

Chapter IV

RESULTS

4.1 Qualities of Fresh Lime Juice

Qualities of fresh lime juice were presented in Table 6. The pH value of all samples were equal to 2.4 with a little variability in °Brix and % acidity. Citrus juices have a maximum buffering capacity so that juices of various titratable acidity may have identical pH values. (Agr. Hand Book No.98). Amount of Vitamin C in fresh lime juice was in the range of 24-29 mg per 100 ml of juice. Fresh lime juice had a yellowish green colour with an average % transmittance value of 79.05%. From sensory test by using Hedonic Scaling method, it was shown that fresh lime juice had an average value of 7.4 which presents the rank of like moderately qualities of each sample were not the same because of variability in composition of the fruit which is influenced by many factors such as rootstock, genetic factors, maturity, and field factors.

4.2 Effect of Potassium Meta-bisulfite

Studying the effect of potassium meta-bisulfite on the preservation of lime juice that stored at refrigerator and room temperature, the results were that after 4 months of storage time at refrigerator temperature, all samples of lime juice which were treated with 100, 200, 300, 400 and 500 ppm of potassium meta-bisulfite as well as the

Table 6 Qualities of fresh lime juice

Sample No.	pH	° Brix	% Acidity	Vit.C mg/100ml	% Colour				
					yellow	White	Grey	Green	Yellow Red
1	2.4	8.23	7.28	28.22	33.0	23.0	8.0	29.5	6.5
2	2.4	8.05	7.28	28.22	30.0	19.5	7.5	36.5	6.5
3	2.4	7.50	7.27	24.90	16.0	16.8	17.8	29.8	19.6
4	2.4	7.80	7.33	28.14	27.5	23.0	8.0	33.0	8.5
5	2.4	7.60	7.01	24.02	19.0	15.8	15.0	33.0	17.2
6	2.4	7.50	7.30	25.05	21.8	14.3	16.0	32.6	15.3
7	2.4	7.80	7.30	28.63	30.0	16.8	12.5	33.8	6.9
8	2.4	7.80	7.53	28.71	30.8	15.6	14.6	33.2	5.8
9	2.4	7.50	7.27	24.90	21.8	14.3	16.0	32.6	15.3
10	2.4	7.60	7.23	24.75	16.0	16.8	17.8	29.8	19.6
Average Value	2.4	7.74	7.28	26.55					

% Transmittance = 79.05

Average value of Hedonic Scaling = 7.4

controlled lime juice were still acceptable. At room temperature, samples treated with 400 and 500 ppm of potassium meta-bisulfite were also still acceptable after the end of 4 months of storage time. Samples treated with 100, 200 and 300 ppm potassium meta-bisulfite as well as the controlled sample were still acceptable at the end of the second month but after that the colour changed quickly to brown colour so that the appearance were not acceptable any more.

Chemical and physical qualities of all treated samples during 4 months of storage time at refrigerator temperature and room temperature had been summarized in Table 7-18. In view of chemical qualities, the pH value of all samples were equal to 2.4 without any changes during the storage test although the % acidity of all samples had a little variability, these should be due to the buffering capacity of lime juice.

Measurement of °Brix that relate to total soluble solids which include sugar, acid, soluble pectin, and other compounds had shown that all samples treated with potassium meta-bisulfite has higher °Brix (8.0-8.7) than the other one which was not treated with potassium meta-bisulfite. (°Brix 7.6-8.0). During the storage test, the °Brix value was nearly constant for each samples.

Course of Vitamin C retention in all samples during the storage test at room temperature and refrigerator temperature were shown in Figure 1-6. For samples that stored at refrigerator temperature, % Vit. C retention in all samples varied irregularly during the storage test with a tendency of decreasing. The quickest decreasing was in



the sample that treated with 400 ppm potassium meta-bisulfite with Vit.C retention of 53.49% at the end of the fourth month. The lowest decreasing were in the sample that treated with 200 and 500 ppm potassium meta-bisulfite with Vit.C retention of 87.12 and 88.62 % consequently at the end of the fourth month. For samples that treated with heat (controlled), 100 ppm and 300 ppm potassium meta-bisulfite, they had nearly the same tendency of decreasing in % Vit.C retention which resulted in 71.50, 76.82 and 61.99% consequently at the end of the fourth month.

Following the physical qualities of all treated samples during the storage test at refrigerator temperature, the % Transmittance of each sample was nearly constant with higher value than fresh sample. Density increasing might be due to the fact that the protopectin, contained in the small albedo particles floating in the juice, is hydrolyzed by the action of acid and heat into soluble pectin which passes into the juice thus actually increasing the amount of soluble pectin in it.

Colour of all samples that stored at refrigerator temperature were still acceptable after the end of the fourth month with a little appearance of browning. Samples treated with heat and 100 ppm potassium meta-bisulfite had more intensity of brown colour than samples treated with 200 and 300 ppm. For samples that treated with 400 and 500 ppm potassium meta-bisulfite, the color is still the same as fresh samples at the end of 6 weeks of storage time, and the colour changed slightly during 10 weeks later. It was evident that increasing

the amount of potassium meta-bisulfite added would result in decreasing of browning development which according to its ability in preventing enzymatic and non-enzymatic discolouration of food as well as loss of ascorbic acid

Sensory test resulted in acceptability for all samples after 8 weeks of storage test at refrigerator temperature. There is only slightly comment on the flavour of sulfiting in the samples that treated with 400 and 500 ppm of potassium meta-bisulfite. So that for storage of lime juice at refrigerator temperature (7.5°C), the amount of potassium meta-bisulfite that should be added must be in the range of 200-300 ppm which is enough for keeping its qualities during 4 months of storage time.

At room temperature, the pH value of all samples were equal to 2.4 without any changes during the storage test. $^{\circ}\text{Brix}$ and % acidity of all samples varied slightly during the storage test. From figure 1-6, it was evident that at room temperature rates of Vit.C destruction was quicker than at refrigerator temperature. After four months of storage time at room temperature, % Vit.C retention in 100, 200, 300 ppm potassium meta-bisulfite treated lime juice had the values lower than 40% whilst the values in 400 and 500 ppm potassium meta-bisulfite treated lime juice were a little higher but not more than 45%.

In view of colour, browning developed more quickly in samples stored at room temperature compared to samples stored at refrigerator temperature. Browning appearance in samples treated with heat and 100 ppm potassium meta-bisulfite were the same during the test which

Table 7 Chemical qualities of heated lime juice(controlled) during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C % Retention
0	2.4	7.6	7.44	24.46	100.0
1	2.4	8.0	7.33	24.45	99.96
2	2.4	7.8	7.38	23.46	95.91
3	2.4	8.1	7.25	22.71	92.85
4	2.4	7.9	7.32	20.81	85.08
5	2.4	8.0	7.38	20.58	84.14
6	2.4	7.8	7.43	19.47	79.60
8	2.4	8.0	7.60	22.64	92.56
10	2.4	8.0	7.72	14.71	60.14
12	2.4	8.0	7.37	14.40	58.87
14	2.4	8.0	7.75	21.20	86.67
16	2.4	8.0	7.43	17.49	71.50
B. Room Temperature					
0	2.4	8.2	7.54	23.61	100.0
8	2.4	8.05	7.44	17.18	72.77
16	2.4	8.4	7.37	14.84	62.85

Table 9 Chemical qualities of lime juice treated with 100 ppm potassium meta-bisulfite during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.4	7.77	29.04	100.0
1	2.4	8.7	7.96	27.18	93.59
2	2.4	8.4	7.60	23.25	80.06
3	2.4	8.35	7.53	21.45	73.86
4	2.4	8.5	7.85	23.57	81.17
5	2.4	8.6	7.56	27.93	96.16
6	2.4	8.7	7.95	24.94	85.87
8	2.4	8.7	7.72	25.81	88.89
10	2.4	8.25	7.74	21.05	72.50
12	2.4	8.56	7.82	26.67	91.84
14	2.4	8.0	7.74	8.85	30.48
16	2.4	8.4	7.71	22.31	76.82
B. Room Temperature					
0	2.4	8.0	7.33	28.61	100.0
8	2.4	8.0	7.25	16.82	58.79
16	2.4	8.4	7.17	10.64	37.19

Table 10 Physical qualities of lime juice treated with 100 ppm of potassium meta-bisulfite during 4 months of storage time.

A. Refrigerator Temperature							
Storage Time (wk)	% Transmittance	% Colour					Browning Appearance
		Yellow	White	Grey	Green	Yellow Red	
0	-	30.8	15.6	14.6	33.2	5.8	0
1	-	28.2	9.0	19.1	32.4	11.3	0
2	-	31.0	10.2	20.8	30.4	7.6	0
3	-	24.4	14.0	23.0	25.8	12.8	0
4	-	22.3	11.0	23.2	27.8	15.7	0
5	-	24.6	9.3	23.8	30.0	12.3	+
6	59.2	25.9	8.1	25.6	28.0	12.4	++
8	63.0	19.2	6.9	28.3	30.0	15.6	+++
10	60.5	21.2	7.8	27.6	26.8	16.6	+++
12	63.6	19.0	7.4	30.0	29.6	14.0	+++
14	61.7	21.1	1.6	35.8	18.8	22.7	+++
16	62.0	30.4	4.2	37.6	22.5	5.3	+++
B. Room Temperature							
0	71.2	24.0	8.3	15.2	35.0	17.5	0
8	70.2	20.7	0	46.8	12.9	19.6	++++
16	-	-	-	-	-	-	++++++

Table 11 Chemical qualities of lime juice treated with 200 ppm potassium meta-bisulfite during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.6	7.74	29.28	100.0
1	2.4	8.65	7.68	28.93	98.80
2	2.4	8.3	7.54	29.08	99.32
3	2.4	8.4	7.63	27.97	95.53
4	2.4	8.4	7.50	27.99	95.59
5	2.4	8.5	7.55	27.55	94.09
6	2.4	8.7	7.95	27.78	94.88
8	2.4	8.4	7.49	22.56	77.05
10	2.4	8.4	7.75	24.84	84.84
12	2.4	8.38	7.96	26.92	91.94
14	2.4	8.3	7.76	22.99	78.52
16	2.4	8.45	7.89	25.51	87.12
B. Room Temperature					
0	2.4	7.85	7.42	26.28	100.0
8	2.4	8.0	7.24	20.24	77.02
16	2.4	8.2	7.16	10.44	39.73

Table 13 Chemical qualities of lime juice treated with 300 ppm potassium meta-bisulfite during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention
0	2.4	8.6	7.74	28.76	100.0
1	2.4	8.4	7.65	28.85	100.31
2	2.4	8.2	7.78	28.93	100.59
3	2.4	8.1	7.44	27.25	94.75
4	2.4	8.4	7.52	27.40	95.29
5	2.4	8.2	7.54	26.42	91.86
6	2.4	8.35	7.60	25.56	88.87
8	2.4	8.4	7.78	17.79	61.86
10	2.4	8.25	7.83	25.26	87.83
12	2.4	8.4	8.03	25.66	89.22
14	2.4	8.2	7.72	22.07	76.74
16	2.4	8.45	7.91	17.83	61.99
B. Room Temperature					
0	2.4	8.15	7.60	27.21	100.0
8	2.4	8.0	7.32	19.88	73.06
16	2.4	8.4	7.32	10.31	37.89

Table 15 Chemical qualities of lime juice treated with 400 ppm potassium meta-bisulfite during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention
0	2.4	8.4	7.66	28.63	100.0
1	2.4	8.35	7.50	28.52	99.61
2	2.4	8.2	7.64	28.26	98.70
3	2.4	8.2	7.45	27.10	94.65
4	2.4	8.2	7.38	22.98	80.27
5	2.4	8.3	7.47	26.11	91.20
6	2.4	8.6	7.83	27.53	96.16
8	2.4	8.15	7.36	17.67	62.05
10	2.4	8.25	7.64	18.95	66.18
12	2.4	8.0	7.60	16.10	56.24
14	2.4	8.3	7.81	17.01	59.42
16	2.4	8.2	7.51	15.31	53.49
B. Room Temperature					
0	2.4	8.0	7.40	29.77	100.0
8	2.4	8.0	7.35	18.35	61.64
16	2.4	8.4	7.45	13.33	44.78

Table 17 Chemical qualities of lime juice treated with 500 ppm potassium meta-bisulfite during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	°Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention
0	2.4	8.5	7.83	28.63	100.0
1	2.4	8.35	7.47	28.71	100.27
2	2.4	8.15	7.63	28.34	98.98
3	2.4	8.4	7.47	27.54	96.17
4	2.4	8.2	7.70	27.70	96.74
5	2.4	8.5	7.71	27.47	95.95
6	2.4	8.5	7.78	27.90	97.45
8	2.4	8.45	7.45	25.35	88.54
10	2.4	8.2	7.79	18.53	64.71
12	2.4	8.15	7.77	26.67	93.15
14	2.4	8.1	7.84	23.22	81.10
16	2.4	8.25	7.63	25.37	88.62
B. Room Temperature					
0	2.4	7.8	7.32	26.28	100.0
8	2.4	8.0	7.24	19.77	75.23
16	2.4	8.4	7.39	11.07	42.12

Table 18 Physical qualities of lime juice treated with 500 ppm potassium meta-bisulfite during 4 months of storage time.

A. Refrigerator Temperature							
Storage Time (wk)	% Transmittance	% Colour					Browning Appearance
		Yellow	White	Grey	Green	Yellow Red	
0	-	29.4	15.9	15.0	34.0	5.7	0
1	-	20.9	20.0	16.1	32.0	11.0	0
2	-	27.1	12.7	20.2	33.0	7.0	0
3	-	23.5	14.2	23.0	27.5	11.8	0
4	-	20.6	13.0	24.0	29.4	13.0	0
5	-	21.8	10.0	24.8	30.4	13.0	0
6	63.0	21.8	11.0	25.0	32.0	10.2	0
8	62.0	16.3	5.6	32.4	30.1	15.6	+
10	61.3	22.0	12.3	24.6	30.5	10.6	+
12	60.3	18.6	11.9	24.7	28.8	16.0	+
14	61.2	24.5	8.8	27.5	30.3	8.9	+
16	62.7	23.2	8.0	27.7	29.2	11.9	+
B. Room Temperature							
0	69.2	24.7	11.5	13.0	35.0	15.8	0
8	67.2	18.8	6.0	37.0	24.3	13.9	+
16	-	11.3	0	31.0	24.0	33.7	+++

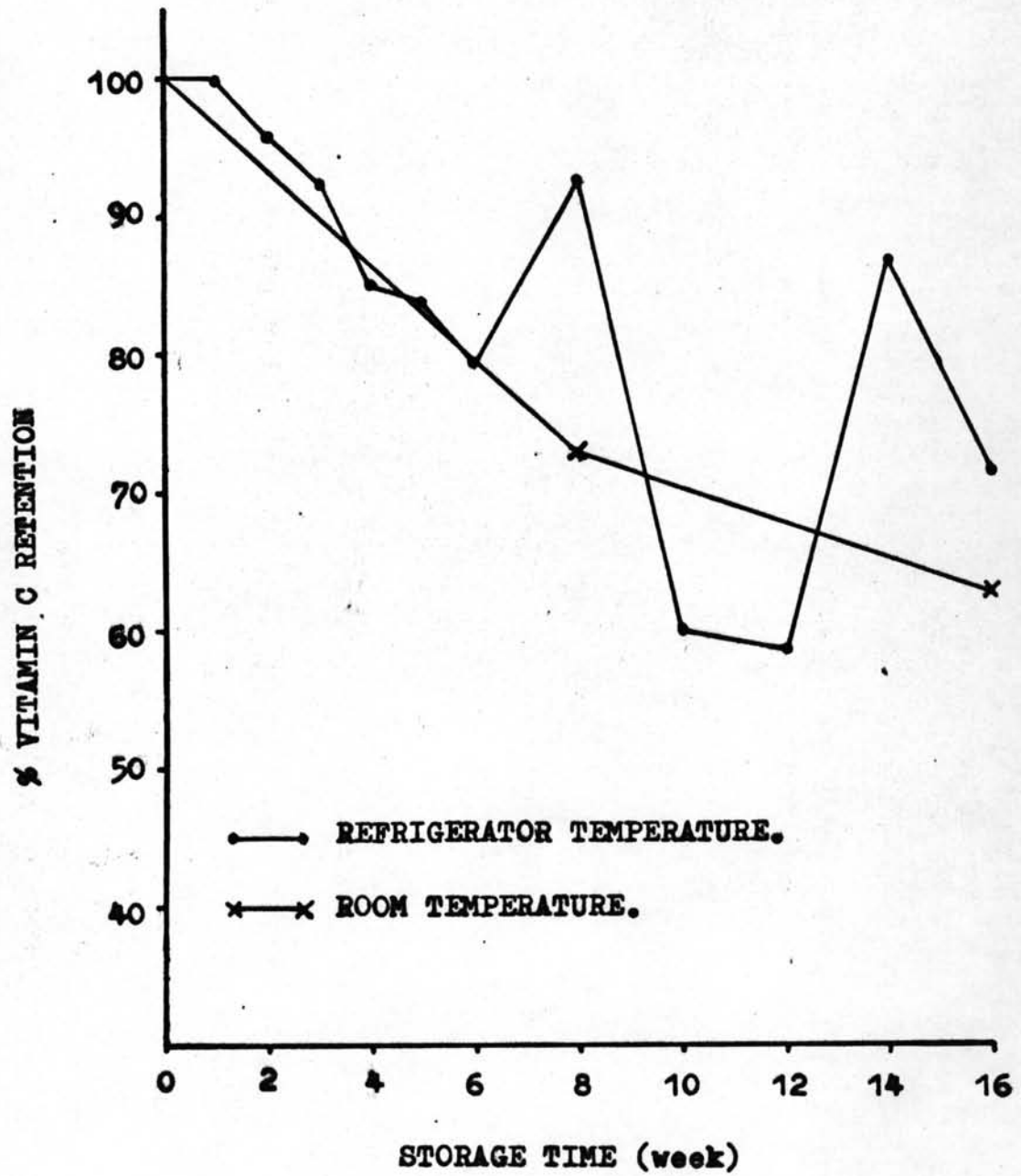


Fig. 1 Course of Vitamin C Retention in Lime Juice (Controlled).

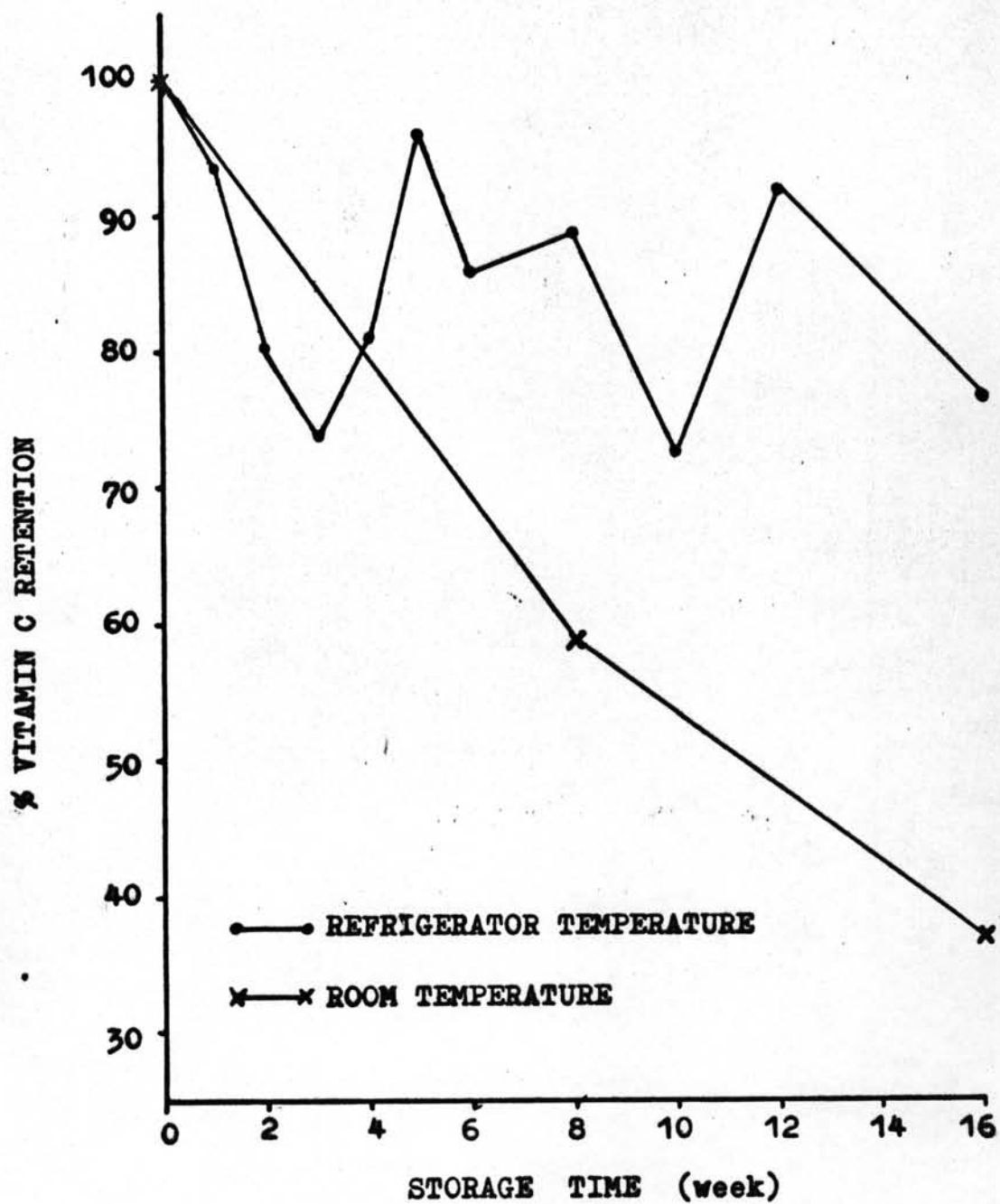


Fig.2 Effect of 100 ppm potassium meta-bisulfite on Vitamin C retention.

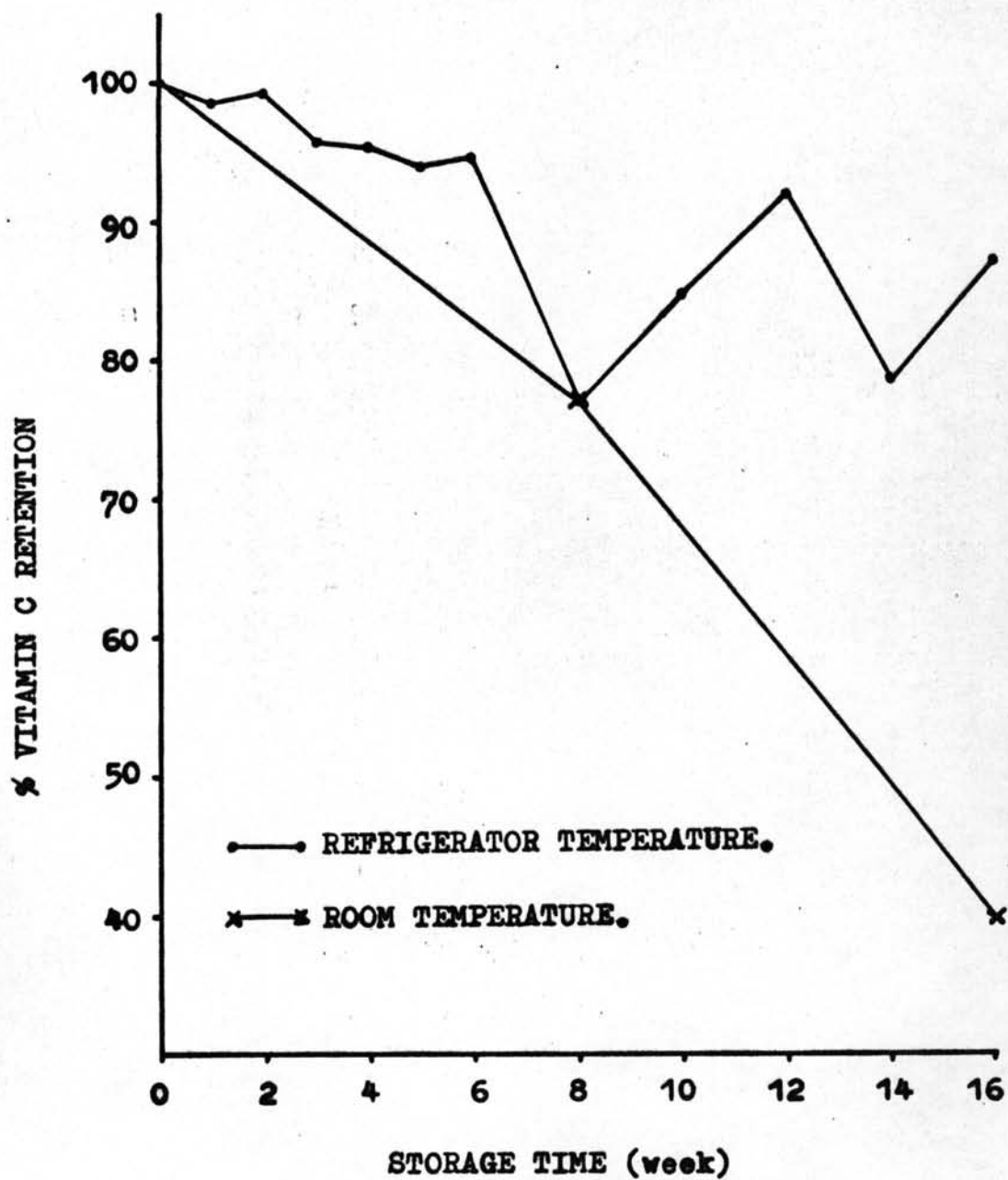


Fig. 3 Effect of 200 ppm potassium meta-bisulfite on Vitamin C retention.

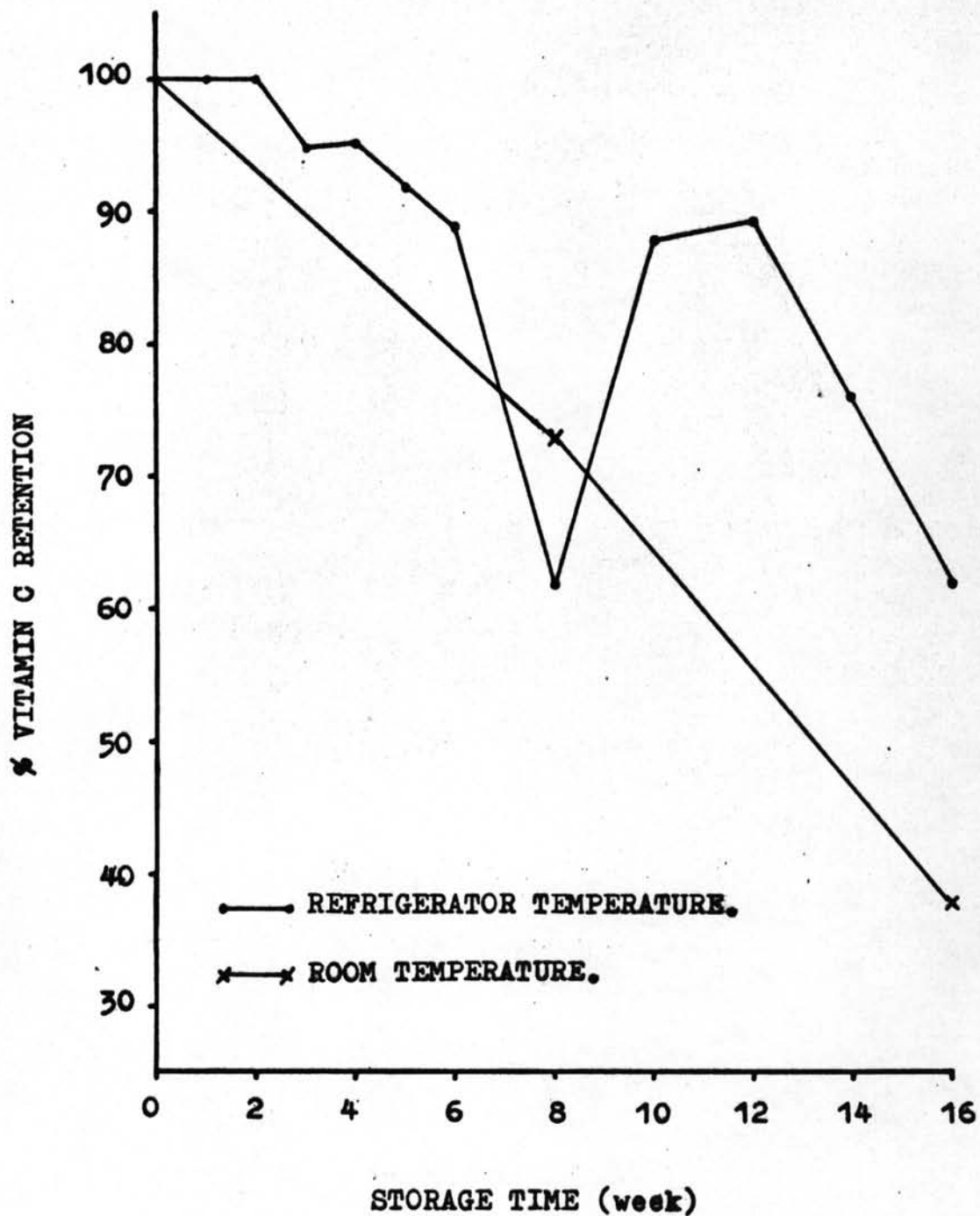


Fig. 4 Effect of 300 ppm potassium meta-bisulfite on Vitamin C retention.

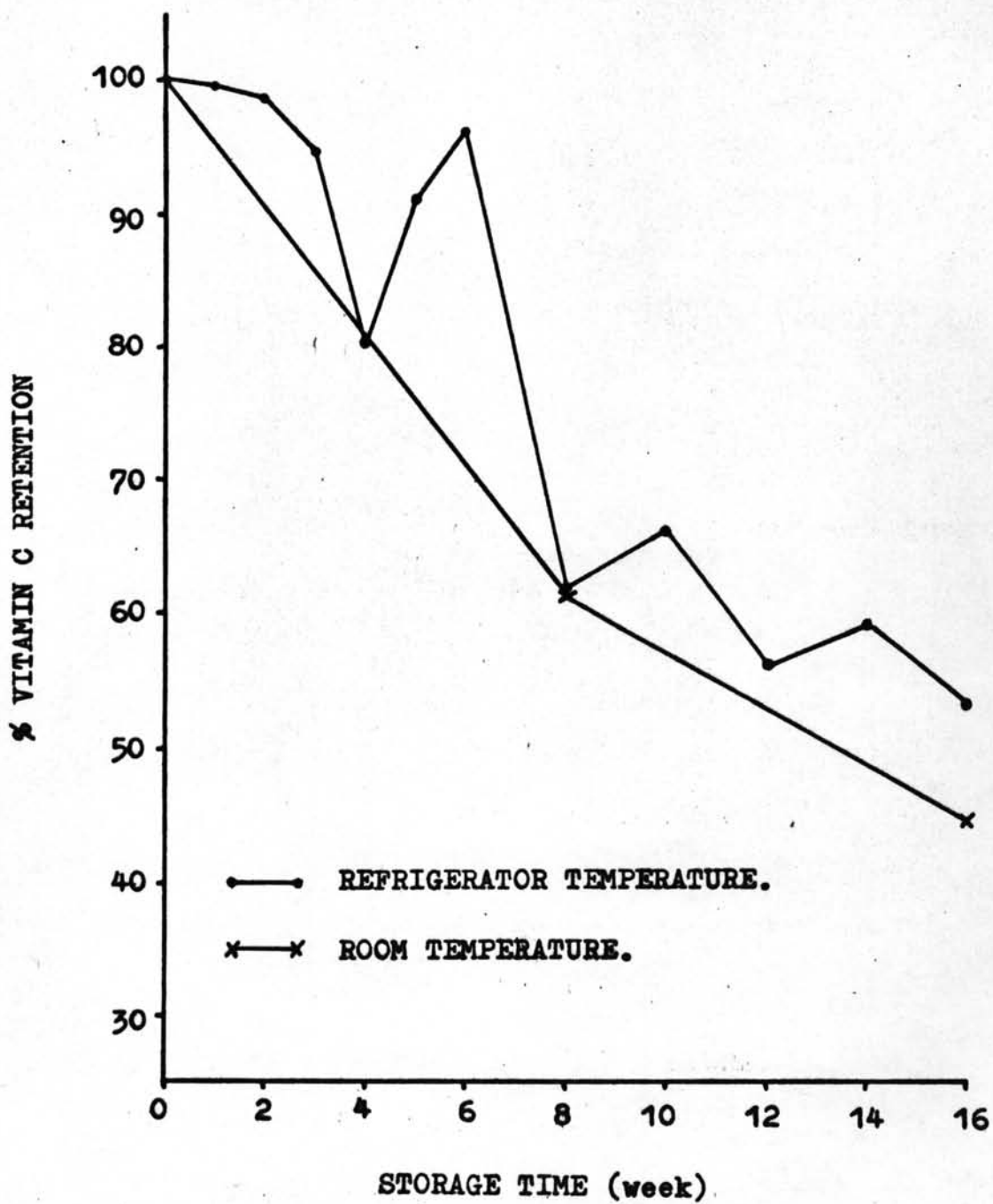


Fig. 5. Effect of 400 ppm potassium meta-bisulfite on Vitamin C retention.

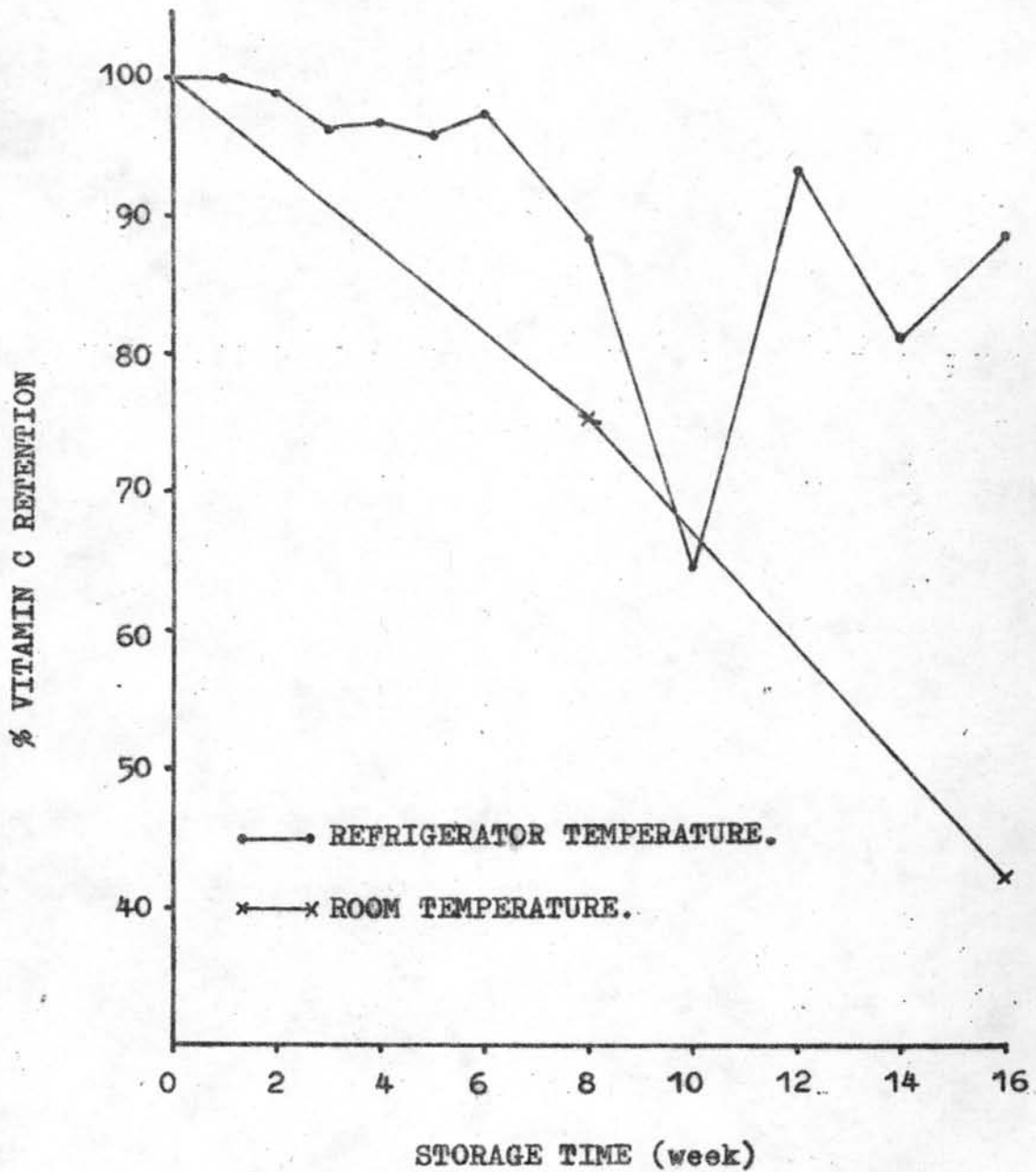


Fig. 6 Effect of 500 ppm potassium meta-bisulfite on Vitamin C retention.

were still acceptable after the end of 8 weeks and turned to brown colour at the end of the sixteenth week. Samples treated with 200 and 300 ppm of potassium meta-bisulfite had better colour and browning appearance than the two samples mentioned firstly. Colour and browning appearance in samples treated with 400 and 500 ppm potassium meta-bisulfite were still acceptable at the end of the sixteenth week. According to colour and browning appearance, the best one was the sample that treated with 500 ppm potassium meta-bisulfite.

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

4.3 Effect of Potassium Sorbate

Studying the effect of potassium sorbate on the preservation of lime juice that stored at refrigerator and room temperature, the results were that after 4 months of storage time at refrigerator temperature, all samples of lime juices treated with 100, 200, 300 400 and 500 ppm potassium sorbate were still acceptable. At room

month of storage test and would not be acceptable any more at the end of the fourth month because of browning appearance.

Chemical and physical qualities of lime juice treated with 100, 200, 300, 400 and 500 ppm potassium sorbate during 4 months of storage time at refrigerator temperature and room temperature had been summarized in Table 19-28. Following chemical qualities, pH value of all samples were equal to 2.4 without any change during the storage test. There was a little variability in both $^{\circ}$ Brix and % Acidity in all samples.

Course of Vitamin C retention in all samples during the storage test at room temperature and refrigerator temperature were shown in Figure 7-11. For samples that stored at refrigerator temperature, % Vit. C retention in all samples varied irregularly during the storage test with a tendency of decreasing the same as samples that treated with various concentration of potassium meta-bisulfite. Lime juice that treated with 400 ppm potassium sorbate had the least variability and decreasing in Vit. C compared to the others. Lime juice treated with 100 ppm potassium sorbate had the quickest tendency of decreasing in Vit. C.

Changes of colour in all samples were the same without any significant difference related to various concentrations of potassium sorbate that added. Browning developed more quickly in samples treated with potassium sorbate compared to samples treated with potassium meta-bisulfite.

Potassium sorbate added in the range of 100 to 500 ppm had no

effect on sensory test for all samples were acceptable without any comment on flavour.

Chemical and physical qualities of lime juice treated with various concentration of potassium sorbate during 4 months of storage time at room temperature had been summarized in Table 19-28. pH values of all samples were also equal to 2.4 with little variability in °Brix and % Acidity. Vit. C destruction in sample treated with 100 ppm and 300 ppm potassium sorbate were nearly the same with 48.09 and 43.27% Vit. C retention consequently after the end of the fourth month. The most highest decreasing in Vit. C content was in the sample treated with 500 ppm potassium sorbate with % Vit. C retention of 4.95 at the end of the fourth month. At the end of storage test % Vit. C retention was greatest in lime juice treated of 400 ppm potassium sorbate (63.46 % Vit. C retention). Increasing amount of potassium sorbate added had no effect on preventing loss of Vit. C.

Due to physical qualities all samples were still acceptable after 2 months of storage time at room temperature, but at the end of the fourth month all samples were not acceptable any more because of browning development. Lime juice treated with 500 ppm potassium sorbate with 4.95 % Vit. C retention was the most brown colour sample whilst sample treated with 400 ppm potassium sorbate (63.46 % Vit. C retention) was the lightest compared to all samples treated with potassium sorbate. It was evident that browning development increased as % Vit. C retention decrease which agreed with the work concerning nonenzymic browning of lemon juice studied by Clegg in 1964.

Table 19 Chemical qualities of lime juice treated with 100 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	^o Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.2	7.80	24.31	100.0
1	2.4	8.1	7.45	24.76	101.85
2	2.4	8.2	7.56	20.49	84.29
3	2.4	8.3	7.41	19.29	79.35
4	2.4	8.35	7.37	16.63	68.41
5	2.4	8.1	7.44	10.47	43.07
6	2.4	8.0	7.56	13.90	57.18
8	2.4	8.1	7.55	15.60	64.17
10	2.4	8.0	7.43	12.64	51.99
12	2.4	8.15	7.62	10.63	43.73
14	2.4	8.15	7.71	14.30	58.82
16	2.4	8.1	7.51	15.85	65.20
B. Room Temperature					
0	2.4	7.9	7.33	25.12	100.0
8	2.4	7.95	7.03	15.29	60.87
16	2.4	8.2	7.23	12.08	48.09



Table 21 Chemical qualities of lime juice treated with 200 ppm of potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention
0	2.4	8.2	7.40	24.46	100.0
1	2.4	8.3	7.33	24.76	101.23
2	2.4	8.1	7.36	22.72	92.89
3	2.4	8.2	7.36	20.71	84.67
4	2.4	8.2	7.44	20.93	85.57
5	2.4	8.05	7.29	18.14	74.16
6	2.4	7.95	7.64	17.90	73.18
8	2.4	7.95	7.43	21.51	87.94
10	2.4	7.9	7.45	20.69	84.59
12	2.4	8.0	7.40	21.94	89.70
14	2.4	8.0	7.54	20.1	82.17
16	2.4	8.0	7.40	16.04	65.58
B. Room Temperature					
0	2.4	8.1	7.65	25.12	100.0
8	2.4	8.0	7.34	13.88	55.25
16	2.4	8.2	7.46	9.56	38.06

Table 23. Chemical qualities of lime juice treated with 300 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.3	7.60	22.54	100.0
1	2.4	8.2	7.33	23.55	104.48
2	2.4	8.0	7.32	21.73	96.41
3	2.4	8.0	7.25	20.94	92.90
4	2.4	7.95	7.13	18.14	80.48
5	2.4	8.05	7.38	21.16	93.88
6	2.4	7.8	7.31	21.79	96.67
8	2.4	7.75	7.42	21.26	94.32
10	2.4	8.0	7.38	18.39	81.59
12	2.4	8.0	7.44	15.31	67.93
14	2.4	8.0	7.51	16.30	72.32
16	2.4	7.9	7.26	21.26	94.32
B. Room Temperature					
0	2.4	8.05	7.11	26.16	100.0
8	2.4	8.0	7.06	15.77	60.28
16	2.4	8.2	7.20	11.32	43.27

Table 25 Chemical qualities of lime juice treated with 400 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention
0	2.4	7.9	7.36	24.31	100.0
1	2.4	8.2	7.76	25.06	103.09
2	2.4	8.15	7.44	20.49	84.29
3	2.4	8.2	7.37	21.88	90.00
4	2.4	8.15	7.28	19.54	80.38
5	2.4	8.0	7.34	21.40	88.03
6	2.4	7.85	7.33	22.32	91.81
8	2.4	8.0	7.46	22.39	92.10
10	2.4	8.0	7.78	20.92	86.06
12	2.4	8.0	7.44	5.71	23.49
14	2.4	8.0	7.48	20.9	85.97
16	2.4	8.05	7.49	18.36	75.52
B. Room Temperature					
0	2.4	8.0	7.09	26.16	100.0
8	2.4	7.9	7.25	21.41	81.84
16	2.4	8.2	6.99	16.60	63.46

Table 27 Chemical qualities of lime juice treated with 500 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention
0	2.4	8.2	7.49	23.57	100.0
1	2.4	8.2	7.41	25.06	106.32
2	2.4	8.05	7.52	24.20	102.67
3	2.4	8.0	7.21	22.35	94.82
4	2.4	8.15	7.32	21.63	91.77
5	2.4	8.0	7.35	22.56	95.71
6	2.4	7.8	7.36	21.90	92.91
8	2.4	8.0	7.62	21.38	90.71
10	2.4	8.0	7.45	14.83	62.92
12	2.4	7.95	7.61	20.34	86.30
14	2.4	7.85	7.52	19.90	84.43
16	2.4	8.0	7.39	11.40	48.37
B. Room Temperature					
0	2.4	8.0	7.23	25.47	100.0
8	2.4	8.0	7.35	18.35	72.05
16	2.4	8.2	7.28	1.26	4.95

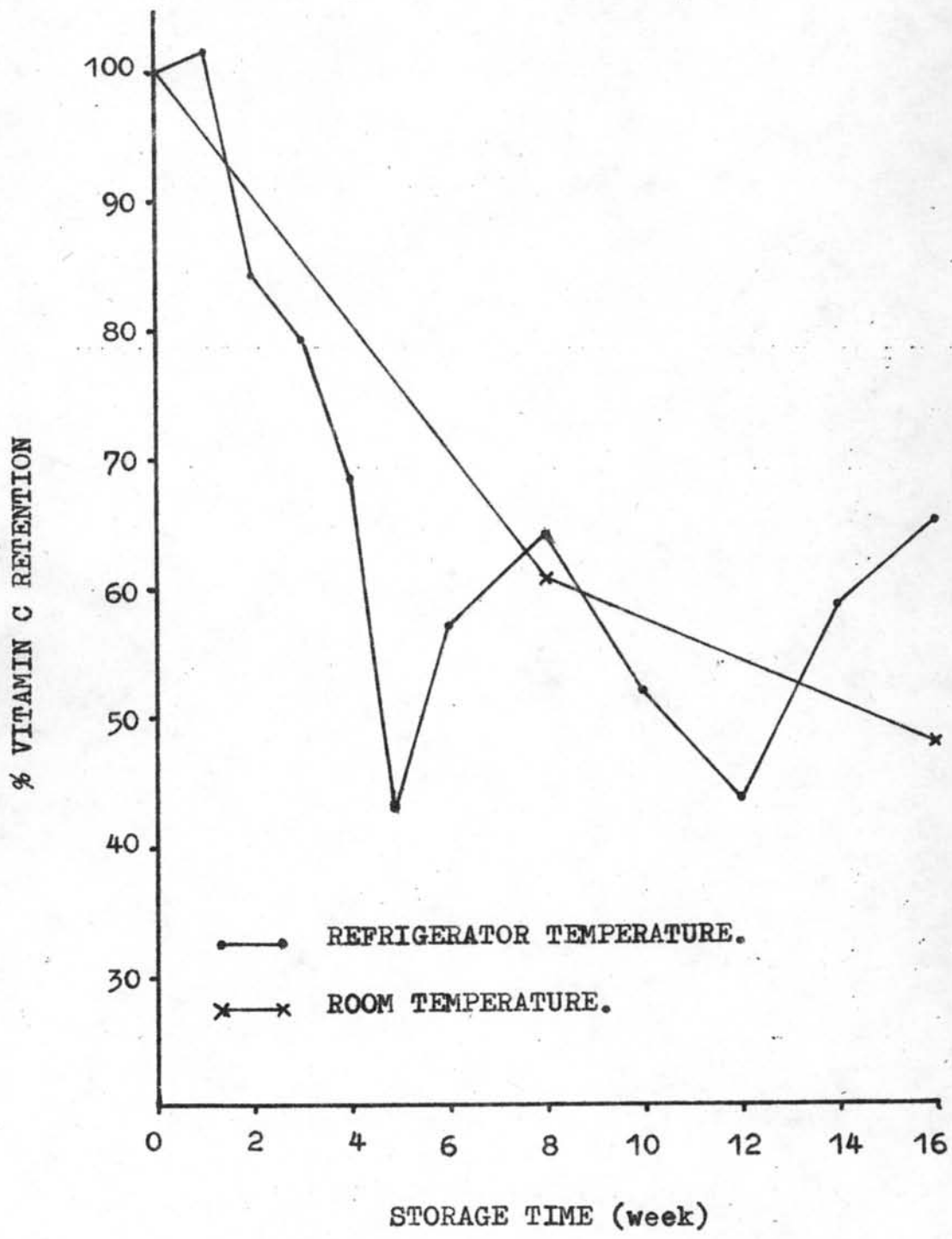


Fig. 7 Effect of 100 ppm potassium sorbate on Vitamin C retention.

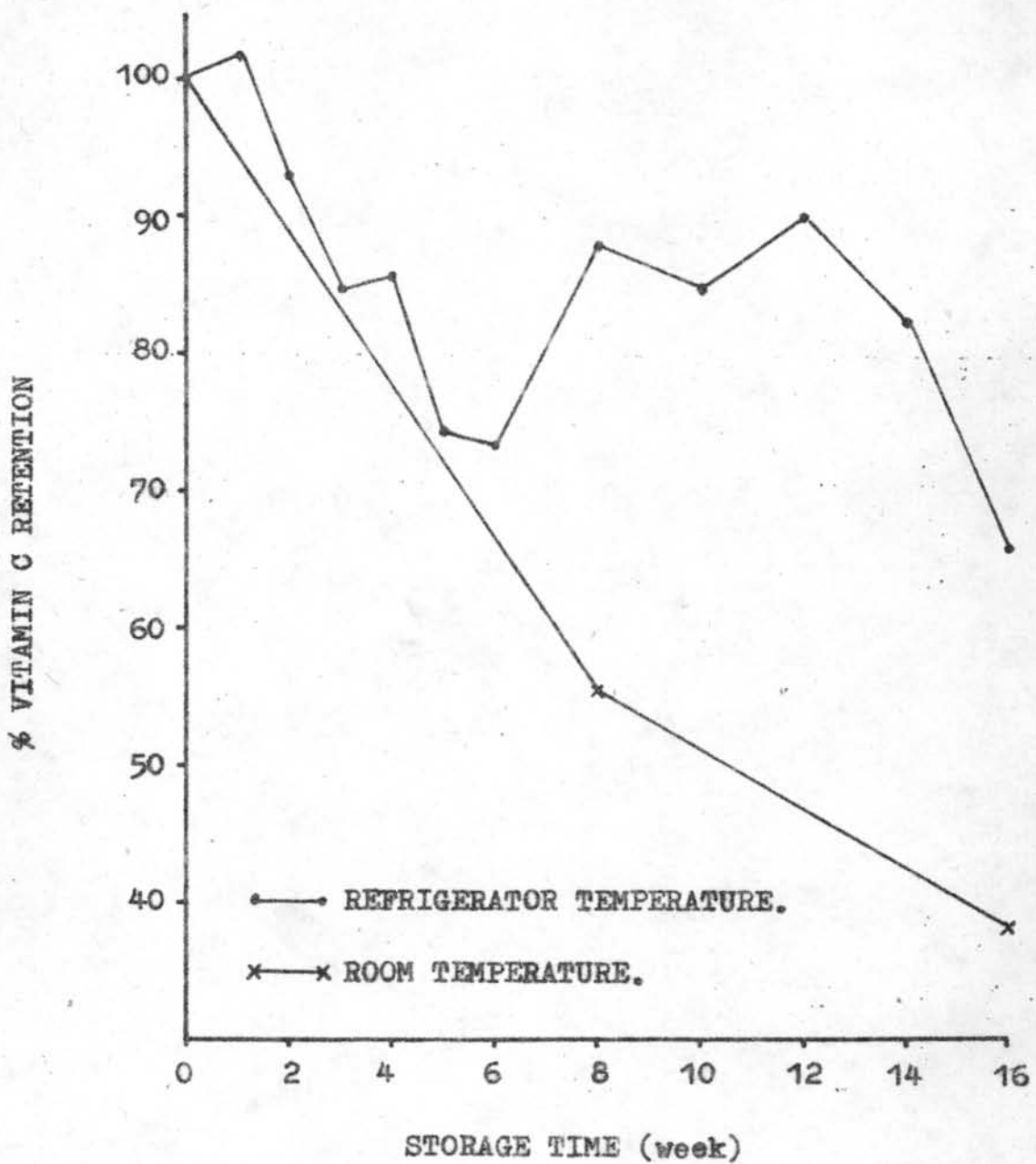


Fig. 8 Effect of 200 ppm potassium sorbate on Vitamin C retention.

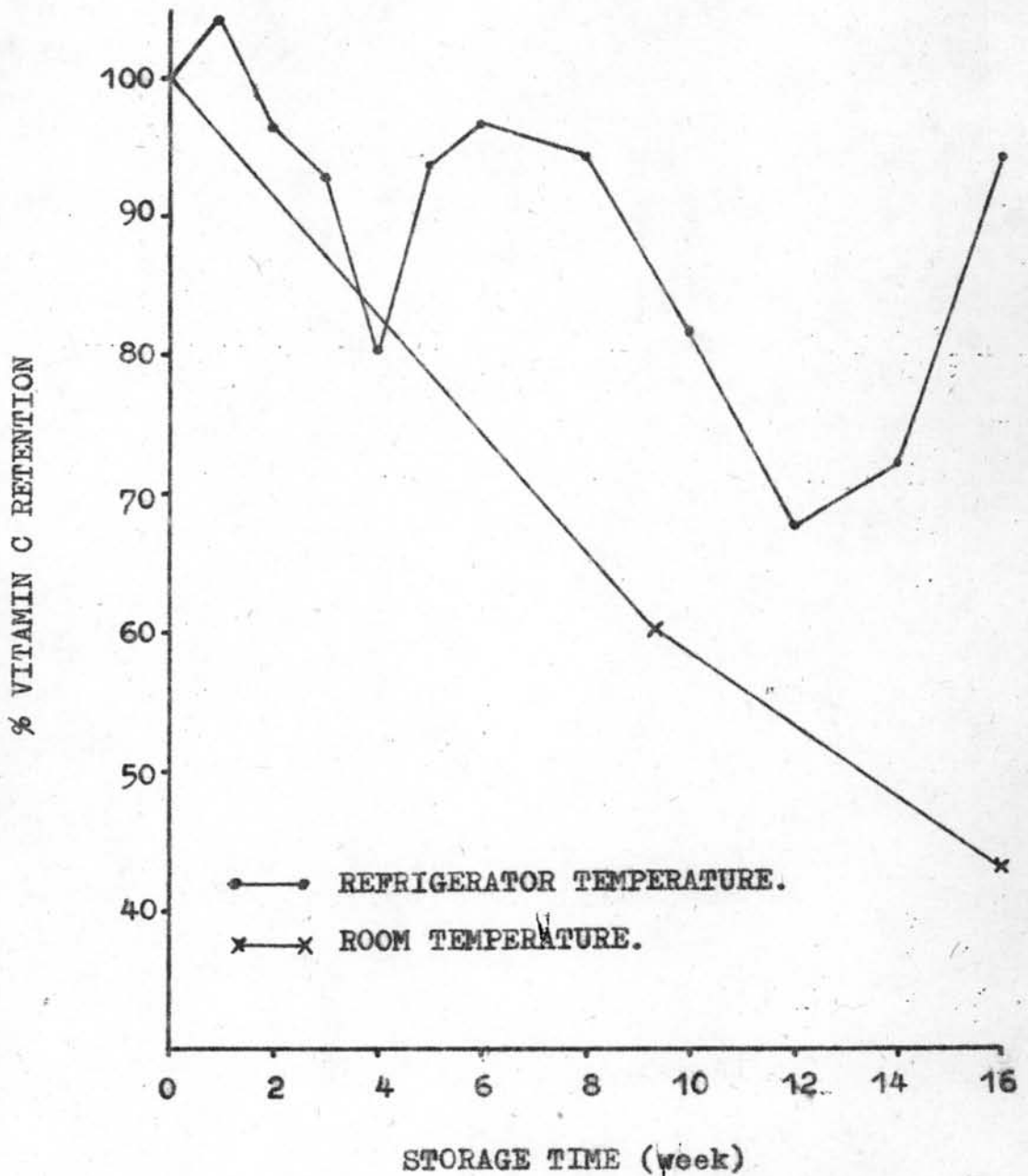


Fig. 9 Effect of 300 ppm potassium sorbate on Vitamin C retention.

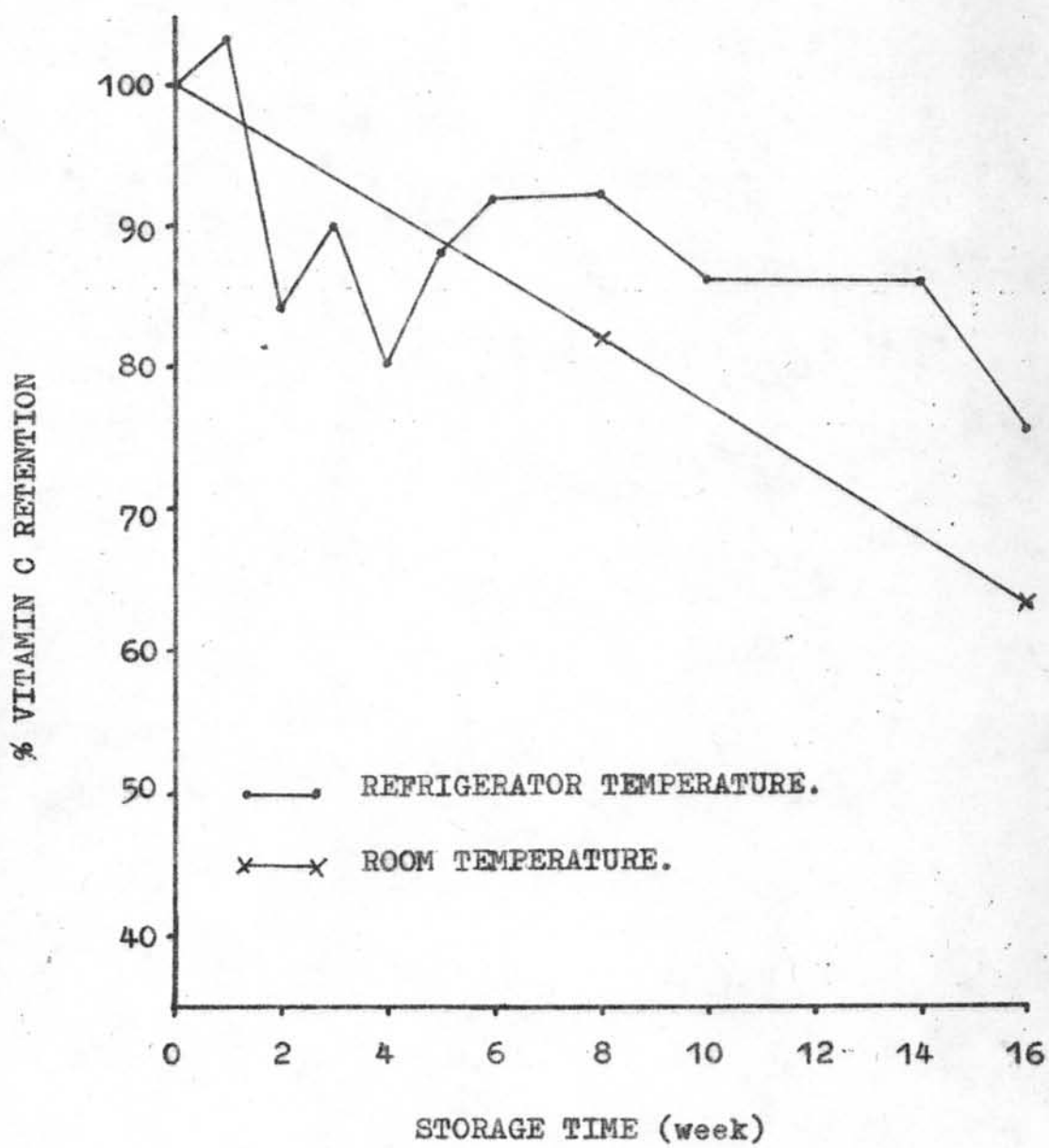


Fig. 10 Effect of 400 ppm potassium sorbate on Vitamin C retention.

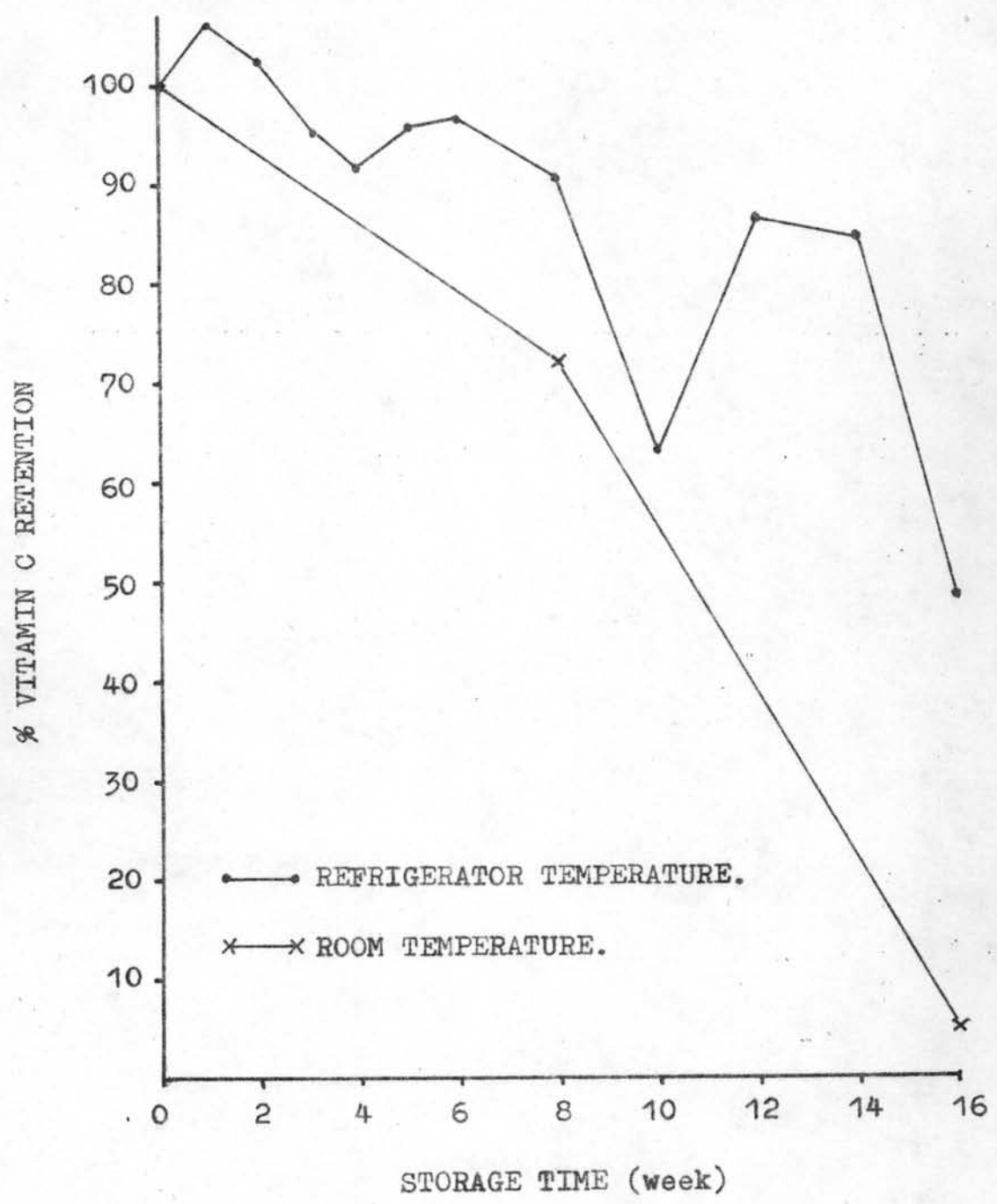


Fig. 11 Effect of 500 ppm potassium sorbate on Vitamin C retention.

In preventing browning development, potassium sorbate was inferior to potassium meta-bisulfite. So that lime juice treated with potassium sorbate alone was not suitable for storage at room temperature. Combination of additives would enhance keeping qualities of lime juice during storage. According to the previous work, orange juice treated with the minimum organoleptically detectable amount of SO_2 (84 ppm) in combination with benzoic acid (360 ppm) or sorbic acid (632 ppm) were better protected against micro-organism growth and colour darkening than juices treated only with 300 ppm SO_2 (Giminez et al., 1963). Therefore, experiments concerning studying combined effect of additives on preservation of lime juice were done.

4.4 Combined Effect of Potassium Meta-bisulfite and Potassium Sorbate

Studying the combined effect of potassium meta-bisulfite and potassium sorbate on the preservation of lime juice during storage test at refrigerator temperature and room temperature, lime juices were treated with various concentration of both potassium meta-bisulfite and potassium sorbate as indicated in Table 3. Sample III 1 was lime juice treated with 200 ppm potassium meta-bisulfite and 300 ppm potassium sorbate. Sample III 2 was lime juice treated with 250 ppm potassium meta-bisulfite and 250 ppm potassium sorbate. Sample III 3 was lime juice treated with 300 ppm potassium meta-bisulfite and 200 ppm potassium sorbate.

The result was that at refrigerator temperature all three samples were still acceptable at the end of the fourth month whilst

at room temperature they were still acceptable at the end of the second month but after 4 months of storage time they were not acceptable any more because of browning appearance.

Chemical and physical qualities of Sample III 1, III 2, and III 3 during 4 months of storage time at refrigerator temperature and room temperature were present in Table 29-34.

At both storage temperature, pH value of all samples were equal to 2.4 without any change during the storage test. °Brix and % Acidity in each sample varied slightly.

Course of Vit. C retention in sample III 1, III 2 and III 3 during 4 months of storage time at room temperature and refrigerator temperature were shown in Figure 12-14. It was evident that loss of Vit. C at room temperature was greater than at refrigerator temperature although the % Vit. C retention varied irregularly during the test but it still varied with tendency of decreasing. The least variability of Vit. C loss was in sample III 1 and the greatest was in sample III 3.

According to colour and general appearance, after 4 months of storage time at refrigerator temperature all three samples had colour and appearance nearly the same as fresh sample and it was better compared to lime juice which was treated either with 500 ppm of potassium meta-bisulfite or potassium sorbate only. At room temperature, all three samples were acceptable at the end of the second month after that browning developed quickly and the samples were not acceptable any more.

Table 29 Chemical qualities of lime juice treated with 200 ppm potassium meta-bisulfite and 300 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	7.9	7.22	35.88	100.0
2	2.4	8.0	6.64	34.52	96.21
4	2.4	8.0	7.44	33.98	94.70
6	2.4	8.2	7.30	31.02	86.45
8	2.4	8.0	7.17	33.18	92.47
10	2.4	8.0	7.23	30.62	85.34
12	2.4	8.2	7.09	31.48	87.74
14	2.4	8.0	7.02	32.55	90.72
16	2.4	8.2	7.04	25.0	69.68
B. Room Temperature					
0	2.4	7.9	7.22	35.88	100.0
2	2.4	8.0	7.05	33.85	94.34
4	2.4	8.0	7.17	31.14	86.79
6	2.4	8.2	7.38	30.37	84.64
8	2.4	8.1	7.32	28.22	78.65
10	2.4	8.3	7.26	26.02	72.52
12	2.4	8.4	6.98	24.82	69.18
14	2.4	8.0	7.19	22.73	63.35
16	2.4	8.0	7.17	23.83	66.42

Table 30 Physical qualities of lime juice treated with 200 ppm potassium meta-bisulfite and 300 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	31.7	11.0	10.1	34.6	12.6	0	-	-
2	35.0	12.7	14.2	35.2	2.9	0	4.3	Dislike slightly
4	26.2	9.0	14.3	35.8	14.7	0	5.6	Like slightly
6	24.1	5.4	14.8	41.3	14.4	0	5.4	Neither like nor dislike
8	30.6	8.8	15.8	39.2	5.6	0	4.7	" "
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	32.8	5.8	14.4	33.8	13.2	0	4.0	Dislike slightly
14	29.0	5.2	12.2	38.8	14.8	+	4.14	" "
16	27.5	7.6	13.8	36.2	14.9	+	5.4	Neither like nor dislike
B. Room Temperature								
0	31.7	11.0	10.1	34.6	12.6	0	-	-
2	30.3	15.0	16.1	31.2	7.4	+	4.8	Neither like nor dislike
4	15.5	4.0	14.2	34.5	31.8	++	4.5	" "
6	24.7	6.5	10.6	33.4	24.8	+++	5.5	Like slightly
8	34.1	7.4	6.0	32.5	20.0	++++	4.6	Neither like nor dislike
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	-	-	-	-	-	+++++	-	-

Table 31 Chemical qualities of lime juice treated with 250 ppm potassium meta-bisulfite and 250 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.0	7.23	35.88	100.0
2	2.4	8.0	7.03	32.88	91.64
4	2.4	8.0	7.32	33.33	92.89
6	2.4	8.0	7.05	33.60	93.65
8	2.4	8.0	6.93	31.94	89.02
10	2.4	8.0	7.03	26.37	73.49
12	2.4	8.1	6.99	31.48	87.74
14	2.4	8.1	7.10	30.73	85.65
16	2.4	8.0	6.87	27.33	76.17
B. Room Temperature					
0	2.4	8.0	7.23	35.88	100.0
2	2.4	7.8	6.89	31.54	87.90
4	2.4	8.0	7.08	30.89	86.09
6	2.4	8.0	7.10	30.76	85.73
8	2.4	8.0	7.09	26.05	72.60
10	2.4	8.2	7.02	25.66	71.52
12	2.4	8.4	6.96	21.85	60.90
14	2.4	8.0	6.91	22.18	61.82
16	2.4	7.9	6.93	13.17	50.64

Table 32 Physical qualities of lime juice treated with 250 ppm potassium meta-bisulfite and 250 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	30.8	11.6	10.0	39.3	8.3	0	-	-
2	35.0	12.7	14.2	35.2	2.9	0	4.0	Dislike slightly
4	25.5	6.0	13.6	38.3	16.6	0	5.2	Neither like nor dislike
6	24.0	4.8	14.3	42.3	14.6	0	6.4	Like slightly
8	33.1	7.5	15.8	40.0	3.6	0	4.3	Dislike slightly
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	30.0	8.6	11.4	38.9	11.1	0	3.6	Dislike slightly
14	29.1	5.1	13.8	37.6	14.4	+	5.4	Neither like nor dislike
16	26.5	6.5	13.3	39.0	14.7	+	5.6	Like slightly
B. Room Temperature								
0	30.8	11.6	10.0	39.3	8.3	0	-	-
2	32.3	13.1	14.5	33.4	6.7	+	4.0	Dislike slightly
4	15.5	4.0	14.2	34.5	31.8	++	4.2	Dislike slightly
6	23.2	6.5	10.6	35.0	24.7	+++	5.1	Neither like nor dislike
8	30.5	8.0	7.5	34.8	19.2	++++	3.4	Dislike moderately
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	-	-	-	-	-	+++++	-	-

Table 33 Chemical qualities of lime juice treated with 300 ppm potassium meta-bisulfite and 200 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.0	7.16	35.49	100.0
2	2.4	8.0	6.86	33.46	94.28
4	2.4	8.2	7.25	33.82	95.29
6	2.4	8.2	7.09	32.44	91.41
8	2.4	8.0	7.08	31.01	87.38
10	2.4	8.0	7.09	28.85	81.29
12	2.4	8.0	7.04	32.22	90.79
14	2.4	8.0	7.01	29.09	81.97
16	2.4	8.0	6.97	24.33	68.55
B. Room Temperature					
0	2.4	8.0	7.16	35.49	100.0
2	2.4	8.0	6.76	29.62	83.46
4	2.4	7.9	6.89	28.29	79.71
6	2.4	8.0	7.10	29.59	83.38
8	2.4	8.0	7.17	24.19	68.16
10	2.4	8.0	6.93	17.70	49.87
12	2.4	8.4	7.09	24.82	69.94
14	2.4	8.0	6.87	13.82	38.94
16	2.4	8.0	6.83	25.67	72.33

Table 34 Physical qualities of lime juice treated with 300 ppm potassium meta-bisulfite and 200 ppm potassium sorbate during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Ranke
0	31.0	11.4	9.7	38.2	9.7	0	-	-
2	35.2	13.4	14.1	35.3	2.0	0	4.8	Neither like nor dislike
4	25.9	5.2	17.0	38.5	13.4	0	5.2	" "
6	24.7	5.5	14.2	41.0	14.6	0	6.2	Like slightly
8	34.6	7.3	15.3	38.8	4.0	0	4.7	Neither like nor dislike
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	32.6	7.2	11.6	38.8	9.8	0	4.4	Dislike slightly
14	28.2	7.7	13.3	39.0	11.8	+	5.3	Neither like nor dislike
16	25.1	6.5	14.4	39.2	14.8	+	6.4	Like slightly
B. Room Temperature								
0	31.0	11.4	9.7	38.2	9.7	0	-	-
2	32.4	12.0	14.4	33.3	7.9	+	4.3	Dislike slightly
4	16.7	3.3	12.2	36.0	31.8	++	4.4	Dislike slightly
6	20.7	7.8	8.5	34.8	28.2	+++	6.0	Like slightly
8	32.0	7.0	6.3	32.6	22.1	++++	3.6	Dislike slightly
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	31.6	0	28.5	20.2	19.7	+++++	-	-

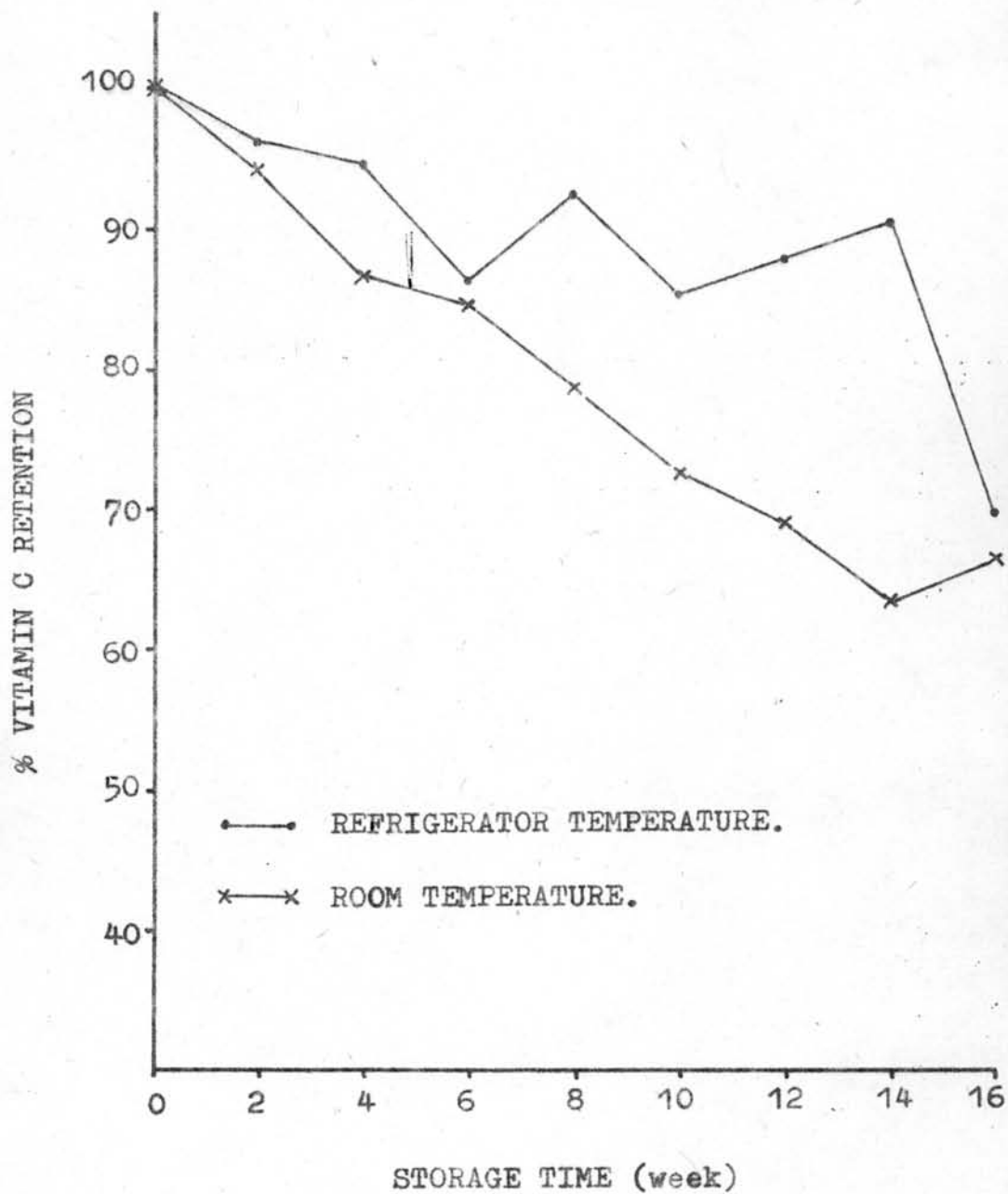


Fig. 12 Effect of 200 ppm potassium meta-bisulfite, and 300 ppm potassium sorbate on Vitamin C retention.

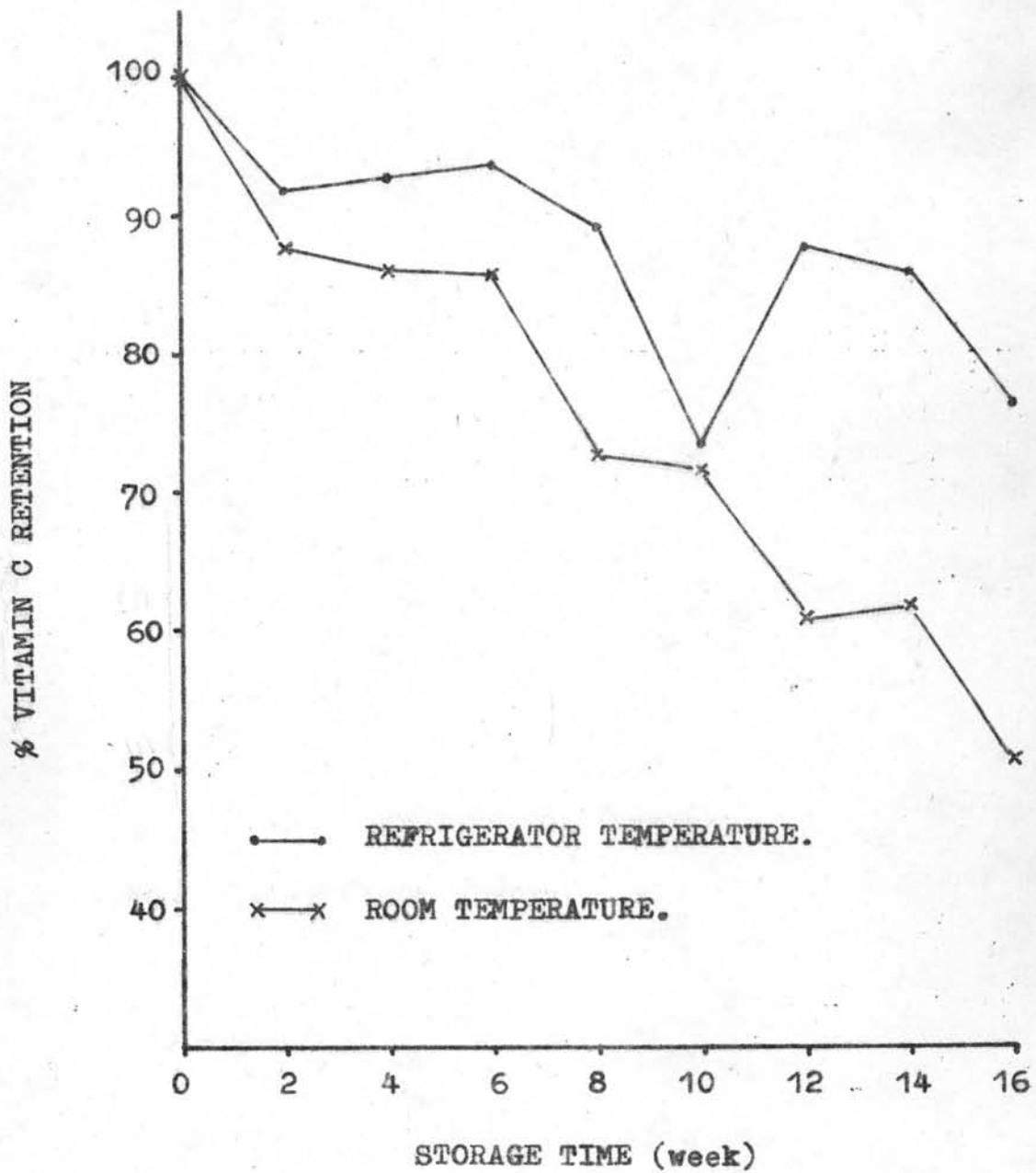


Fig. 13 Effect of 250 ppm potassium meta-bisulfite, and 250 ppm potassium sorbate on Vitamin C retention.

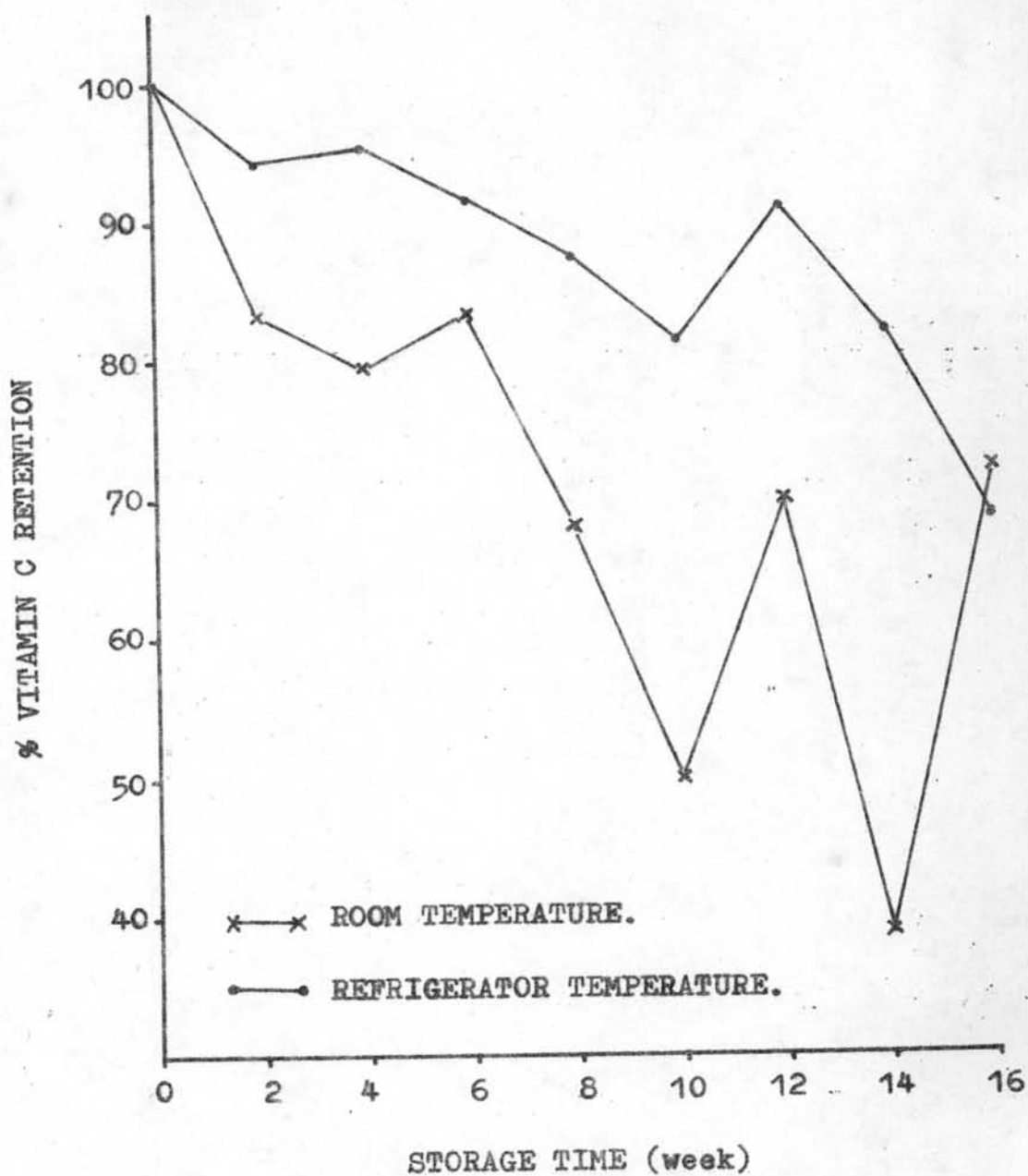


Fig. 14 Effect of 300 ppm potassium meta-bisulfite, and 200 ppm potassium sorbate on Vitamin C retention.



Results from sensory test revealed that at refrigerator temperature, all three samples were still acceptable at the end of the fourth month. At room temperature, Sample III 2, and III 3 were not acceptable at the end of the second month whilst sample III 1 was still acceptable. There were so many comments on off flavour taste which caused by adding potassium meta-bisulfite, heat processing and juice extraction. Inactivation of enzyme by using direct heat caused off flavour to appear. Method of juice extraction used in this experiment was not good because bitter principles from seeds and peel could dissolve into lime juice during processing.

As the whole, keeping qualities of all three samples were nearly the same and combination of potassium meta-bisulfite and potassium sorbate resulted in good keeping qualities of lime juice compared to lime juice treated with each kind of additives alone.

4.5 Combined Effect of Potassium Meta-bisulfite, Potassium Sorbate and Ascorbic Acid.

Studying the combined effect of potassium meta-bisulfite, potassium sorbate and ascorbic acid on the preservation of lime juice during storage test at refrigerator temperature and room temperature, samples of lime juice were treated with various concentration of additive as indicated in Table 4.

The result was that at refrigerator temperature, all three samples treated with various combination of potassium meta-bisulfite and potassium sorbate with addition of 30 mg ascorbic acid per 100ml of

lime juice were still acceptable at the end of four months of storage time whilst the samples stored at room temperature had colour and general appearance that were still acceptable at the end of the second month with not so good results of sensory test.

Chemical and physical qualities of all samples at refrigerator temperature and room temperature were present in Table 35-40. Keeping qualities of all three samples were the same as the results in studying the combined effect of potassium meta-bisulfite and potassium sorbate. The only one different result was the final concentration of ascorbic acid in the samples. Course of Vit.C retention in all three samples during 4 months of storage time at room temperature and at refrigerator temperature were shown in Figure 15-17. At refrigerator temperature, the least % Vit. C retention (69.79 %) was in the sample treated with 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate and 30 mg ascorbic acid per 100 ml of lime juice at the end of the fourteenth week. But the final concentration of ascorbic acid (45.09 mg per 100 ml of sample) was still higher than average concentration of ascorbic acid in fresh lime juice. Therefore, keeping lime juice for four months at refrigerator temperature, the amount of 30 mg ascorbic acid added per 100ml of lime juice would be excess for enhancing nutritional value of the juice. According to browning appearance which caused by destruction of ascorbic acid and the intensity of browning was proportional to the amount of ascorbic acid destruction, the amount of ascorbic acid added should be lower to the content that only yielded final concentration the same as fresh lime juice.

Table 35 Chemical qualities of lime juice treated with 200 ppm potassium meta bisulfite, 300 ppm potassium sorbate and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	7.90	6.94	63.43	100.0
2	2.4	7.98	6.69	61.15	96.41
4	2.4	8.0	7.10	56.91	89.72
6	2.4	8.1	7.10	58.09	91.58
8	2.4	7.9	7.21	52.56	82.86
10	2.4	8.0	7.11	54.34	85.67
12	2.4	8.2	7.00	58.33	91.96
14	2.4	8.0	6.90	56.55	89.15
16	2.4	8.0	6.98	47.0	74.08
B. Room Temperature					
0	2.4	7.9	6.94	63.43	100.0
2	2.4	8.0	7.09	58.85	92.78
4	2.4	8.0	7.08	55.04	86.77
6	2.4	8.1	7.23	52.47	82.72
8	2.4	8.2	7.38	51.94	81.89
10	2.4	8.2	7.26	47.35	74.65
12	2.4	8.4	6.76	44.44	70.06
14	2.4	8.1	7.18	48.55	76.54
16	2.4	8.0	7.02	36.33	57.28

Table 36 Physical qualities of lime juice treated with 200 ppm potassium meta-bisulfite, 300 ppm potassium sorbate and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	31.7	11.0	10.1	34.6	12.6	0	-	-
2	35.0	12.7	14.2	35.2	2.9	0	4.1	Dislike slightly
4	25.5	6.0	13.6	38.3	16.6	0	5.9	Like slightly
6	24.1	5.4	14.8	41.3	14.4	0	5.9	" "
8	33.8	8.7	15.4	37.1	5.0	0	4.1	Dislike slightly
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	33.8	6.1	12.8	37.2	10.1	0	4.8	Neither like nor dislike
14	29.0	5.2	12.2	38.8	14.8	+	4.9	" "
16	27.5	7.6	13.8	36.2	14.9	+	5.2	" "
B. Room Temperature								
0	31.7	11.0	10.1	34.6	12.6	0	-	-
2	31.8	15.8	15.2	31.3	5.9	+	3.9	Dislike slightly
4	15.5	4.0	14.2	34.5	31.8	++	4.5	Neither like nor dislike
6	23.2	6.5	10.6	35.0	24.7	+++	5.5	Like slightly
8	34.1	7.4	6.0	32.5	20.0	++++	4.3	Dislike slightly
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	-	-	-	-	-	+++++	-	-

Table 37 Chemical qualities of lime juice treated with 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.0	7.14	64.61	100.0
2	2.4	8.0	6.95	63.17	97.77
4	2.4	8.2	6.92	60.98	94.38
6	2.4	8.2	7.10	62.29	96.41
8	2.4	8.2	7.24	60.31	93.34
10	2.4	8.1	7.23	56.64	87.66
12	2.4	8.2	6.99	56.39	87.28
14	2.4	8.0	7.07	45.09	69.79
16	2.4	8.0	7.02	53.83	83.32
B. Room Temperature					
0	2.4	8.0	7.14	64.61	100.0
2	2.4	7.8	6.96	56.83	87.96
4	2.4	8.0	6.90	50.73	78.52
6	2.4	8.0	7.11	52.34	81.01
8	2.4	8.0	7.17	51.01	78.95
10	2.4	8.1	7.01	46.73	72.33
12	2.4	8.4	6.99	45.37	70.22
14	2.4	8.0	6.91	45.64	70.64
16	2.4	8.0	6.97	38.07	58.92

Table 38 Physical qualities of lime juice treated with 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	30.8	11.6	10.0	39.3	8.3	0	-	-
2	35.2	13.4	14.1	35.3	2.0	0	4.9	Neither like nor dislike
4	25.5	6.0	13.6	38.3	16.6	0	5.4	" "
6	24.0	4.8	14.3	42.3	14.6	0	6.4	Like slightly
8	33.1	7.5	15.8	40.0	3.6	0	3.8	Dislike slightly
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	32.6	7.2	11.6	38.8	9.8	0	4.6	Neither like nor dislike
14	29.1	5.1	13.8	37.6	14.4	+	5.3	" "
16	26.5	6.5	13.3	39.0	14.7	+	5.2	" "
B. Room Temperature								
0	30.8	11.6	10.0	39.3	8.3	0	-	-
2	32.3	13.1	14.5	33.4	6.7	+	4.9	Neither like nor dislike
4	15.5	4.0	14.2	34.5	31.8	++	5.6	Like slightly
6	24.2	4.5	8.5	34.2	28.6	+++	5.9	" "
8	30.5	8.0	7.5	34.8	19.2	++++	3.7	Dislike slightly
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	-	-	-	-	-	+++++	-	-

Table 39 Chemical qualities of lime juice treated with 300 ppm potassium meta-bisulfite, 200 ppm potassium sorbate and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	7.8	6.94	64.51	100.0
2	2.4	7.8	6.65	59.90	92.85
4	2.4	8.0	7.14	60.65	94.02
6	2.4	8.0	6.83	59.71	92.56
8	2.4	8.0	7.06	60.78	94.22
10	2.4	8.1	7.03	58.05	89.99
12	2.4	7.6	6.14	52.22	80.95
14	2.4	8.0	6.87	56.55	87.66
16	2.4	8.0	6.76	47.67	73.90
B. Room Temperature					
0	2.4	7.8	6.94	64.51	100.0
2	2.4	8.0	6.84	59.62	92.42
4	2.4	8.0	7.04	53.66	83.18
6	2.4	8.0	7.01	53.44	82.84
8	2.4	8.0	6.88	54.65	84.72
10	2.4	8.0	6.87	42.83	66.39
12	2.4	8.2	6.91	48.15	74.64
14	2.4	7.8	6.64	33.45	51.85
16	2.4	8.0	6.80	41.67	64.59

Table 40 Physical qualities of lime juice treated with 300 ppm potassium meta-bisulfite, 200 ppm potassium sorbate and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	31.0	11.4	9.7	38.2	9.7	0	-	-
2	28.3	13.3	14.0	37.9	6.5	0	4.2	Dislike slightly
4	25.9	5.2	17.0	38.5	13.4	0	5.6	Like slightly
6	24.7	5.5	14.2	41.0	14.6	0	5.4	Neither like nor dislike
8	34.6	7.3	15.3	38.8	4.0	0	4.2	Dislike slightly
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	32.5	9.1	9.8	39.0	9.6	0	3.8	Dislike slightly
14	28.2	7.7	13.3	39.0	11.8	+	4.7	Neither like nor dislike
16	25.1	6.5	14.4	39.2	14.8	+	6.2	Like slightly
B. Room Temperature								
0	31.0	11.4	9.7	38.2	9.7	0	-	-
2	32.4	12.0	14.4	33.3	7.9	+	3.9	Dislike slightly
4	10.0	5.0	14.2	38.8	32.0	++	5.4	Neither like nor dislike
6	20.7	7.8	8.5	34.8	28.2	+++	5.8	Like slightly
8	29.1	7.0	6.3	35.6	22.0	+++	3.7	Dislike slightly
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	-	-	-	-	-	+++++	-	-
16	-	-	-	-	-	+++++	-	-

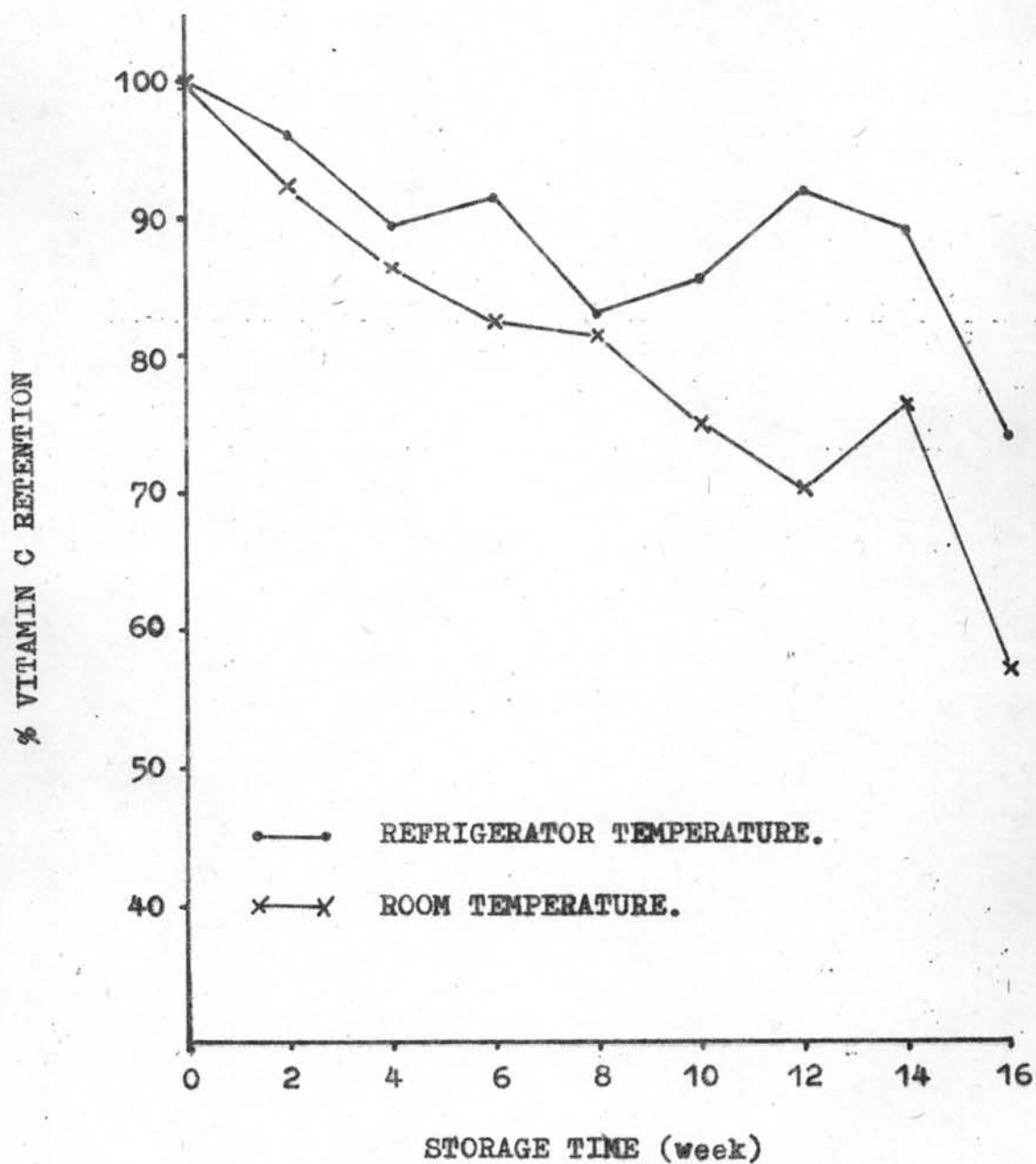


Fig. 15 Effect of 200 ppm potassium meta-bisulfite, 300 ppm potassium sorbate, and ascorbic acid on Vitamin C retention.

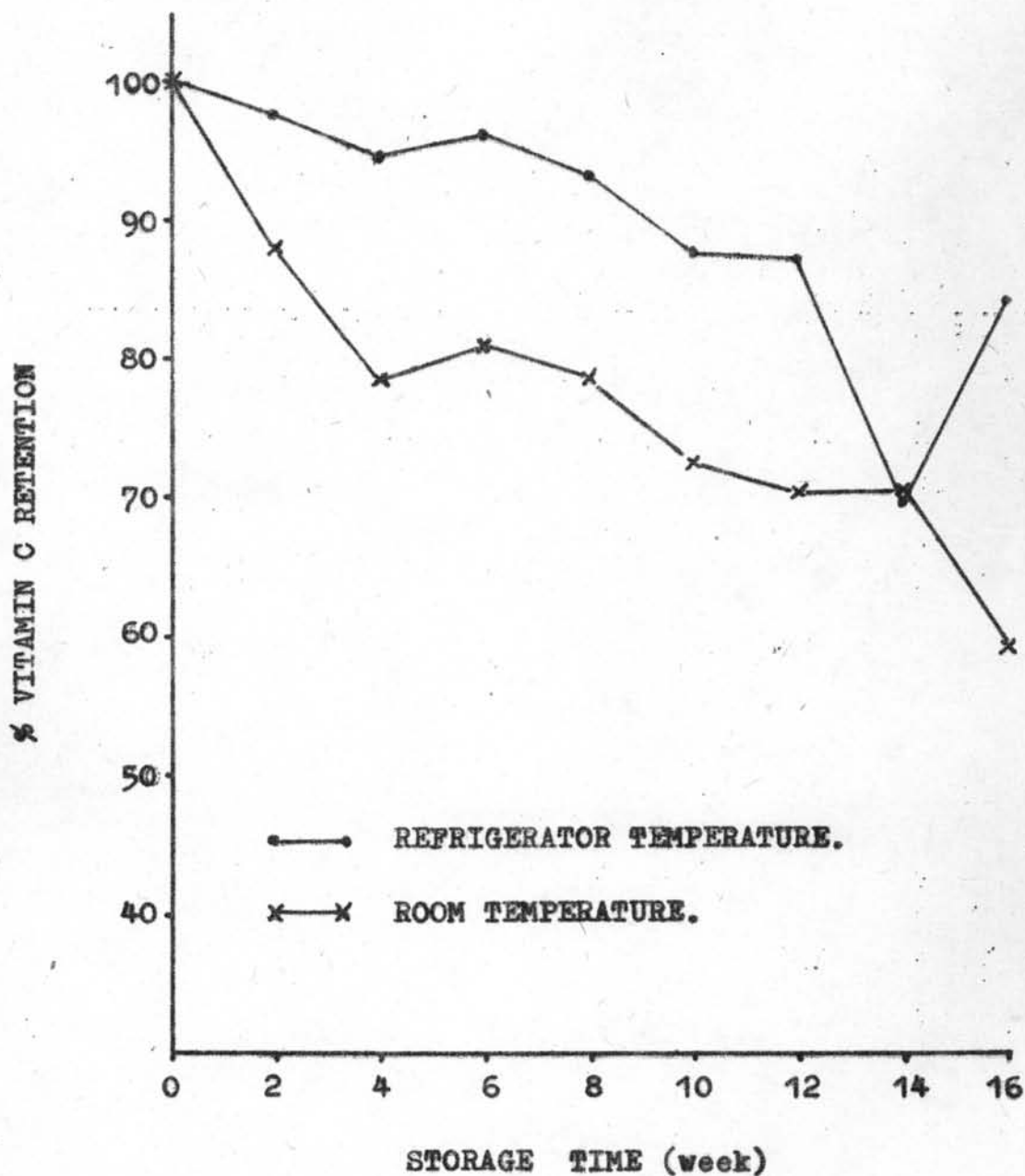


Fig.16 Effect of 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate, and ascorbic acid on Vitamin C retention.

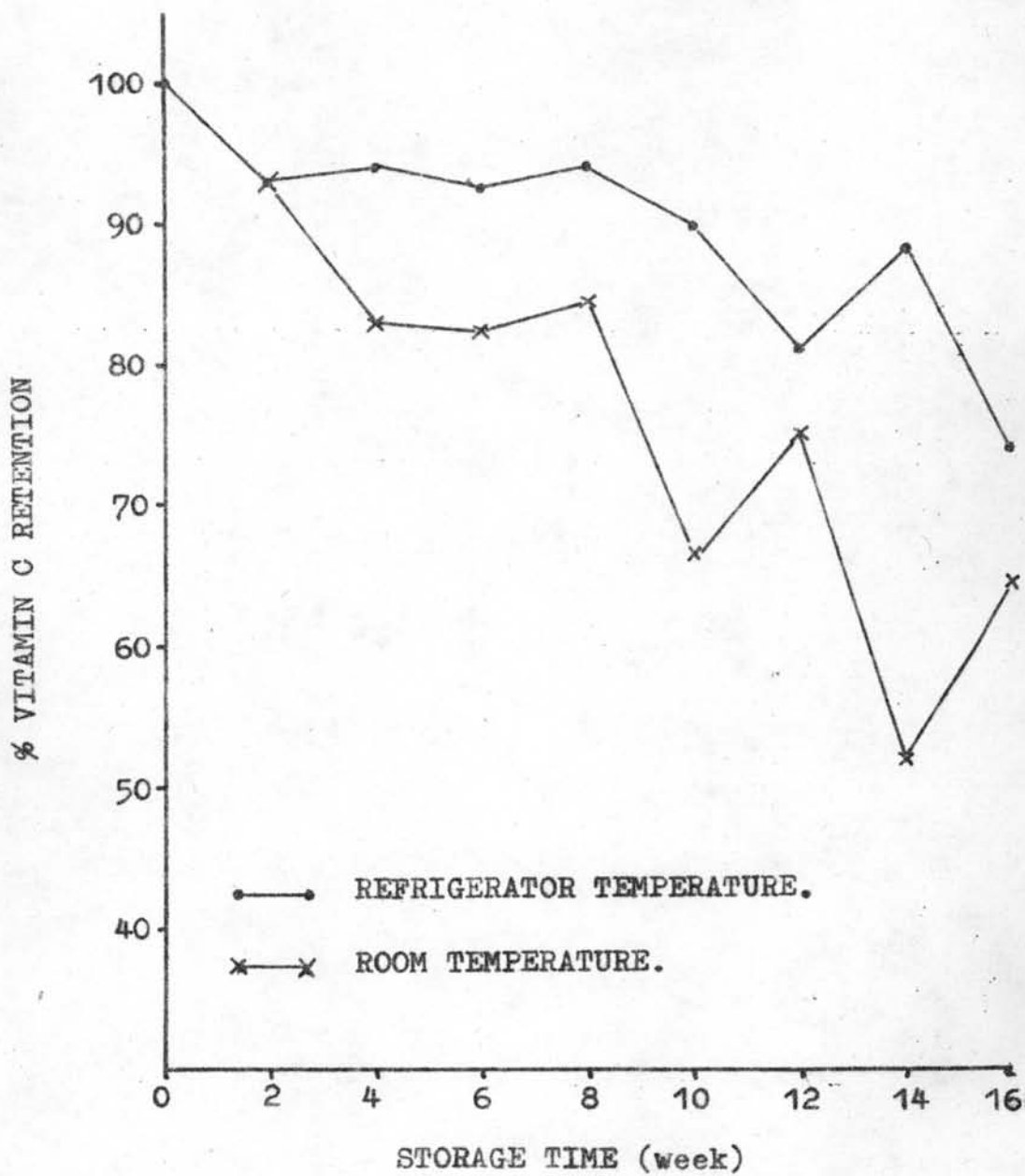


Fig. 17 Effect of 300 ppm potassium meta-bisulfite, 200 ppm potassium sorbate, and ascorbic acid on Vitamin C retention.

At room temperature, loss of ascorbic acid was quicker than at refrigerator temperature. The least % Vit. C retention (51.85) was in the sample treated with 300 ppm potassium meta-bisulfite, 200 ppm potassium sorbate and 30 mg ascorbic acid per 100 ml of lime juice at the end of the fourteenth week. The final concentration of ascorbic acid was 33.45 mg per 100 ml which was a little higher than fresh sample, but due to colour and general appearance it would not be acceptable any more. During the two month period which all three sample were still acceptable, the least % Vit. C retention (78.52) was in the sample treated with 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate and 30 mg ascorbic acid per 100 ml of lime juice at the end of the fourth week. The final concentration of ascorbic acid (50.73 mg per 100 ml) was higher than fresh sample thus the amount of ascorbic added should be lower than this experiment.

4.6 Combined Effect of Potassium Meta-bisulfite, Potassium Sorbate, Butylated Hydroxy-anisole, and Ascorbic Acid.

Studying combined effect of potassium meta-bisulfite, potassium sorbate, butylated hydroxy-anisole (BHA) and ascorbic acid on the preservation of lime juice at refrigerator and room temperature, samples of lime juice were treated with various concentration of these additives as indicated in Table 5.

The results were that at refrigerator temperature all three samples had qualities and appearance which were still acceptable at the end of the fourth month of storage test whilst at room temperature it were acceptable only at the end of the second month and it were

not acceptable any more at the end of the fourth month. There was no significant effect resulted from adding BHA, an antioxidant, into samples of lime juice which were treated with various concentration of potassium meta-bisulfite, potassium sorbate and ascorbic acid.

Chemical and physical qualities of all three samples at refrigerator temperature and room temperature were present in Table 41-46. In view of chemical qualities at both storage temperature, pH values of all three samples were equal to 2.4 without any change throughout the storage test. °Brix and % Acidity of each sample varied slightly during the test.

Course of Vit. C retention in all three samples were shown in Fig 18-20. Vit. C retention in each sample varied irregularly with tendency of decreasing during the storage test. At refrigerator temperature, the least % Vit. C retention (72.08 %) was in the sample treated with 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate, 2 ppm BHA and 30 mg ascorbic acid per 100 ml of sample at the end of the fourth month. At room temperature, the least % Vit. C retention (54.09 %) was in the sample treated with 200 ppm potassium meta-bisulfite 300 ppm potassium sorbate, 2 ppm BHA and 30 mg ascorbic acid per 100 ml of juice at the end of the fourth month. But at this storage time, its appearance was not acceptable any more. During the storage time which the samples were still acceptable, the least % Vit. C retention (76.39%) was in the sample V 3. Values of the least % Vit. C retention at both temperature were a little higher compare to samples in part 5. This might due to the effect of BHA

Table 41 Chemical qualities of lime juice treated with 200 ppm potassium meta-bisulfite, 300 ppm potassium sorbate, 2 ppm BHA and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.0	7.32	64.71	100.0
2	2.4	8.0	7.05	62.02	95.84
4	2.4	8.0	6.98	60.08	92.85
6	2.4	8.2	7.48	54.67	84.48
8	2.4	8.2	7.32	55.19	85.29
10	2.4	8.0	7.09	54.16	83.70
12	2.4	8.4	7.01	55.37	85.57
14	2.4	8.0	7.07	50.55	78.12
16	2.4	8.1	6.99	48.0	74.18
B. Room Temperature					
0	2.4	8.0	7.32	64.71	100.0
2	2.4	8.0	6.91	58.27	90.05
4	2.4	8.0	6.99	54.80	84.69
6	2.4	8.2	7.12	50.79	78.49
8	2.4	8.1	7.17	50.39	77.87
10	2.4	8.2	7.16	42.12	65.09
12	2.4	8.4	6.60	34.44	53.22
14	2.4	8.0	6.99	48.0	74.18
16	2.4	8.0	6.98	35.0	54.09

Table 42 Physical qualities of lime juice treated with 200 ppm potassium meta-bisulfite, 300 ppm potassium sorbate, 2 ppm BHA and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	31.7	11.0	10.1	34.6	12.6	0	-	-
2	35.0	12.7	14.2	35.2	2.9	0	5.0	Neither like nor dislike
4	25.5	6.0	13.6	38.3	16.6	0	5.7	Like slightly
6	24.1	5.4	14.8	41.3	14.4	0	6.0	" "
8	33.8	8.7	15.4	37.1	5.0	0	4.7	Neither like nor dislike
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	32.6	7.2	11.6	38.8	9.8	0	4.6	Neither like nor dislike
14	29.0	5.2	12.2	38.8	14.8	+	5.3	" "
16	27.5	7.6	13.8	36.2	14.9	+	4.8	" "
B. Room Temperature								
0	31.7	11.0	10.1	34.6	12.6	0	-	-
2	31.3	15.8	15.2	31.3	5.9	+	5.0	Neither like nor dislike
4	15.5	4.0	14.2	34.5	31.8	++	4.7	" "
6	23.2	6.5	10.6	35.0	24.7	+++	5.6	Like slightly
8	34.1	7.4	6.0	32.5	20.0	++++	3.3	Dislike moderately
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	-	-	-	-	-	+++++	-	-

Table 43 Chemical qualities of lime juice treated with 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate, 2 ppm BHA and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	8.0	7.15	64.51	100.0
2	2.4	8.0	7.25	63.46	98.37
4	2.4	8.0	7.16	59.02	91.49
6	2.4	8.2	7.25	61.65	95.57
8	2.4	8.0	7.15	59.54	92.30
10	2.4	8.0	7.46	41.77	64.75
12	2.4	8.2	6.92	57.32	88.85
14	2.4	8.0	7.02	51.55	79.91
16	2.4	8.0	6.95	46.50	72.08
B. Room Temperature					
0	2.4	8.0	7.15	64.51	100.0
2	2.4	7.8	6.85	57.40	88.98
4	2.4	8.0	6.99	50.49	78.27
6	2.4	8.2	7.15	52.99	82.14
8	2.4	8.0	7.14	52.71	81.71
10	2.4	8.2	7.19	45.31	70.24
12	2.4	8.4	7.05	43.33	67.17
14	2.4	8.0	6.98	44.45	68.90
16	2.4	8.0	7.04	39.0	60.46

Table 44 Physical qualities of lime juice treated with 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate, 2 ppm BHA and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	30.8	11.6	10.0	39.3	8.3	0	-	-
2	35.2	13.4	14.1	35.3	2.0	0	5.7	Like slightly
4	25.9	5.2	17.0	38.5	13.4	0	6.4	" "
6	24.0	4.8	14.3	42.3	14.6	0	6.7	Like moderately
8	34.6	7.3	15.3	38.8	4.0	0	5.2	Neither like nor dislike
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	32.6	7.2	11.6	38.8	9.8	0	3.8	Dislike slightly
14	29.1	5.1	13.8	37.6	14.4	+	4.7	Neither like nor dislike
16	26.5	6.5	13.3	39.0	14.7	+	6.2	Like slightly
B. Room Temperature								
0	30.8	11.6	10.0	39.3	8.3	0	-	-
2	32.3	13.1	14.5	33.4	6.7	+	5.5	Like slightly
4	16.7	3.3	12.2	36.0	31.8	++	5.5	" "
6	24.2	4.5	8.5	34.2	28.6	+++	5.4	Neither like nor dislike
8	30.5	8.0	7.5	34.8	19.2	++++	3.6	Dislike slightly
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	-	-	-	-	-	+++++	-	-

Table 45 Chemical qualities of lime juice treated with 300 ppm potassium meta-bisulfite, 200 ppm potassium sorbate, 2 ppm BHA and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature					
Storage Time (wk)	pH	° Brix	% Acidity	Vit.C mg/100 ml	Vit.C %Retention
0	2.4	7.8	6.93	63.53	100.0
2	2.4	8.0	6.75	60.77	95.66
4	2.4	8.0	7.08	60.65	95.47
6	2.4	8.1	7.08	61.00	96.02
8	2.4	8.0	7.07	60.47	95.18
10	2.4	8.0	7.13	56.46	88.87
12	2.4	8.4	7.04	59.44	93.56
14	2.4	8.0	6.97	58.91	92.73
16	2.4	7.8	6.50	45.83	72.14
B. Room Temperature					
0	2.4	7.8	6.93	63.53	100.0
2	2.4	7.8	7.00	59.04	92.93
4	2.4	8.0	6.97	54.96	86.51
6	2.4	8.0	7.01	51.70	81.38
8	2.4	8.0	6.99	48.53	76.39
10	2.4	8.0	7.09	43.89	69.09
12	2.4	8.2	6.92	42.22	66.46
14	2.4	7.8	6.76	44.44	69.95
16	2.4	7.8	6.78	35.0	55.09

Table 46 Physical qualities of lime juice treated with 300 ppm potassium meta-bisulfite, 200 ppm potassium sorbate, 2 ppm BHA and ascorbic acid during 4 months of storage time.

A. Refrigerator Temperature								
Storage Time (wk)	% Colour					Browning Appearance	Hedonic Scaling	
	Yellow	White	Grey	Green	Yellow Red		Average Value	Rank
0	31.0	11.4	9.7	38.2	9.7	0	-	-
2	28.3	13.3	14.0	37.9	6.5	0	4.3	Dislike slightly
4	25.9	5.2	17.0	38.5	13.4	0	5.9	Like slightly
6	24.7	5.5	14.2	41.0	14.6	0	6.0	" "
8	34.6	7.3	15.3	38.8	4.0	0	4.6	Neither like nor dislike
10	31.8	6.6	14.1	38.9	8.6	0	-	-
12	32.5	9.1	9.8	39.0	9.6	0	4.2	Dislike slightly
14	28.2	7.7	13.3	39.0	11.8	+	4.7	Neither like nor dislike
16	25.1	6.5	14.4	39.2	14.8	+	5.4	" "
B. Room Temperature								
0	31.0	11.4	9.7	38.2	9.7	0	-	-
2	32.4	12.0	14.4	33.3	7.9	+	4.5	Neither like nor dislike
4	10.0	5.0	14.2	38.8	32.0	++	6.4	Like slightly
6	20.7	7.8	8.5	34.8	28.2	+++	5.1	Neither like nor dislike
8	28.7	7.0	6.8	32.5	25.0	++++	3.9	Dislike slightly
10	33.5	0	21.5	24.5	20.5	+++++	-	-
12	33.2	0	24.0	19.1	23.7	+++++	-	-
14	32.0	0	24.9	21.1	22.0	+++++	-	-
16	-	-	-	-	-	+++++	-	-

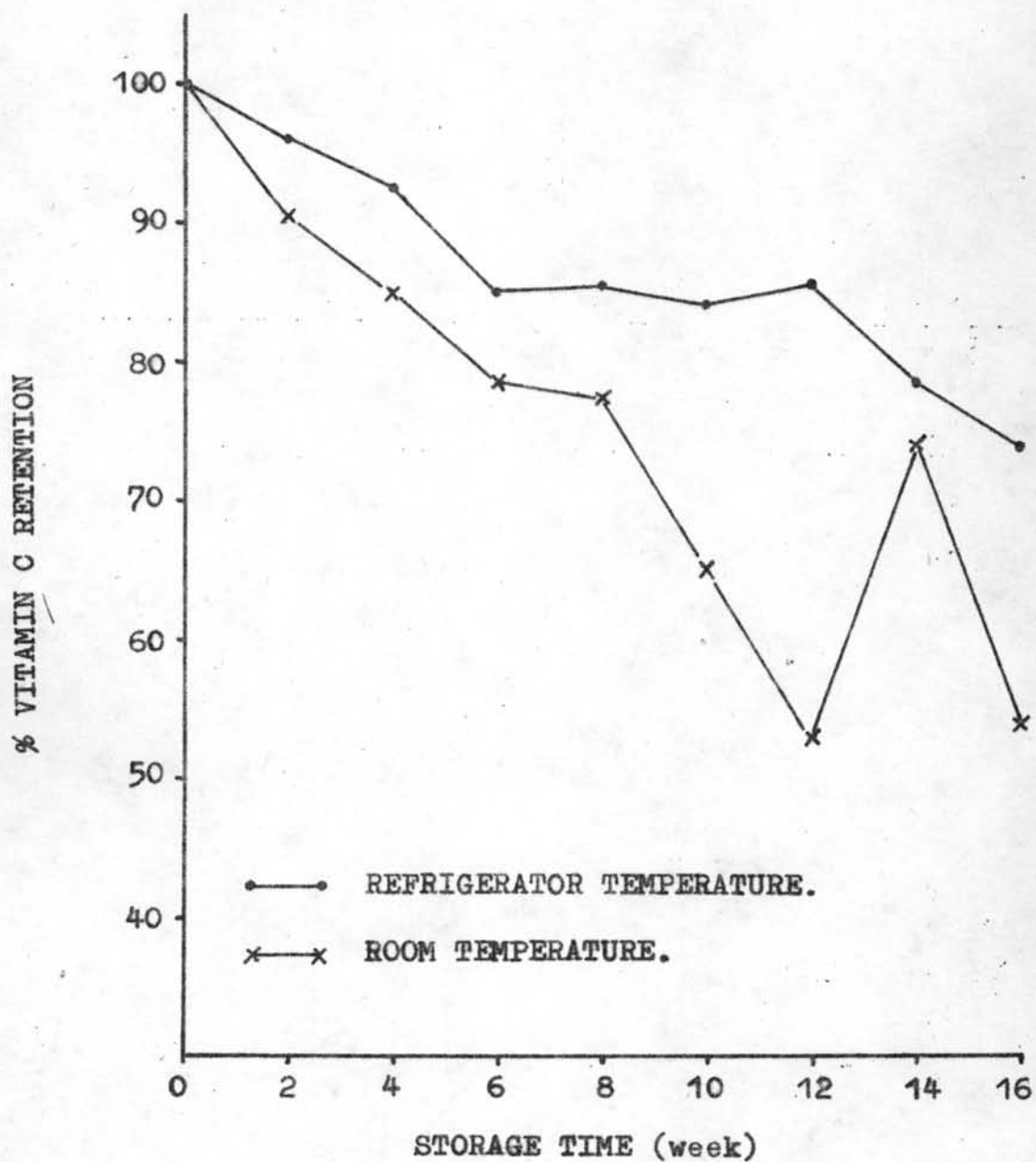


Fig. 18 Effect of 200 ppm potassium meta-bisulfite, 300 ppm potassium sorbate, 2 ppm BHA, and ascorbic acid on Vitamin C retention.

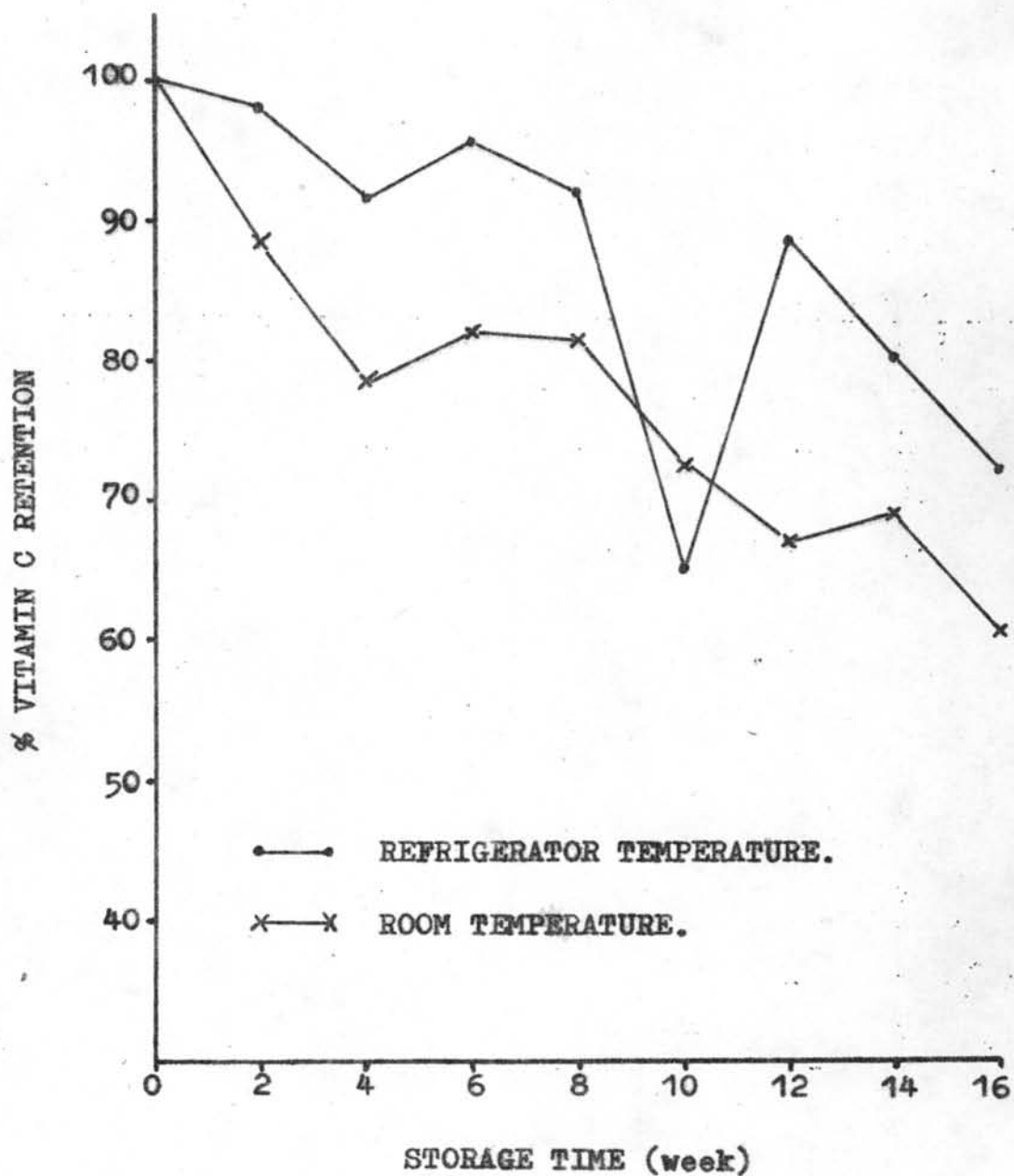


Fig. 19 Effect of 250 ppm potassium meta-bisulfite, 250 ppm potassium sorbate, 2 ppm BHA, and ascorbic acid on Vitamin C retention.

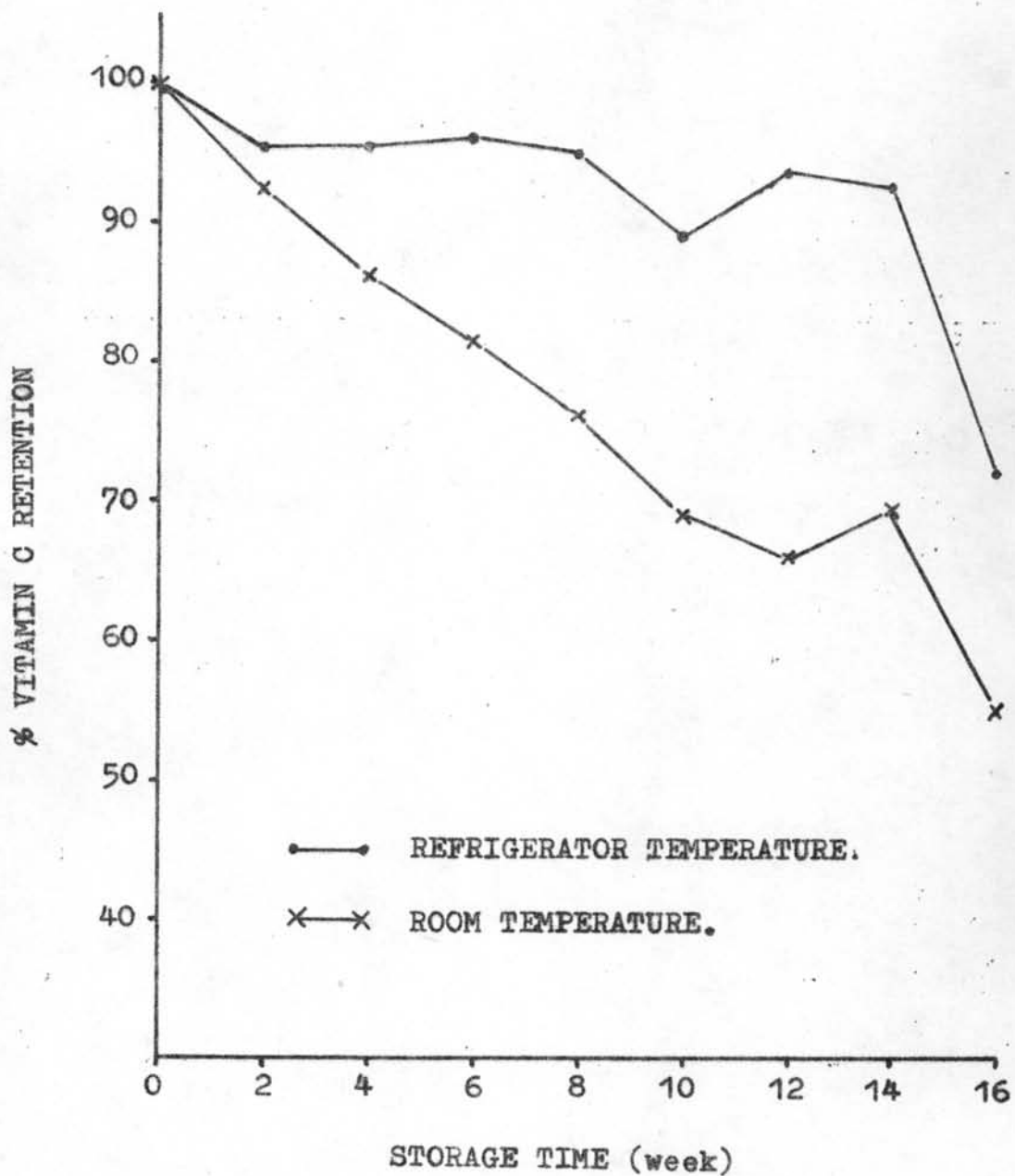


Fig. 20 Effect of 300 ppm potassium meta-bisulfite, 200 ppm potassium sorbate, 2 ppm BHA, and ascorbic acid on Vitamin c retention.

which was an antioxidant. But there was not significant different between samples treated with 2 ppm BHA and without BHA. Therefore addition of BHA at this level would not necessary.

Results from sensory test indicated that at refrigerator temperature all three samples were still acceptable at the end of fourth month whilst at the end of 2 months of storage time at room temperature, general appearance of all samples were still acceptable but the results from sensory test were not so good.

4.7 Effect of Corporated Air

Studying effect of corporated air which was introduced into treated samples during storage test on the preservation of lime juice. halves of the samples were poured out after a certain period of store time and were continually stored at room temperature for 4 weeks. Qualities of these samples were presented in Table 47-49. The result was that corporated air enhanced rates of Vit. C destruction. % Vic.C retention decreased very quickly to the value lower than 5% in most of the samples. The decreasing of Vit. C was very great compared to samples stored for four months at room temperature without any corporated air. It was evident that the presence of atmospheric oxygen will greatly increase the rates of Vit. C destruction.

Samples that added with ascorbic acid had more intense of brown colour compared to the sample that treated only with potassium meta-bisulfite and potassium sorbate. It due to the fact that brown is proportional to the level of ascorbic acid which was the product of browning. (Clegg, 1964).

Table 47 Qualities of treated lime juices which halves of the samples were poured out after 6 weeks of storage time at room temperature and were continually stored at room temperature for 4 weeks.

Sample No.	pH	Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention	Browning Appearance
III 1	2.4	8.4	7.22	1.86	5.18	++++++
III 2	2.4	8.2	7.19	1.86	5.18	++++++
III 3	2.4	8.1	7.21	1.86	5.24	++++++
IV 1	2.4	8.2	7.19	2.23	3.52	+++++++
IV 2	2.4	8.0	7.26	2.23	3.46	+++++++
IV 3	2.4	8.1	7.17	1.86	2.88	+++++++
V 1	2.4	8.2	7.30	1.86	2.87	+++++++
V 2	2.4	8.0	7.31	1.86	2.88	+++++++
V 3	2.4	8.2	7.20	1.86	2.93	+++++++

Table 48 Qualities of treated lime juices which halves of the samples were poured out after 8 weeks of storage time at room temperature and were continually stored at room temperature for 4 weeks.

Sample No.	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention	Browning Appearance
III 1	2.4	8.0	6.70	1.60	4.46	++++++
III 2	2.4	8.1	7.12	1.78	4.96	++++++
III 3	2.4	8.0	7.23	1.78	5.00	++++++
IV 1	2.4	8.1	6.92	2.13	3.36	++++++
IV 2	2.4	8.0	7.29	1.78	2.75	++++++
IV 3	2.4	8.0	7.04	1.78	2.76	++++++
V 1	2.4	8.0	7.17	1.78	2.75	++++++
V 2	2.4	8.2	7.24	3.02	4.68	++++++
V 3	2.4	8.0	7.08	1.96	3.08	++++++



Table 49 Qualities of treated lime juices which halves of the samples were poured out after 10 weeks of storage time at room temperature and were continually storage at room temperature for 4 weeks.

Sample No.	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention	Browning Appearance
III 1	2.4	8.0	7.00	1.79	4.99	++++++
III 2	2.4	8.0	6.85	1.96	5.46	++++++
III 3	2.4	8.0	6.76	1.43	4.03	++++++
IV 1	2.4	8.0	7.07	6.61	10.42	+++++++
IV 2	2.4	8.0	6.95	12.41	19.21	+++++++
IV 3	2.4	8.0	6.58	5.27	8.17	+++++++
V 1	2.4	8.0	6.95	4.82	7.45	+++++++
V 2	2.4	8.1	6.89	17.68	27.41	+++++++
V 3	2.4	8.0	6.79	8.84	13.91	+++++++

4.8 Effect of Coporated Air and Changes of Storage Temperature

Studying the effect of coporated air and changes of storage temperature which is the condition that might be happened during consumer utilization, halves of the samples were poured out after a certain of storage time at refrigerator temperature and were continually stored at room temperature for 4 weeks.

Qualities of these samples were present in Table 50-52. It was evident that high storage temperature would enhance rate of Vit. C destruction and also enhanced non-enzymatic browning. % Vit.C retention in all treated samples at the end of the storage test were very low compared to treated samples stored at refrigerator temperature without coporated air and any change in storage temperature.

Table 50 Qualities of treated lime juices which halves of the samples were poured out after 6 weeks of storage time at refrigerator temperature and were continually stored at room temperature for 4 weeks.

Sample No.	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention	Browning Appearance
III 1	2.4	8.0	7.26	1.49	4.15	++++++
III 2	2.4	8.4	7.13	1.58	4.41	++++++
III 3	2.4	8.4	6.57	1.49	4.19	++++++
IV 1	2.4	8.0	7.06	2.05	3.23	+++++++
IV 2	2.4	8.4	7.12	1.67	2.59	+++++++
IV 3	2.4	8.0	6.31	1.86	2.88	+++++++
V 1	2.4	8.4	7.46	1.86	2.87	+++++++
V 2	2.4	8.3	6.93	4.09	6.34	+++++++
V 3	2.4	8.2	6.54	2.05	3.22	+++++++

Table 51 Qualities of treated lime juices which halves of the samples were poured out after 8 weeks of storage time at refrigerator temperature and were continually stored at room temperature for 4 weeks.

Sample No.	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention	Browning Appearance
III 1	2.4	8.0	7.07	1.60	4.46	+++++
III 2	2.4	8.0	6.86	4.62	12.88	+++++
III 3	2.4	8.0	7.11	1.78	5.01	+++++
IV 1	2.4	8.0	6.97	3.64	5.74	+++++
IV 2	2.4	8.1	7.08	4.44	6.88	+++++
IV 3	2.4	8.1	6.75	2.31	3.58	+++++
V 1	2.4	8.1	7.12	2.06	3.19	+++++
V 2	2.4	8.0	7.08	3.73	5.77	+++++
V 3	2.4	8.2	6.46	5.87	9.24	+++++

Table 52 Qualities of treated lime juices which halves of the samples were poured out after 10 weeks of storage time at refrigerator temperature and were continually stored at room temperature for 4 weeks.

Sample No.	pH	° Brix	% Acidity	Vit.C mg/100ml	Vit.C %Retention	Browning Appearance
III 1	2.4	8.0	7.02	1.61	4.49	++++++
III 2	2.4	8.0	6.95	1.43	3.99	++++++
III 3	2.4	8.0	6.85	1.61	4.54	++++++
IV 1	2.4	8.0	6.88	4.55	7.17	++++++
IV 2	2.4	8.0	7.01	6.52	10.09	++++++
IV 3	2.4	8.0	6.77	10.36	16.06	++++++
V 1	2.4	8.0	6.97	5.98	9.24	++++++
V 2	2.4	8.0	7.07	4.73	7.33	++++++
V 3	2.4	7.8	6.92	5.80	9.13	++++++