T H E S I S

THE EFFECT OF SUGAR CONTENT ON CUT FLOWER KEEPING LIFE OF CARNATIONS

Submitted by

Richard L. Knappenberger

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WE HEREBY RECOMMEND THAT THE THESIS PREPARED UNDER OUR SUPERVISION BY RICHARD L. KNAPPENBERGER

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Committee on Graduate Work

[redacted]

Major Professor

[redacted]

Head of Department

Examination Satisfactory

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[redacted]

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Chapter I

INTRODUCTION

The market value of the 1948-49 carnation crop in the United States was estimated by Fossum (8) to be 20 million dollars. This value has increased each year since then.

Of the three leading carnation production centers in the United States, Colorado occupies a unique position in that 66 per cent of the crop is sold out of state. Although Colorado carnations are sold in all the major markets of the country, the largest proportion of the crop is exported to the southern and southeastern sections of the nation. It is here that Colorado finds its carnations actively competing with those shipped from the eastern and western sections of the country.

Superior quality is the only basis upon which Colorado can compete with carnation production centers having lower production costs or shorter shipping distances. Maintaining the "peak quality" for which Colorado carnations are famous involves not only the production of superior flowers but shipment of flowers of longer keeping quality.

Keeping is perhaps the major constituent of quality. A carnation must keep for the wholesaler and retailer, and especially for the ultimate consumer upon whose satisfaction depends future sales. Unless all three handlers of carnations are satisfied, the outlet for Colorado's carnations will decline and other flowers may take their place or some other area with cheaper carnations will benefit from Colorado's loss.

The purpose of this investigation was threefold. First, could the sugar content of carnations be used as a basis upon which to predict the keeping life of the flower? Secondly, could the sugar content be correlated with light and temperature preceding cutting?

If these questions could be answered in the affirmative, shippers could predict the potential life of carnations and avoid long distance shipping during periods of adverse conditions.

The third purpose of this study was to investigate the effects of keeping solutions on the sugar content of cut carnations. If keeping were found to be dependent upon sugar content, artificial alteration of this sugar would be of much value. Wholesalers could bolster the sugar content and improve keeping, retailers could keep their flowers longer and avoid dumpage, and the ultimate consumer would realize longer periods of enjoyment from his investment.

Problem

Can the sugar content of a fresh cut flower be correlated with its cut flower life? If so, can the cut flower life be extended by artificially increasing the initial sugar content?

Problem analysis.--Before answering the major question, it is necessary to answer the following:

1. What effect does aging of a cut flower have on the sugar content?
2. Do carnations under similar environmental conditions cut on successive days vary in their sugar content?
3. Can variations in sugar content of carnations cut on successive days be correlated with cut flower keeping life?
4. What effects do the pre-harvest physiological conditions of light and temperature have on the sugar content of the flower stems?
5. Do cut flower keeping solutions affect the sugar content of cut carnations?

Delimitations.--This study was limited to White and Red Sim carnations grown at the Research Greenhouses, Colorado A & M Experiment Station.

Definition of terms.--Sleepiness - is a term used to describe an undesirable condition of cut carnations

that is characterized by an incurving of the edges of the petals, the petals becoming discolored and losing their turgor.

Cut flower keeping life - denotes the number of days that a cut flower will remain in a desirable condition.

Sugar content - as used in this study refers to the total relative sugars as determined by paper chromatography.

Chapter II

REVIEW OF LITERATURE

The keeping life of cut flowers seems to be influenced by a complex of factors involving reserve food supply, pre-harvest conditions, respiration rate, water uptake and bacterial activity during the keeping period.

Food accumulation during the pre-harvest period

Dubrunov and Gladysheva (6) found fruits on the higher branches of apple trees to be higher in sugar content than fruits from lower branches.

Soil management practices were found by Kenworthy and Mitchell (15) to influence the soluble solids of Montmorency cherries at harvest. They concluded that any soil management practice--mulching, fertilization, clean cultivation, etc.--which promoted vigor and supplied nutrients and moisture to the plants appeared to result in a reduction of soluble solids.

Haun and Cornell (10) tested the rooting responses of geranium cuttings as influenced by nutrition of the stock plants grown at three levels of nitrogen, three levels of phosphorous and three levels of potassium

in all combinations. In testing leaves and stems for carbohydrates, they found high nitrogen gave lower total carbohydrates. Potassium and phosphorous gave no differences in total carbohydrates. These results were substantiated by Odom (20), who found that the percentage of non-protein soluble solids was inversely proportional to the nitrogen available to carnation plants. He found potassium and phosphorous levels did not appreciably affect the soluble solids.

Although Tincker (29) felt that water relations and levels of soil fertility were important in subsequent cut flower life, Post (24) states that such factors probably influence cut flower keeping life to no great extent. He states that light and temperature are more important, and cites the difference in keeping of roses cut on different days and at different times of the day as an excellent indication that the sugar reserve in the stem and flower at the time of cutting is the most important factor in keeping.

Working with carnations, Holley (13) concluded that under conditions of low light intensity and high temperatures, the carnation utilized food faster than it synthesized it. Odom (20) ascertained that the food supply in carnation cuttings was affected by the average daily light intensity of one to several days preceding sampling, and that several days of cloudy weather reduced

both the dry weight and non-protein soluble solids. He also found the maximum accumulation of food followed the maximum light intensity by one or two hours.

Sugar and respiration

Curtis and Clark (3) point out that the respiration rate of apples per unit of fresh weight is highest in very young fruits and diminishes rapidly as maximum maturity and size is approached.

The amount of sugars lost by apples during cold storage was insufficient to account for the respiration observed by Krotkov and Helson (16). Platenius (23) established that asparagus stored at 50°F lost 30 per cent of the total sugars in 275 hours and at 35°F lost an equivalent amount in 1000 hours. He observed similar differences in green peas and sweet corn.

Williams, et al, (30) found that green beans stored in cracked ice increased in sucrose content while those stored at room temperatures lost sugar mostly from a reduction in reducing sugars.

Hewitt and Curtis (11) concluded that the respirational loss of carbohydrates of tomato, bean, and milkweed leaves overnight increased with each increment of temperature. Denny (4) established the overnight loss of carbohydrates to be more than one-half that accumulated in daylight hours. Bushnell (1) in measuring the losses of

carbohydrate in potato plants between 6:30 pm and 5:00 am found that at 20°C the percentage loss due to respiration was 53.5 and at 29°C was 93.9.

Goris (9) found sugar in carrot tissue to be more rapidly exhausted in the presence of 3-indole acetic acid.

Chemical and mechanical aids to cut flower keeping

Although Hitchcock and Zimmerman (12) tried 51 different chemicals in various concentrations in water and found them of no value in extending flower keeping, later workers have tested many compounds that have extended cut flower life. Aspirin has been recommended as an aid to keeping, but Tincker (29) found it to cause petal edge burn in some flowers.

Laurie (18) and Ratzek (25) found copper containers to increase the life of cut flowers because of their disinfecting qualities.

Neff (19) found 100 grams of glucose or sucrose and 0.5 grams of potassium nitrate to a liter of water beneficial for keeping cut flowers. Laurie (17) recommended hydrazine sulfate, sodium amytol and sucrose to extend keeping life. Post (24) recommended "Bloomlife" and "Floralife", both containing sugar and a disinfectant, for keeping some flowers.

Thornton (28) lengthened the storage life of roses by increasing the carbon dioxide content of the storage chamber. Crocker (2), Ferguson (7), and Wintz (31) found ethylene and ethylene-like gases to reduce the keeping life of carnations.

Laurie (18) said that cutting the stems of those flowers with small conducting vessels underwater increased the keeping. The same author found shallow water increased the keeping of snapdragons, carnations, pansies, etc., by two to three days as opposed to deep water. Ries (26) found cutting stems underwater to be of no value in extending keeping.

Dickey (5) felt that the ability of stems to take up water was the limiting factor in cut flower keeping. He thought most flowers had enough stored energy present in the stem to enable them to keep.

Chapter III

METHODS AND MATERIALS

A series of experiments were designed to determine the relationship of the sugar content of cut carnation stems to the subsequent keeping life of the flowers. In addition the correlation of environmental conditions preceding cutting with the sugar content of the cut carnation stem was attempted. The third phase of the investigation concerned the effect of various keeping solutions upon the sugar content of cut carnation stems during a specified keeping interval.

General methods and procedures

To determine the keeping life of cut carnations, samples of five stems each were placed in a container of water of neutral pH and kept at nearly constant temperature and humidity for the duration of the testing interval. Continuous temperature and humidity records were kept. Flowers were considered to have reached the end of their useful life when the petals began curving inward, became slightly discolored and lost their turgor. The number of days of keeping life of each replication was determined

by finding the weighted mean or the mean flower days.

The sugar content of the cut carnation stems was determined in all cases by Johnson's (14) modification of one dimensional paper chromatography as originally outlined by Partridge (21).

Preliminary experiments indicated that the top six nodes of five carnation stems composed a reliable sample. Samples were packaged in cellophane and frozen at 20°F until needed for sugar determinations.

Samples were thawed and the juice extracted by squeezing under constant pressure. The extract was then centrifuged at 5500 rpm for 15 minutes and the supernatant filtered through Whatman #42 filter paper. A five ml aliquot was taken from this filtrate and five microliters spotted on Whatman #1 paper. Two spots were made of each sample.

Spotted papers were placed in tanks containing a mixture of four parts butanol, one part glacial acetic acid, and two parts water as formulated by Johnson (14). When the solvent front approached the top of the paper, the papers were removed from the tanks, dried until all odor of the solvent had dissipated, and then sprayed with Partridge's aniline hydrogen phthalate reagent (22). After drying, the papers were developed at 120° C for 15 minutes and cut into strips containing the developed sugars. The optical density of the developed strips was measured by

means of a densitometer (Welch and Co. Densichron). These readings were graphed and the total relative sugars determined by measuring the area of the graph with a polar planimeter.

Statistical methods

Correlation coefficients (r) were determined between sugar content and keeping, sugar content and light, and sugar content and temperature by the formula of Snedecor (27) as follows:

$$r \sqrt{\frac{S(xy) - N(\bar{x}\bar{y})}{(Sx^2 - N\bar{x}^2)\ (Sy^2 - N\bar{y}^2)}}$$

Analysis of variance was used in all other statistical determinations.

Experiment 1

To determine the changes in total sugars in White Sim carnations during the keeping interval, an experiment was designed in which six samples of five stems each were frozen immediately after cutting and their sugar content compared to that of six samples of five stems each cut on the same day from the same bench. These latter were kept for a period of seven days in the keeping room before analysis.

Experiment 2

This experiment was composed of three parts. Twenty stems of Red Sim carnations were cut daily from the same bench at 8:00 am for a 30-day period beginning February 16, and terminating March 17, 1955. Five stems of six nodes each were taken at random and the sugar determined chromatographically. The remaining 15 stems were kept at a temperature of 64° F. ± 2° F. and a humidity of 42 to 58 per cent, to determine their mean keeping life. The relationship between sugar content and keeping life was investigated.

For the second part of the experiment, 20 stems of White Sim carnations were cut from the same bench daily at 8:00 am for a 27-day period from March 24 to April 22, 1955. Five stems of six nodes each were taken at random and the sugar content determined chromatographically. The remaining 15 stems were placed in the keeping room for determination of their mean keeping life. The temperatures in the keeping room ranged from 67° to 75° F. with a humidity of 60 to 80 per cent. A correlation between the sugar content and the keeping life was attempted.

In the last part of the experiment, 15 stems of White Sim carnations were cut daily at 8:00 am from the same bench for a 15-day period from June 7 to June 21, 1955. Five stems of six nodes each were taken at random

and the sugar content determined chromatographically. The remaining stems were kept at a temperature of 63° F. ± 3° F. and a humidity of 88 to 98 per cent in the keeping room. After the mean flower days were determined, the correlation coefficient for sugar content and keeping life was calculated.

Experiment 3

The relationships between the daily relative sugar content as determined for each of the three sections of Experiment 2 and the continuous light and temperature records of one day, the sum of two days, and the sum of three days previous to cutting were investigated.

Experiment 4

White Sim carnations were kept seven days in eight different keeping solutions and compared to an untreated control to determine whether these solutions affected the sugar content.

The keeping solutions used were: 1) water, 2) 100 ppm chlorine in water, 3) 1/2 teaspoon ammonium aluminum sulfate per gallon of water, 4) 1 tablespoon fructose per quart of water, 5) 1 tablespoon glucose per quart of water, 6) 1 tablespoon sucrose per quart of water. Treatments 7 and 8 were Morlife, and Floralife respectively. These commercial keeping compounds were used according to the manufacturer's directions.

Each treatment and the control consisted of five replications of five carnation flowers each. The untreated control was cut, allowed to become turgid in water, and then immediately frozen. The treatments, cut at the same time as the untreated control, were kept for seven days in the keeping room. At the end of this period, the sugar contents of the control and treatments were determined chromatographically.

Chapter IV

RESULTS

A series of experiments were designed to determine the relationship of sugar content of cut carnation stems to the subsequent keeping life of the flowers. The correlation of environmental conditions preceding cutting with the sugar content of the cut carnation stem was attempted. The effect of various keeping solutions upon the sugar content of cut carnations during a keeping interval was investigated.

Samples of five stems each were used to determine the keeping life, which is reported in mean flower days for each sample.

The sugar content of the cut carnation stems was determined by one dimensional paper chromatography. Readings of the optical density of developed strips containing the sugars were graphed. The total relative sugars were determined by measuring the areas of the graphs with a polar planimeter. All total sugar measurements are relative values and are reported in square inches of area.

Experiment 1

To investigate the changes in total relative sugars in White Sim carnations during the seven-day keeping period, six samples were frozen immediately after cutting and their total sugar content compared to that of six samples cut on the same day from the same bench. The latter were placed in the keeping room for seven days before analysis.

The differences in total relative sugars between the fresh cut carnations and those kept seven days were highly significant (Table 1). The mean total sugar for fresh cut carnations was 0.795 square inches compared to 0.285 square inches for those kept seven days.

Table 1.--THE DIFFERENCES IN TOTAL RELATIVE SUGAR CONTENT OF FRESH CUT CARNATIONS AND THOSE PLACED IN THE KEEPING ROOM FOR SEVEN DAYS.

Sample	Fresh (square inches)	Kept 7 days (square inches)	Difference
1	0.642	0.232	
2	0.910	0.265	
3	0.640	0.288	
4	0.842	0.252	
5	0.992	0.335	
6	0.745	0.340	
Total	4.771	1.712	
Mean	0.795	0.285	0.51
Minimum difference for significance			
at 5 per cent level			0.14
at 1 per cent level			0.20

Experiment 2

The day to day total relative sugar content of Sim carnations was correlated with their mean keeping life for three different periods.

For the period February 16 to March 17, 1955, 20 stems of Red Sim carnations were cut daily, five stems were selected at random and their sugar content determined chromatographically. The remaining 15 stems were placed in the keeping room for determination of their mean keeping life. The correlation coefficients for mean keeping life and total relative sugar content were calculated.

The mean keeping days and the total sugar content are presented in Fig. 1 for the 30-day period. This graph shows that both the sugar and mean keeping life declined from February 16 until February 26 and increased until March 17 when this test was terminated. The correlation coefficient of 0.67 was highly significant for correlation of total sugar content and mean keeping life.

Twenty stems of White Sim carnations were cut daily from March 24 to April 22, 1955. Five stems were selected at random and their relative sugar content measured chromatographically. An attempt was made to correlate the total sugar content with the mean keeping life of the remaining 15 stems which had been kept in the keeping room. There was no correlation between total relative sugar content and mean keeping life during this period.

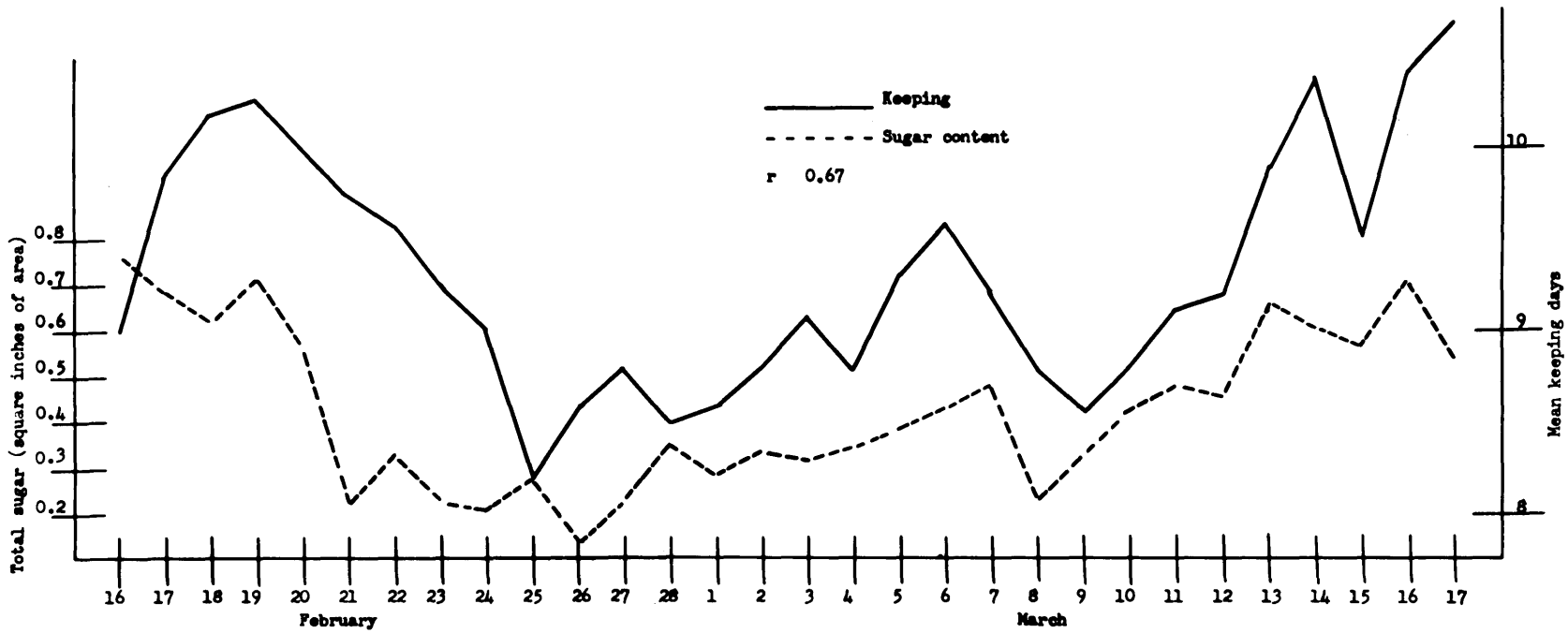

Fig. 1 Correlation of total relative sugar content and mean keeping life of Red Sim carnations for the period February 16 to March 17, 1955.

The last part of Experiment 2 covered a 15-day period from June 7 to June 21, 1955. Fifteen stems of White Sim carnations were cut daily and five stems selected at random for sugar measurements. The remaining 10 carnations were placed in the keeping room and their mean keeping life determined. The relationship between total sugar content and mean keeping life was investigated.

Except for minor variations, sugar content and mean keeping life paralleled closely for the duration of the testing period (Fig. 2). The correlation coefficient of 0.86 was highly significant.

Experiment 3

Correlations between the daily relative sugar content of each of the three periods of Experiment 2 and the continuous greenhouse light and temperature records of one day, the sum of two days and the sum of three days previous to cutting were attempted (Table 2). The correlations between light and temperature in all three parts of the experiment were highly significant. Significant negative correlations of -.404 and -.492 were obtained between total relative sugar content and light one day previous to cutting for the periods beginning February 16 and June 7. No correlation between sugar content and light one day previous to cutting was found for the period beginning March 24.

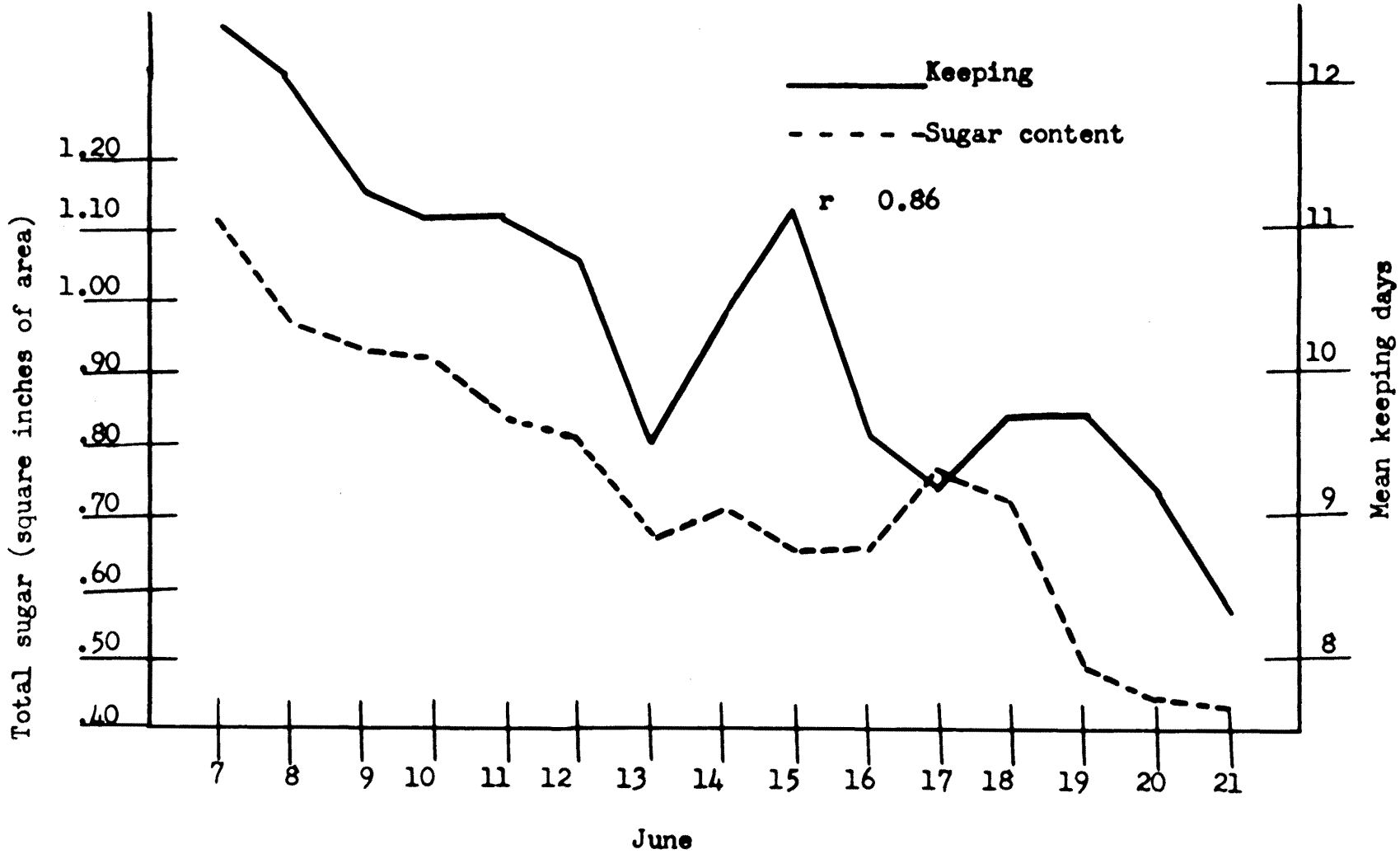

Fig. 2 Correlation of total relative sugar content and mean keeping life of White Sim carnations for the period June 7 to June 21, 1955.

Although the negative correlation of -.618 between sugar content and temperature one day previous to cutting was highly significant for the June 7 period, there was no correlation between these factors for the other two periods.

The sum of light and temperature for two days and three days previous to cutting did not correlate with relative sugar content for any period.

Table 2.--CORRELATION COEFFICIENTS (r) BETWEEN RELATIVE SUGAR CONTENT AND LIGHT ONE DAY PREVIOUS TO CUTTING, RELATIVE SUGAR CONTENT AND TEMPERATURE ONE DAY PREVIOUS TO CUTTING, AND LIGHT AND TEMPERATURE FOR SIM CARNATIONS FOR THREE PERIODS.

Period	Sugar and light	Sugar and temperature	Light and temperature	r required	
February 16 to March 17, 1955	-.404*	-.02	.627**	.361	.463
March 24 to April 22, 1955	-.091	-.092	.807**	.381	.487
June 7 to June 21, 1955	-.492*	-.618**	.813**	.482	.606

*Significance at 5 per cent level
**Significance at 1 per cent level

Experiment 4

White Sim carnations were kept seven days in eight different keeping solutions and compared to an untreated control to ascertain the effects of these solutions on the sugar content. Each treatment and the control consisted of five samples of five carnations each. The untreated

control was allowed to become turgid in water and then frozen. The flowers for the treatments were cut the same day but kept for seven days before the sugar content was measured.

The fresh cut carnations yielded an average of 0.392 square inches of total relative sugars compared to 0.255 for flowers kept in water for seven days. Flowers kept in Floralife, sucrose and Morlife had more total relative sugars after seven days than those kept in water (Table 3), their mean total sugars being .407, .385, and .363 respectively. Alum, fructose, glucose and chlorine contained less total relative sugars than those kept in water. Treatments with Floralife or sucrose caused significantly more sugar residual in the stems than treatment with water alone. All other differences were not sufficiently large for significance when analyzed statistically.

Table 3.--THE EFFECT OF KEEPING SOLUTIONS ON THE SUGAR CONTENT OF WHITE SIM CARNATIONS.

Treatments	Replications					Mean sugar content (in square inches)
	A	B	C	D	E	
Fresh cut	0.210	0.400	0.310	0.470	0.570	0.392
Water	0.160	0.165	0.325	0.315	0.310	0.255
Morlife	0.145	0.370	0.320	0.560	0.420	0.363
Floralife	0.535	0.475	0.420	0.220	0.385	0.407
Alum	0.210	0.205	0.200	0.245	0.225	0.217
Chlorine	0.040	0.165	0.110	0.205	0.215	0.147
Sucrose	0.260	0.300	0.425	0.600	0.340	0.385
Fructose	0.165	0.175	0.240	0.185	0.290	0.211
Glucose	0.285	0.075	0.210	0.120	0.220	0.182

Minimum difference for significance

at 5 per cent level	0.13
at 1 per cent level	0.17

Chapter V

DISCUSSION

The carnation market is highly competitive and becomes more so each year. To compete with areas having cheaper production costs and lower shipping costs, Colorado must deliver to its customers carnations of superior quality.

Perhaps the major requisite of quality is long cut flower life. A reliable test to predict this life would be of immense value in avoiding shipping loss and consumer dissatisfaction.

Respiration is an important factor limiting the useful life of cut flowers and sugars are primary substrates used in respiration. It could be expected therefore, that the sugar content of a carnation would influence its keeping life. The total sugar content of a cut flower should decrease during the keeping interval if sugar is being respired.

A comparison of six samples of White Sim carnations kept seven days in the keeping room with six samples cut the same day but frozen immediately showed that sugars are utilized during the keeping interval.

As sugars are utilized during the keeping interval, the higher the initial sugar content the longer a flower should keep. The day to day sugar content of Sim carnations was compared to the day to day keeping during three different periods. In two of the three periods, the higher the sugar content the longer the flowers kept. In the other period, no correlation existed; but as the keeping room temperature fluctuated due to a faulty thermostat, the lack of correlation during this period is meaningless.

The data from these experiments show that sugar content is a reliable indicator for potential keeping life of cut carnations.

It would be expected that a positive correlation would exist between light and total sugar content were light the only factor taken into consideration. In two of the three periods, as light increased, the total sugar content decreased. Photosynthesis increases with increasing light intensity up to a certain intensity, after which the photosynthetic rate remains constant or decreases as other factors have become limiting. In the greenhouse, temperature probably becomes the most limiting factor as far as sugar accumulation and photosynthesis are concerned. As temperature increases, both respiration and translocation increase and very little sugar is left in the stem. The total sugar content decreased with increasing light,

not because light itself affected the sugar accumulation but rather because light increased respiration and translocation by its effect on the plant temperatures. During sunny periods, plant temperatures were undoubtedly higher than the surrounding air temperatures. Light measurement, therefore, gave a more accurate measure of plant temperatures than did the recorded greenhouse temperature.

Sugar content did not vary inversely with greenhouse temperature except during the final period. Although this appears contrary to the expected effect of temperature, it is probable that the temperatures during all three periods were well above that required for the most efficient production of sugar and that respiration and translocation were taking place at nearly maximum rates, allowing little sugar to accumulate in the stems.

Since temperature and light are very closely related, it is to be expected that a high correlation exists between these two factors. In all three of the periods of this experiment, light and temperature followed one another very closely.

Carnations placed in Morlife, Floralife and sucrose solutions for seven days had approximately the same sugar content as fresh cut carnations. Only carnations treated with Floralife and sucrose had significantly higher sugar contents after being kept seven days than those kept in water alone.

The carnation stems were either able to absorb sugar from some solutions or these compounds acted as respiratory inhibitors. Carnation stems probably have the ability to absorb compounds from keeping solutions selectively. There is the possibility that all the sugars in the keeping solutions were absorbed in the same amounts. Glucose and fructose could have been utilized, however, faster than was sucrose.

The presence of bactericides in keeping solutions contributes greatly to the life of cut flowers, especially when the flowers are kept at warmer temperatures. Sugars plus bactericides enable flowers to keep longer than either alone. As bacteria could utilize glucose or fructose more readily than sucrose, the total sugar content of carnations kept in these sugars would be lower. Bacteria are selective and may utilize certain sugars faster than the stems can absorb them.

Suggestions for further study

As revealed by this study, the effect of light and temperature previous to cutting on the sugar content of carnations has not been conclusively established. A study in which these factors are closely controlled, could yield more precise data upon their individual role in affecting sugar content and keeping.

One dimensional sugar chromatography revealed that sucrose, glucose and fructose were present in carnation

stems. Further study of the role of these sugars as they influence keeping would be helpful.

The influence of different chemicals upon the keeping life of carnations should be investigated more fully to determine how they affect the post-harvest physiology of cut flowers. The possibility of using respiratory inhibitors to extend keeping life should also be included in this study.

Chapter VI

SUMMARY

The purpose of this study was to investigate the effects of total relative sugar content on the keeping life of cut carnations. If sugar content influences the time carnations will keep, it could be used as a basis for predicting the useful life of cut flowers. The influence of light and temperature upon sugar content and the effect of keeping solutions on sugar content were also studied.

1. The sugar content of freshly cut carnations varied as much as 50 per cent from day to day.

2. During a seven-day keeping period cut carnations lost approximately 65 per cent of their original sugar content.

3. The correlation coefficients (r values) between sugar content at harvest and the mean keeping life were 0.67 for the period February 16 to March 17, and 0.86 for the period June 7 to June 21, 1955. It would follow that the higher the initial sugar content at harvest, the longer cut carnations could be expected to keep.

4. There was an indication that the pre-harvest environmental conditions of light and temperature affect

the sugar content, however the interrelations of these with other environmental factors are so complex that no valid conclusions can be drawn from these data on the effect of light and temperature on sugar content.

5. Cut carnations when placed in sucrose, Morlife, and Floralife maintained their initial sugar content during a seven-day keeping period. Cut carnations placed in water and water solutions of alum, chlorine, fructose and glucose for a seven-day keeping period lost 35 per cent or more of their initial sugar content.

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APPENDIX A

Table A.--TOTAL RELATIVE SUGAR CONTENT, AVERAGE DAYS KEEPING, TEMPERATURE ONE DAY PREVIOUS, AND LIGHT ONE DAY PREVIOUS TO CUTTING FOR RED SIM CARNATIONS FROM FEBRUARY 16 TO MARCH 17, 1955.

Date	Sugar (sq. in.)	Average keeping (days)	Temperature (1 day previous)	Light (1 day previous)
Feb. 16	0.765	9.00	56.9	7.2
17	0.690	9.87	59.1	15.8
18	0.625	10.20	58.6	12.4
19	0.725	10.27	54.8	4.2
20	0.565	10.00	54.3	2.5
21	0.225	9.75	57.0	15.0
22	0.330	9.56	57.8	16.4
23	0.230	9.25	59.0	16.1
24	0.210	9.00	58.4	14.0
25	0.270	8.20	58.8	17.1
26	0.145	8.60	59.7	15.8
27	0.230	8.83	55.9	5.8
28	0.360	8.53	57.8	15.0
Mar. 1	0.290	8.60	57.2	16.0
2	0.345	8.80	60.2	17.4
3	0.320	9.08	56.4	12.6
4	0.345	8.78	58.4	17.7
5	0.375	9.33	58.8	12.4
6	0.430	9.60	58.4	17.1
7	0.475	9.22	57.4	14.4
8	0.230	8.78	58.4	18.3
9	0.330	8.56	61.8	18.9
10	0.430	8.80	62.6	18.7
11	0.470	9.13	58.5	15.5
12	0.460	9.17	59.5	19.4
13	0.665	9.89	60.9	18.3
14	0.610	10.40	60.2	13.4
15	0.565	9.53	58.1	16.4
16	0.715	10.42	60.3	6.2
17	0.535	10.67	59.0	15.5

Table B.--TOTAL RELATIVE SUGAR CONTENT, AVERAGE DAYS KEEPING, TEMPERATURE ONE DAY PREVIOUS, AND LIGHT ONE DAY PREVIOUS TO CUTTING FOR WHITE SIM CARNATIONS FROM MARCH 24 TO APRIL 22, 1955.

Date	Sugar (sq. in.)	Average keeping (days)	Temperature (1 day previous)	Light (1 day previous)
Mar. 24	0.585	7.60	59.5	21.60
25	0.560	6.87	55.0	9.37
26	0.295	6.93	58.0	6.50
27	0.410	7.07	59.0	21.12
28	0.360	6.67	61.0	25.00
30	0.285	7.07	63.0	19.12
31	0.495	6.73	64.0	22.50
Apr. 3	0.380	7.13	62.0	20.50
4	0.520	7.27	57.5	12.75
5	0.660	6.87	56.0	13.00
6	0.565	7.33	59.5	21.75
7	0.455	7.27	61.0	22.62
8	0.685	7.53	61.5	20.50
9	0.715	7.13	58.5	14.75
10	0.710	7.00	63.0	24.50
11	0.500	7.00	65.0	25.25
12	0.495	7.20	56.5	9.37
13	0.580	6.53	58.5	19.75
14	0.510	6.33	64.5	26.75
15	0.590	6.67	65.0	26.00
16	0.460	6.73	62.0	25.62
17	0.475	7.00	65.0	23.62
18	0.545	6.93	66.5	23.50
19	0.545	6.93	65.5	26.50
20	0.485	6.53	62.2	18.87
21	0.515	6.80	62.2	25.00
22	0.830	6.67	62.0	24.87

Table C.--TOTAL RELATIVE SUGAR CONTENT, AVERAGE DAYS KEEPING, TEMPERATURE ONE DAY PREVIOUS, AND LIGHT ONE DAY PREVIOUS TO CUTTING FOR WHITE SIM CARNATIONS FROM JUNE 7 TO 21, 1955.

Date	Sugar (sq. in.)	Average keeping (days)	Temperature (1 day previous)	Light (1 day previous)
June 7	1.120	12.5	63.5	14.0
8	0.975	12.1	65.5	18.2
9	0.935	11.3	59.0	6.7
10	0.920	11.1	57.5	12.0
11	0.835	11.1	61.2	16.5
12	0.800	10.8	63.7	22.0
13	0.670	9.5	62.7	12.0
14	0.710	10.4	66.0	18.2
15	0.650	11.1	66.5	15.2
16	0.655	9.6	60.5	11.0
17	0.760	9.2	65.7	19.7
18	0.720	9.7	64.2	14.2
19	0.490	9.7	65.7	17.2
20	0.445	9.2	69.7	25.0
21	0.430	8.3	68.7	23.0

APPENDIX B

INVESTIGATION OF THE LOCATION OF SUGARS IN CARNATIONS

A study was made to determine the amount of sugar in the different parts of the carnation to ascertain which part could be used for an adequate sample.

Five samples of five carnations each were divided into separate parts as follows:

1. Leaves,
2. Top six nodes of the stem,
3. Bottoms of the stems, and
4. Flower heads.

The total relative sugar content was determined for each part chromatographically.

The leaves were lower and the heads significantly higher in sugar content than the other parts. The top six nodes and the bottoms of the stems however, contained approximately the same amount of sugar.

Although the heads contained more sugar than other portions, the sugar was present predominantly in the form of nectar and therefore probably not utilizable in respiration.

The top six nodes plus their leaves were used as a sample because of uniformity of size and the relative ease of analysis.

Table C.--LOCATION OF SUGARS IN WHITE SIM CARNATIONS.

Treatments	Replications					x
	1	2	3	4	5	
Leaves	.56	.32	.44	.22	.18	.34
Top six nodes	1.47	1.01	1.14	1.06	1.06	1.15
Bottom of stems	1.34	1.02	1.08	1.26	1.36	1.21
Flower heads	2.22	2.26	2.04	2.13	2.28	2.19

Minimum difference for significance	
at 5 per cent level	.18
a5 1 per cent level	.25