 8, 10 week respectively. After pouring they were kept at room temperature, vitamin C retention were 5.24, 5.00, 4.03% respectively, the percentage vitamin C retention was calculated from the initial values (83.38, 68.16, 49.87%) to be 6.28, 7.33, 8.08% respectively. The half-bottle-lime juice treated with 300 ppm of potassium metabisulfite had vitamin C retention of 2.54% (Figure 14).

Table 27 shows that vitamin C retention of full-bottle-lime juice treated with 200 ppm of potassium metabisulfite and 300 ppm of potassium sorbate which halves of the samples were poured out after 6, 8, 10 weeks of storage time at refrigerator temperature and were continued storing at room temperature for 4 weeks were 4.15, 4.46, 4.49% respectively, but starting with full bottle with combined additions before pouring out vitamin C retention were 86.45, 92.47, 85.34% at the end of 6, 8, 10 weeks respectively. After pouring at 6, 8, 10 weeks the percentage vitamin C retention was calculated from the initial values to be 4.8, 4.82, 5.26%. (Figure 15)

Table 28 shows that vitamin C retention of full-bottle-lime juice treated with 300 ppm of potassium metabisulfite and 200 ppm of potassium sorbate which halves of the sample were poured out after 6, 8, 10 weeks of storage time at refrigerator temperature and were continued storing at room temperature for 4 weeks were 4.19, 5.01, 4.54% respectively. But starting with full bottle with combined additives before pouring out vitamin C retention were 91.41, 87.38, 81.29% respectively. After pouring at 6, 8, 10 weeks the percentage vitamin C retention was calculated from the initial values (91.41, 87.38, 81.29%) to be 4.58, 5.73, 5.58% respectively. (Figure 16)

From tables 25-28. The results were that incorporated air which was introduced in to the sample, had the effect on the qualities of lime juice in terms of vitamin C and appearance. At the end of 4 weeks after utilization had no nutrition value in term of vitamin C any more. This indicated that the sample should be consumed within 4 weeks if it was stored at room temperature.

Table 25 Percentage vitamin C retention of treated lime juice with 200 ppm of potassium metabisulfite and 300 ppm of potassium sorbate which halves of the samples were poured after 6, 8, 10 weeks of storage time at room temperature and were continued storing at room temp for 4 weeks(Sinchumpasak, 1976 Table 29,47,48,49) and half-bottle lime juice treated with 200 ppm of potassium metabisulfite at room temperature.

Percentage Vitamin C Retention								
Storage time (week)	III <sub>1</sub> full bottle at room temp	III <sub>1</sub> (half-bottle)			I <sub>2</sub> half bottle at room temp	III <sub>1</sub> (half-bottle)		
		6 weeks	8 weeks	10 weeks		6 weeks	8 weeks	10 weeks
0	100.00				100.00			
2	93.34				42.14			
4	86.79	5.18	4.46	4.99	2.45	6.12	5.67	6.88
6	84.64				3.29			
8	78.65				3.41			
10	72.52				2.86			
12	69.18				3.28			
14	63.35				2.85			
16	66.42				3.04			

Table 26 Percentage vitamin C retention of lime juice treated with 300 ppm of potassium metabisulfite and 200 ppm of potassium sorbate which halves of the samples were poured out after 6, 8, 10 weeks of storage time at room temperature and were continued storing at room temperature for 4 weeks, (Sinchumpasak, 1976 Table 33,47,48,49) and half-bottle-lime juice treated with 300 ppm of potassium metabisulfite at room temperature.

Percentage Vitamin C Retention								
Storage time (week)	III <sub>3</sub> full bottle at room temp	III <sub>3</sub> (half bottle)			I <sub>4</sub> half bottle at room temp	III <sub>3</sub> (half bottle)		
		6 weeks	8 weeks	10 weeks		6 weeks	8 weeks	10 weeks
0	100.00				100.00			
2	83.46				39.94			
4	79.71	5.24	5.00	4.03	2.54	6.28	7.33	8.08
6	83.38				3.97			
8	68.16				3.38			
10	49.87				3.60			
12	69.94				2.74			
14	38.94				2.41			
16	72.33				2.89			

Table 27 Percentage vitamin C retention of lime juice treated with 200 ppm of potassium metabisulfite and 300 ppm of potassium sorbate which halves of the samples were poured out after 6, 8, 10 weeks of storage time at refrigerator temperature and were continued storing at room temperature for 4 weeks, (Sinchumpasak, 1976, Table 29, 50, 51, 52) and half-bottle lime juice treated with 200 ppm of potassium metabisulfite at room temperature.

Percentage Vitamin C Retention								
Storage time (week)	III <sub>1</sub> full bottle at refrigerator temp	III <sub>1</sub> (half bottle)			I <sub>2</sub> half bottle at room temp	III <sub>1</sub> (half bottle)		
		6 weeks	8 weeks	10 weeks		6 weeks	8 weeks	10 weeks
0	100.00				100.00			
2	96.21				42.14			
4	94.70	4.15	4.46	4.49	2.45	4.80	4.82	5.26
6	86.45				3.29			
8	92.47				3.41			
10	85.34				2.86			
12	87.74				3.28			
14	90.72				2.85			
16	69.68				3.04			



Table 28 Percentage vitamin C retention of lime juice treated with 300 ppm of potassium metabisulfite and 200 ppm of potassium sorbate which half of the samples were poured out after 6, 8, 10 weeks of storage time at refrigerator temperature and were continually stored at room temperature for 4 weeks (Sinchumpasak, 1976 refer to Table 33, 50, 51, 52) and half-bottle-lime juice treated with 300 ppm of potassium metabisulfite at room temperature.

Percentage Vitamin C Retention								
Storage time (week)	III <sub>3</sub> full bottle at refrigerator temp	III <sub>3</sub> (half bottle)			I <sub>4</sub> half bottle at room temp	III <sub>3</sub> (half bottle)		
		6 weeks	8 weeks	10 weeks		6 weeks	8 weeks	10 weeks
0	100.00				100.00			
2	94.28				39.94			
4	95.29	4.19	5.01	4.54	2.54	4.58	5.73	5.58
6	91.41				3.97			
8	87.38				3.38			
10	81.29				3.60			
12	90.79				2.74			
14	81.97				2.41			
16	68.55				2.89			

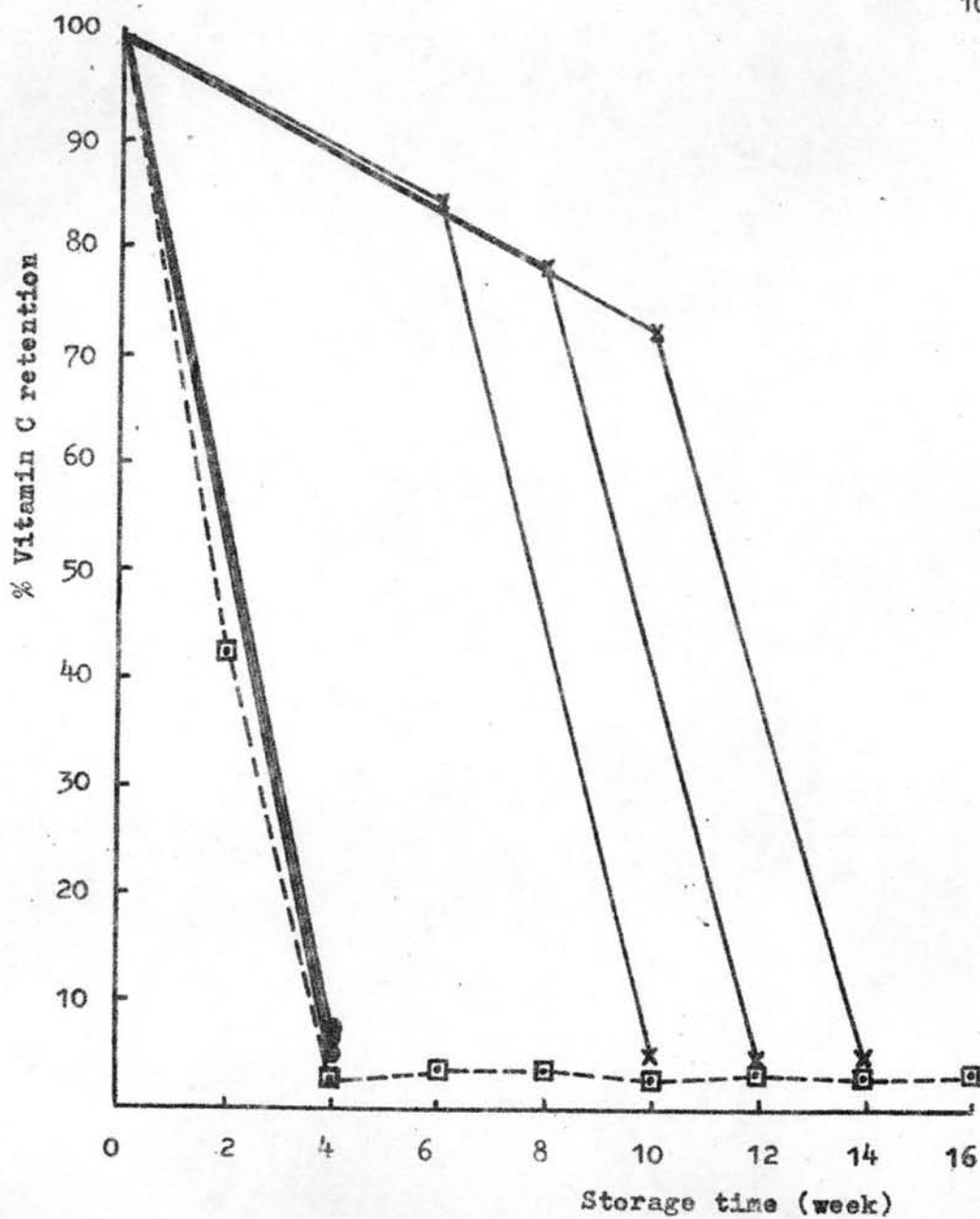


Figure 13 Vitamin C retention of half and full-bottle lime juice with single and combined effect at room temperature

- 200 ppm of potassium metabisulfite
- X 200 ppm of potassium metabisulfite + 300 ppm of potassium sorbate.
- lime juice after pouring

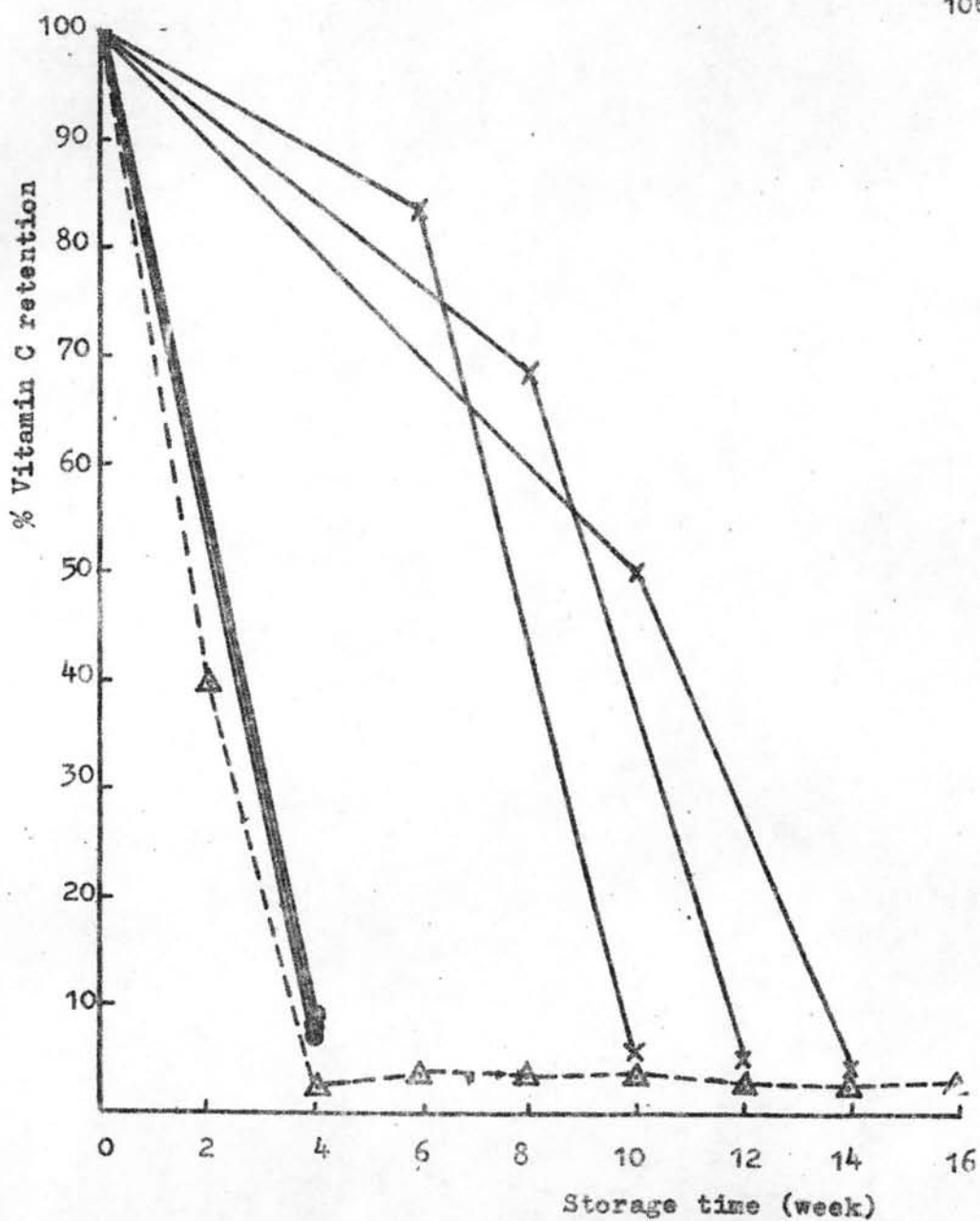


Figure 14 Vitamin C retention of half and full-bottle lime juice with single and combined effect at room temperature.

- ▲ 300 ppm of potassium metabisulfite,
- × 300 ppm of potassium metabisulfite+200 ppm of potassium sorbate
- lime juice after pouring.



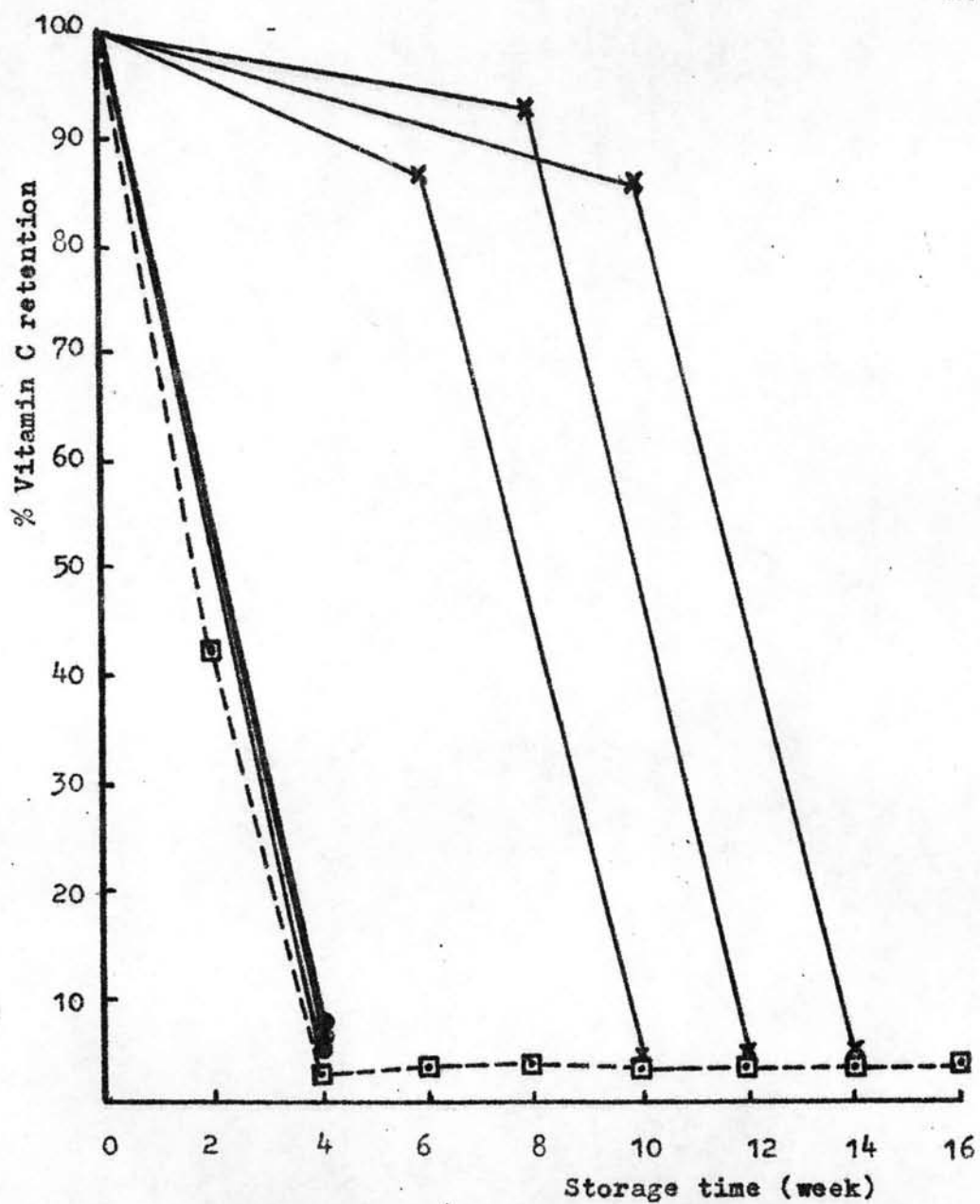


Figure 15 Vitamin C retention of half and full-bottle-lime juice with **single** and **combined** effect at room temperature

- 200 ppm of potassium metabisulfite,
- X 200 ppm of potassium metabisulfite+300 ppm of potassium sorbate
- lime juice after pouring.

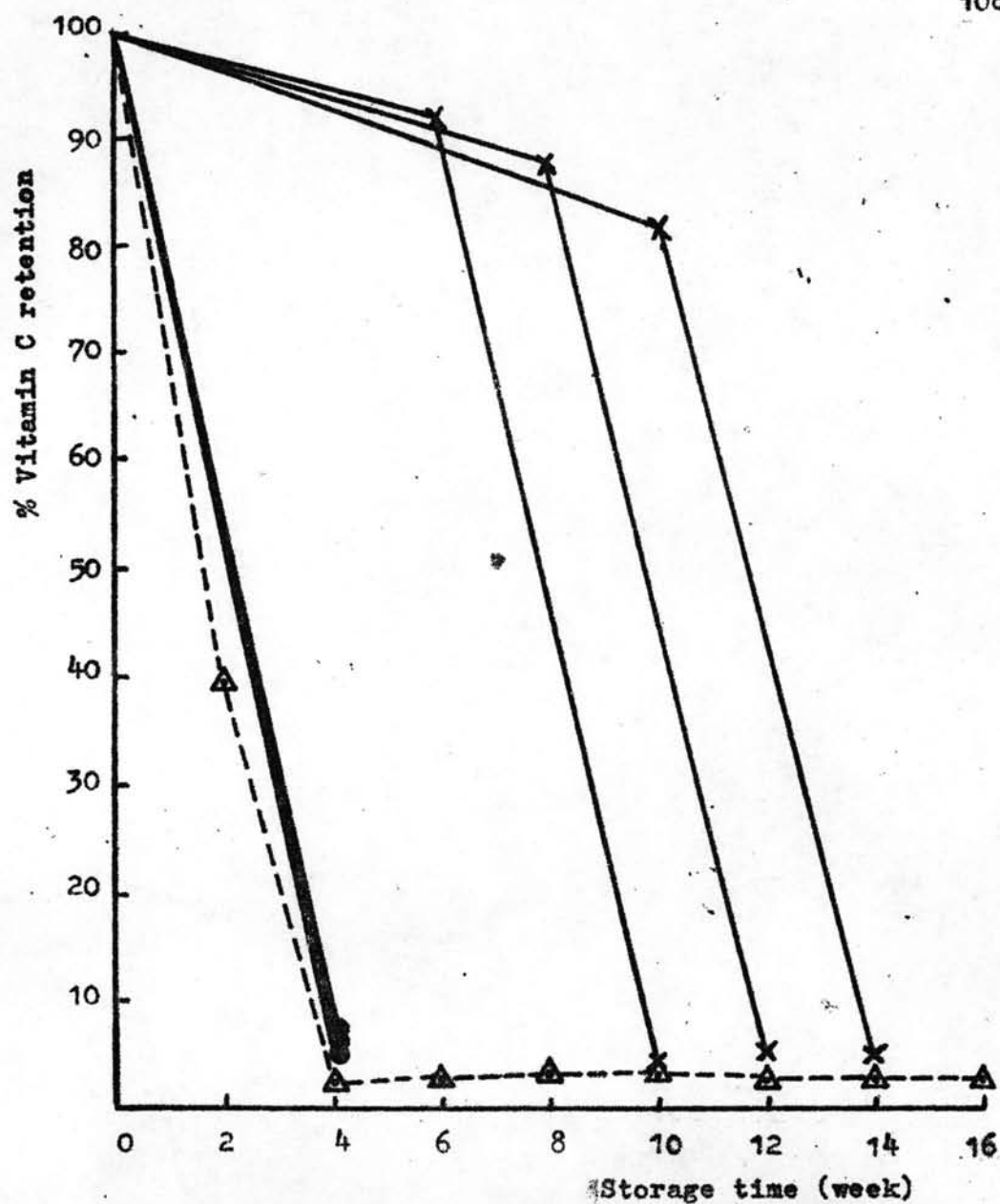


Figure 16 Vitamin C retention of half and full-bottle-lime juice with single and combine effect at room temperature

Δ 300 ppm of potassium metabisulfite

X 300 ppm of potassium metabisulfite+200 ppm of potassium sorbate

● lime juice after pouring

#### 4.4.3 Effect of Stannous Chloride in Lime Juice with Incorporated Air

The effect of stannous chloride on qualities of lime juice with incorporated air at room temperature and refrigerator temperature during 1 month was investigated. The chemical and physical qualities of all treated samples with heat, 200 ppm of potassium metabisulfite, 200 ppm of stannous chloride during 1 month of storage time at both temperatures had been summarized in Tables 29-31. Color of all samples stored at refrigerator temperature and room temperature were acceptable at the end of 1 month. The appearance of samples treated with heat and 200 ppm of potassium metabisulfite at room temperature were slightly brown, but the samples treated with stannous chloride were better than the others, and appeared similar to the fresh lime juice.

Regarding the vitamin C retention in samples at refrigerator temperature, the samples treated with 200 ppm of stannous chloride had the lowest decreasing (Figure 17). The controlled samples stored at room temperature had 6.89% in vitamin C retention at the end of 1 month of storage. Vitamin C retention of treated sample with potassium metabisulfite and stannous chloride at room temperature were 4.00, 14.78% respectively. For samples stored at refrigerator temperature, treated with stannous chloride had the best vitamin C retention (88.50%).

The data indicated that the addition of stannous chloride into citrus juice retarded or inhibited browning of lime juice, the findings of Higby and Pritchett (1965) confirmed these results.

Table 29 a Chemical qualities of half-bottle-lime juice (controlled) during 1 month of storage time.

A Refrigerator Temperature		
Storage time (week)	Vit. C mg/100 cm <sup>3</sup>	Vit. C % retention
0	36.00	100.0
1	25.81	71.69
2	25.43	70.64
3	23.05	64.03
4	21.99	61.08
B Room Temperature		
0	36.00	100.0
1	19.00	52.78
2	12.03	33.42
3	7.09	19.69
4	2.48	6.89

Table 29 b Physical qualities of half-bottle-line juice (controlled) during 1 month of storage time.

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
1	45.0	10.0	34.0	2.0	9.0	0
2	43.0	10.0	38.0	2.0	7.0	0
3	42.0	9.0	41.0	2.0	6.0	0
4	42.0	8.0	42.0	2.0	6.0	0
B Room Temperature						
1	41.0	10.0	37.0	2.0	10.0	0
2	39.0	10.0	40.0	2.0	9.0	0
3	37.0	9.0	43.0	2.0	9.0	0
4	37.0	8.0	44.0	2.0	9.0	+++

Table 30 a Chemical qualities of half-bottle lime juice treated with 200 ppm of potassium metabisulfite during 1 month of storage time.

A Refrigerator Temperature		
Storage time (week)	Vit. C mg/100 cm <sup>3</sup>	Vit.C % retention
0	36.00	100.00
1	32.98	91.61
2	31.96	88.78
3	31.92	88.67
4	30.50	84.72
B Room Temperature		
0	36.00	100.00
1	23.30	64.72
2	11.34	31.50
3	3.55	9.86
4	1.44	4.00

Table 30 b Physical qualities of half-bottle lime juice with 200 ppm of potassium metabisulfite during 1 month of storage time.

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
1	44.0	9.0	36.0	2.0	9.0	0
2	42.0	9.0	39.0	2.0	8.0	0
3	43.0	8.0	40.0	1.0	8.0	0
4	43.0	7.0	41.0	1.0	8.0	0
B Room Temperature						
1	40.0	11.0	36.0	4.0	9.0	0
2	28.0	10.0	48.0	4.0	10.0	++
3	25.0	8.0	54.0	3.0	10.0	++
4	25.0	8.0	55.0	3.0	9.0	++++

Table 31 a Chemical qualities of half-bottle lime juice treated with 200 ppm of stannous chloride during 1 month of storage time.

A Refrigerator Temperature		
Storage time (week)	Vit.C mg/100 cm <sup>3</sup>	Vit.C % retention
0	36.00	100.00
1	35.13	97.98
2	32.99	91.64
3	32.27	89.64
4	31.86	88.50
B Room Temperature		
0	36.00	100.00
1	23.66	65.73
2	19.59	54.42
3	9.51	26.42
4	5.32	14.78



Table 31 b Physical qualities of half-bottle-lime juice treated with 200 ppm of stannous chloride during 1 month of storage time.

A Refrigerator Temperature						
Storage time (week)	% Color					Browning Appearance
	Green	Grey	Yellow	White	Orange	
1	44.0	6.0	40.0	2.0	8.0	0
2	46.0	2.0	43.0	2.0	7.0	0
3	46.0	2.0	44.0	1.0	7.0	0
4	47.0	1.0	44.0	1.0	7.0	0
B Room Temperature						
1	42.0	8.0	38.0	2.0	10.0	0
2	42.0	8.0	39.0	2.0	9.0	0
3	42.0	5.0	42.0	2.0	9.0	0
4	39.0	5.0	45.0	2.0	9.0	0

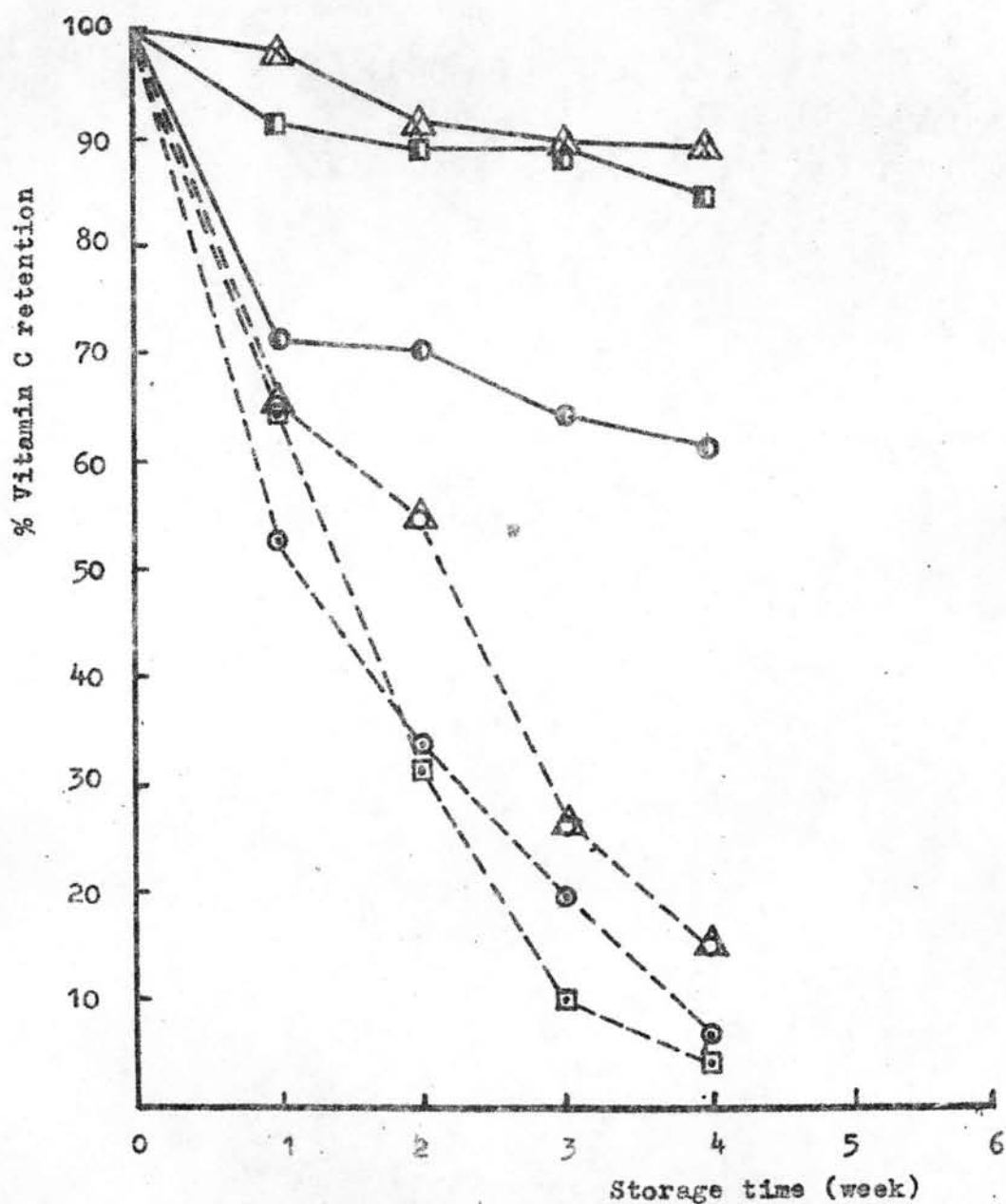


Figure 17 Effect of 200 ppm of potassium metabisulfite, 200 ppm of stannous chloride on vitamin C retention in half-bottle lime juice.

- control, ■ 200 ppm of potassium metabisulfite,
- ▲ 200 ppm of stannous chloride at refrigerator temperature
- control, □ 200 ppm of potassium metabisulfite,
- △ 200 ppm of stannous chloride at room temperature.