ABSTRACT

STUDIES OF THE EFFECTS OF POST-HARVEST HANDLING PRACTICES ON THE KEEPING QUALITY AND MARKETABILITY OF BETTER TIMES ROSES

by Philip E. Parvin

Faced with sharply declining sales of roses, while sales of other cut flowers were increasing, the economic health of the rose industry was apparently at stake. In 1960, a survey of retail florists revealed two recurrent reasons why decreasing numbers of roses were being used. One was the relatively short period of time roses would last in the home. Included in this complaint was the rapid color change to an undesirable bluish cast by the Better Times rose, the principle red rose in production. The other reason given was the lack of confidence the florist felt in the ability of the rose to open and develop in the customer's home. There was an increasing awareness that it was impossible to tell from the appearance of the rose while still under the influence of refrigeration, whether it would develop satisfactorily or whether within a short period of 24 to 36 hours the portion of the stem directly under the flower would become limp and the head droop over, never opening.

An extensive investigation, lasting three years, was begun in June 1960. Five general areas of study were pursued: the effects of preservatives; materials known as "foams", usually of an ureaformaldahyde base used to hold flowers in position when arranged in containers; packaging; N^6-Benzylaminopurine and three-stage handling interactions on keeping quality.

Over 2,000 roses were used in screening commercially available and experimental chemical preservative formulations. The influence of pH and iron content on the efficacy of preservatives, as well as preliminary work on the influence of time and duration of application of preservatives is reported.

Since the use of "foam" materials is such a wide-spread practice among retail florists today, another study area involved the influence of various "foam" materials on rose keeping quality. Eighteen hundred roses were used in the screening of available materials, as well as studies of water loss and the effect on vase life when maximal moisture conditions were provided in a vase containing a preservative solution. These results were compared to those obtained when no reservoir of water was provided. It should be pointed out that this data refers to products in use from 1960 - 1963 and do not necessarily reflect on the modified formulations currently available.

The effect of shipping roses in plastic bags, with and without techniques for supplying moisture enroute, was determined. An experimental vertical shipping carton was designed and subjected to transcontinental shipping tests.

Rates of respiration of roses, in water and in preservative solutions, were determined on over a thousand roses. The effect of N^6 when used as a dip on the rate of respiration, is reported and a study was conducted on techniques for applying N^6 to the rose.

The influence of four variables in handling practices was studied at three stages in the marketing channels. Data was collected on the effect of time out of water, temperature of solution, use of preservative vs. water, and conditioning at low temperatures on the vase life

of roses. After studies were made of these variables at the grower, wholesaler and retailer stages of marketing, extensive interaction trials were conducted of all combinations of selected treatments. The tentative recommendations for handling were then further tested under actual conditions by a California grower who shipped the roses to Michigan for the wholesale and retail handling phases.

Based on the results from 138 different treatments, replicated three times, involving vase life determinations on over 3,500 roses, specific recommendations for handling roses are made.

By following these practices, the problem of "bent neck" can be eliminated, confidence in the dependability of normal development and opening can be restored, and the vase life of roses can be more than doubled.

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INTRODUCTION

In 1959, floricultural crops, including cut flowers, pot plants, bedding plants, cultivated greens, bulbs and flower seed crops were valued at wholesale prices at approximately $305 million (105). There were over 16 million rose bushes in production from which 360.2 million flowers were sold at a value of $30.9 million. This ranked the rose crop highest in value of all cut flowers in the United States.

Roses have always ranked high in the opinion of the customer, too. In 1948, Swingen (95) published the results of a market survey that showed the rose was the preferred flower of shoppers in Texas at all times of the year. A short time later, the Opinion Research Corporation (65) released a consumer motivations study which reported that the "image" of the rose was of the highest quality. Sherman (90) in 1956 reported that in a test in Ohio, involving a large number of housewives, 51 per cent chose roses, when asked to express a preference between prepackaged units of roses, carnations and chrysanthemums.

In spite of these consumer attitudes and opinions, rose sales dropped sharply in the 2 years from 1959 to 1961, while carnations virtually held their own and chrysanthemums increased.

The United States Department of Agriculture reported on these changes in 6 states, representing approximately 44 per cent of the nation's producing rose plants, 45 per cent of the cut roses sold and 42 per cent of the total value of sales. While carnation sales went from $15.84 to $15.80 million and chrysanthemum sales increased from $17.3 to $18.2 million during the 2-year period, 1959-61, roses declined from $12.6 to $11.6 million (95).

Faced with this sharp decline in sales, rose growers, acting through their trade association, Roses, Incorporated, expressed grave concern. Immediate assistance was sought and research grants were tendered in hopes of remedying this situation.

Professor Paul R. Krone, of Michigan State University, responding to this request, laid the groundwork for this series of investigations by surveying a large number of retail florists as to their opinions on the rose. An analysis of replies from this survey revealed that two major factors were consistantly offered as reasons why retail florists didn't use more roses in their shops. One was most frequently listed as "poor keeping quality". The other was "undependable performance." Subsequent interviews revealed that in 1960, there was a high incidence of a physiological disorder variously referred to as "bent neck" and "rose neck droop" (42) (84). This term refers to a condition that can occur when apparently high quality roses, in a firm turgid condition are removed from refrigeration, only to wilt after a few hours at room temperature. The specific symptom is flacidity of the stem region directly below the bud, resulting in the flower head hanging down at an acute angle and not opening. The wilting develops rapidly, usually after the flowers have been delivered to the customer. It was thought that this condition was responsible to a large extent for the reluctance of many retailers to use roses.

In 1960 a research project was initiated to investigate ways of improving the competitive position of the rose in the cut flower market. Since it is impossible to judge from the external appearance of the rose while under refrigeration, which will wilt and which will develop normally, it seemed imperative that the causal factors be determined and avoided. Although there have been extensive research reports published in the field of post-harvest physiology, much of the work relates back to the influence of pre-harvest environmental factors.

The purpose of this series of studies was to investigate the influence of various handling practices and post-harvest environmental factors on the keeping quality of roses. An educational program could then be launched to attempt to change the "unreliable" image resulting in an anticipated increase in sales.

REVIEW OF LITERATURE

The literature on research to investigate means of increasing the longevity of cut flowers is extensive. Aarts (1) credits Palladius with being one of the earliest authors in this field. He wrote a chapter "De rosis viridibus servandis" (on the storage of green roses) in his publication "De Re Rustica" in 350 A.D. At the opposite end of the chronological scale, two papers (16, 45), were presented at the 1964 American Society for Horticultural Science meetings on physiological changes in senescing roses.

I. General Summaries of Keeping Quality Research

Several good reviews of general factors affecting keeping quality have been published (1, 21, 39, 59, 77, 78, 101, 104). Twigg (104) suggested that five factors be considered in a study of keeping quality of roses: a. "Bluing" and fading of the petals, b. wilting or bending of the stem directly below the flower bud, c. wilting of petals and foliage, d. rapid opening of the bud, and e. failure of the bud to open.

Aarts (1) published in 1957 an outstanding review of the literature on chemical treatments to affect keeping quality. He reviewed in detail research into various chemical compounds and reported his work on bacterial compounds, the influence of sugar, acidity, fungus development, growth substances and inhibitors, enzyme poisons, glucosides, and inorganic salts and micro-elements on keeping quality of cut flowers. He believed that research in the area of metabolic inhibitors to reduce sugar requirements offers the most promising area for success.

Mastalerz (59) published in 1960 a good review of the internal physiology of the flower stem after cutting, and issued a strong plea for all segments of the floricultural industry--from the grower through the wholesaler, to the retailer, to become concerned about extending cut flower life. Poor handling practices were endagering the economic health of the industry.

In 1962, Rogers (77, 78, 79, 80, 81, 82, 83, 84, 85) published a series of nine articles reviewing many aspects of keeping quality, considering factors applicable to both pre- and post-harvest conditions. He stated that short vase life of flowers could be one of the most important reasons why florists are apparently unable to develop an appreciable home use market in the U.S. (77).

II. Relation of Stored Carbohydrates at Time of Harvest to Subsequent Keeping Quality.

Undoubtedly, the size of the carbohydrate reserve at time of harvest has an important bearing on the cut flower's keeping quality (34, 35, 41, 43, 78). Holley (35) estimates that one-third of the cut flower life is influenced by the pre-harvest environment. Carbohydrate content is influenced by environmental factors such as light intensity, available water, growing temperature, and age of plant. Holley (34) reported that unless these factors are in balance, allowing plants to accumulate stored food materials, cut flower life cannot be expected to be maximized. In 1955, Knappenberger (41) published charts showing the correlation of sugar content in stems with vase life of carnations. He found that flowers with the highest sugar content in the stems at harvest time kept longest. To further correlate these two factors, Korns (43) has reported that the percentage of dry matter decreases steadily as the cut flower ages.

Rogers (78), in an excellent review of pre-harvest environmental factors affecting keeping quality, reported again a direct relationship between dry matter and keeping quality.

Nutrition

Several reports have been released on the relationship of nutrient levels during growth to keeping quality of cut flowers (22, 33, 39, 53, 89, 103, 113). Dorner (22), in reviewing work done at Illinois, reported poor keeping quality from flowers cut from "over-fertilized" plants, and Knapp (39) observed in 1950 that high nitrates resulted in a high per cent of premature wilting. Seeley (89) experimented with a range of soil nitrate levels for roses. Although 25 to 100 ppm of nitrate was recommended for optimum production and stem length, he reported no differences in keeping quality of roses grown at levels of 50 to 400 ppm. Twigg's (103) work in 1953 supported this when he reported that all roses kept equally well regardless of the nitrate levels used in the test. Rogers (78) and Twigg (104) concluded from their extensive reviews of the literature that in general, if the nutritional practices are within the range for normal growth, then nitrate is not a critical factor in keeping quality.

Light Intensity

The relationship of light intensity during growth of the plant affects subsequent keeping quality of cut flowers because of its effect on the accumulation of carbohydrates (36, 37, 38, 53, 88, 113).

Tests conducted in 1944 by Howland (36) showed that roses cut in the afternoon kept better than those cut in the morning. In an elaboration of this work (38) Howland measured the rate of accumulation of dry matter in rose leaves and plotted this data on a daily and seasonal

basis. Not only could he show the difference in dry weight between morning and afternoon, but also significant differences between accumulation in December and April. In this test, roses cut in the afternoon kept 7 per cent longer during the winter and spring, and 11 per cent longer during August than those cut in early morning. Rogers (78) suggests this as a possible explanation of the generally poorer keeping quality of roses at Christmas as compared with Mother's Day.

Mastalerz (53) cautions that a reduction in light intensity prior to cutting not only reduces the vase life but also reduces the length of time that flowers can be successfully stored at 31°F. In a paper delivered at the annual meeting of the American Society for Horticultural Sciences, 1964, Wesenberg (113) reported an interaction of night temperature and light intensity during the day. A night temperature as high as 75°F did not decrease the longevity of flowers on potted chrysanthemums unless the light intensity was reduced. Shading consistently decreased flower life.

Carbon Dioxide Concentrations

Due to the comparatively recent increase in research having to do with plant growth in higher than normal concentrations of carbon dioxide, only two reports are cited. Holley (35) reported that under conditions where keeping quality is reduced due to low carbohydrate accumulation, the practice of adding carbon dioxide to the greenhouse atmosphere may be found to give significant improvement in the life of the cut flower. Rogers (78) also reports that the addition of CO_2 to the environment during the growing period should be useful in increasing the dry matter. Additional work is currently underway to study the effect of elevated carbon dioxide levels on subsequent keeping quality.

Stage of Maturity

Cutting the rose at the proper stage of maturity has a decided effect on its keeping quality (39, 42, 104). This is due to the relationship of stored carbohydrates to stage of development and the maturation of the stem in the "neck" section at time of cutting. Knapp (39) reported that in order for the same variety of rose to produce maximum vase life, it must be allowed to remain on the plant longer in the winter than in the summer. Kohl (42), in a study of factors affecting "rose neck droop", correlated the relative strength of support tissue in the neck of the rose stem with age of shoot. He found that roses cut too early, tended to be unable to support the weight of the flower bud in certain varieties.

III. Post-Harvest Factors Affecting Keeping Quality

Factors affecting keeping quality of flowers after they have been cut include storage conditions, involving temperature, duration, humidity, controlled atmosphere and re-conditioning factors after storage; ethylene injury; chemical additives such as sugars and respiratory inhibitors; bluing of red roses, and metalic pigment stabilizers; plastic coatings, the matter of water uptake; sanitation; use of commercial preservatives and various handling practices.

A. Storage Conditions.

Marketing flowers in Europe differs from marketing in the United States in many ways. One is the almost complete lack of storage facilities (79). Growers are generally located close to their markets, and flowers not sold the day they arrive, are either dumped or returned to the producer. In this country, the use of storage facilities to

extend the sales period of a given crop, as well as permitting the establishment of markets thousands of miles from the grower, is an important part in the handling of cut roses. Several workers have investigated various aspects of cut flower storage (20, 24, 31, 55, 64).

Temperature and Humidity

Reducing the temperature, to reduce the rate of respiration, has been shown to be effective in extending the vase life of flowers (6, 39, 48). Siegelman (92) measured the rate of respiration of cut heads of roses as a function of temperature. He reported a Q_{10} for the 5°C - 15°C range as 3.7. As early as 1904, Perret (69) recommended the use of low temperature storage and stressed that the humidity should be relatively high.

In 1937, Bancroft (6) reported that roses would keep one day longer if conditioned overnight at a low temperature and 80 per cent relative humidity, rather than for only 3 hours. Laurie (48) recommended a temperature of 45°F and a relative humidity of 60 to 80 per cent for conditioning roses. Hitchcock (27) found no advantage in raising the humidity over 80 per cent. Later, Knapp (39) reported best vase life for roses that had been conditioned at 38°F. He claimed that 38°F was significantly better than 42°F for this purpose.

Neff (64) is credited with a major contribution to the literature, when he published his paper on dry storage of carnations in 1939. He discovered that carnation heads held 55 days dry at 33°F had only slightly less total sugars than when freshly cut, but similar flower heads in water held at the same temperature for the same length of time had lost one-half of their total sugars.

Fisher (24) worked with several cut flower species and varied the temperature in storage from 31°F to 44°F. His data showed 31°F storage best for roses, while those stored dry were generally superior to those stored with stems in a commercial preservative. Mastalerz (55), working with the length of time various flowers could be successfully stored suggested 15 days for Better Times roses in 31°F dry storage. The importance of critical control of storage temperature in this range is emphasized by Wright's (116) work which showed that the freezing point of rose petals is 30.0°F.

When properly handled, roses can be stored dry successfully for 2 weeks at 31°F. It is important though that they be properly reconditioned when they are removed from storage. Mastalerz (56) plotted the water uptake of dry stored roses as a function of water temperature. By varying the initial temperature of the water into which the stems of the stored roses were placed, he was able to show a 23 per cent gain in weight of roses within 24 hours using 122°F water, and only a 10 per cent increase with 40° water.

<u>Modified Atmosphere</u>

Another approach used to conserve the carbohydrate supply in storage is to reduce the rate of respiration by modifying the atmosphere (29, 31, 99, 102, 106). Over thirty years ago, Thornton (99) found that with increases in carbon dioxide content, the storage period for roses could be extended 7 days at 38°. When the concentration of carbon dioxide exceeded the 7 to 10 per cent range, the tissues were injured. Injury increased as the storage temperatures dropped below 38°F.

Some techniques were devised to increase the carbon dioxide from natural metabolic processes. Hague (29) credited the natural build-up

of carbon dioxide in roses packaged directly after cutting for the increase in keeping quality over similar roses in water at the same storage temperatures.

Uota has been attempting to increase the storage life of roses by still another approach. He is working with low oxygen atmospheres, and in a recent report (106) he stated that not only did low oxygen atmospheres lengthen the storage life of roses held at 32°F, but controlled atmospheres of 1/2 to 1 per cent oxygen used at "transit temperatures" (50-70°F) have been very effective in decreasing the rate at which roses open.

Asen (5) reported successfully retarding the opening of roses treated with ethylene oxide, but the limit of tolerance of the rose (and humans) to this gas is small.

B. Ethylene

Girardin is reported to have blamed illuminating gas for injuring trees almost 100 years ago, but it wasn't until 1901 that ethylene was identified as the responsible constituent (116). Since then, there has accumulated an extensive literature on sources, effects and controls of this gas. Krone (44) published a comprehensive bulletin on the effect of ethylene gas on flowering plants. Excellent recent reviews include Rogers (81) and Williamson (116). Its physiological effects on roses include hastening maturity and senescence, and pre-mature petal drop. Although ethylene is a normal metabolic by-product, proof that a plant disease can stimulate production of this gas is quite recent (115). Minute concentrations of ethylene, on the order of one part of gas in forty million parts of air can produce decided responses. Since chemical or mechanical methods of analysis were inadequate to detect such small quantities, over a period of 20 years, a number of methods of detecting ethylene by measurable test plant responses have been devised. Krone (44) suggested the use of various indicator plants including Lycopersicon and Swainsona. Using pea seedlings, Williamson (116) was able to show the relative production of ethylene from various rose diseases. With 0 equal to no production through 5 for the maximum response of pea seedlings, he reported powdery mildew as 1, rust - 2, anthracnose - 3, brown canker - 4, and maximum ethylene - 5, from black spot. It was interesting to note that healthy rose leaves produced little or no ethylene, black spot fungus on agar produced little or no ethylene, but black spot on rose leaves produced enough ethylene for the maximum response rating. Mechanical damage to rose leaves or leaves injured by spider mites also yield greatly increased quantities of ethylene.

Among recommended control measures are included complete insect and disease control and avoidance of bruising (115), low temperature for storage (25) (68), and absorbtion from the atmosphere by brominated activated charcoal (81).

C. Water Uptake

The maintenance of a continuous, plentiful supply of water throughout the stem of the rose is essential for maximum keeping quality. Many of the common practices in commercial handling are aimed at this goal, e.g., smashing or splitting woody stems. In most cases, the side effects of such practices are worse than the original condition. Any practice that tends to reduce vascular blocking should be considered. In 1911, Overton (66) proposed that cells, injured in cutting, may produce toxins which result in premature wilting and death. In 1935, Ratsek (75) using dyes to microscopically trace accumulations of bacteria in flower stems, concluded that these accumulations, especially in the sieve plates, formed a mechanical obstruction to water movement. Aarts (1) has presented evidence that there is both a direct and indirect effect of bacteria in the water. He states that their harmful effect is based on the formation of filterable, proteinaceous particles which mechanically block the vascular bundles. Ford (26) identified 19 different species of bacteria from swabs of flower containers. The bacteria most commonly associated with cut flower containers are naturally occurring soil and water forms. Laurie (47, 49) has emphasized the importance of using bacteriacides, while Knappenberger (40) further supports this by reporting that calcium hypochlorite, a dilute bacteriacide, was effective in extending vase life only if the water or vase was dirty. Aarts, in addition to establishing pH 4.0 as optimal for extending rose vase life, also showed a non-bacterial blockage of vascular bundles. Even under conditions where the development of bacteria was completely inhibited, blockage was frequently noted. As a result of his investigations (1) he concluded that active vascular bundle blockage is an aerobic, phosphorolating process. Before active bundle blocking can occur, three factors must have taken place: 1) damaging of the cells, 2) presence of air, and 3) release of a certain enzyme. He postulates that one advantage of low pH in extending rose vase life is that this enzyme may be inactivated by a low pH. Pokorny (72) supports the value of a pH of 4.0 for maximum rose life.

The aerobic requirement for active stem blocking may help explain why placing roses in deep water is beneficial. Laurie (47), Mastalerz (57), and Pridham have presented data to show that little or no water enters the stem via the bark, so the absorbing surface is not increased by plunging in deep water. Aarts suggests that the assumption that cutting stems breaks the cohesion of the water in the vascular bundles and the resulting air uptake hinders water uptake is not in accord with more recent research on the movement of water in higher plants. He found that the air entering the vascular bundles does not necessarily affect the water uptake in the form of air bubbles breaking the water column. Consequently it is assumed that even though the stem is not re-cut under water, the placing of rose stems in deep water has a favorable effect, if the presence of oxygen is a requisite for the development of active vascular bundle blocking. This, too, could explain the favorable results obtained by placing stems in very hot water. Due to increased water movement, this practice aids in removing the air which might be a major factor in actively blocking the vascular bundles. Above all, placing stems in boiling water would neutralize or break down the harmful enzymes. Tinga (102) suggests that one function of a detergent as a wetting agent may be to act as an enzyme poison, breaking down pectin esterase.

A water deficit is also a major problem involved in "bent neck" of roses. Kohl (42) reported that this symptom was due to a water deficit in the immature cells of the stem. Under microscopic examination, it was determined that the water conducting vessels in the neck portion of the rose flower were poorly developed, particularly if the rose had been cut in the tight bud stage. This underdevelopment results in two weaknesses: the flow of water is restricted, and with even a slight deficit, the reduced turgor combined with the lack of mechanical support from the thin walled semi-flaccid cells, permits the heavy flower head to droop

over, preventing normal development and unfolding of the petals. Kohl reported that an additional 24 hours of development on the plant could allow sufficient increase of fiber content to provide the necessary support and increased water-conducting system.

Plastic dips, to reduce water loss from transpiration have proven successful under limited conditions (91, 114).

D. Chemical Additives

The goal of many research projects in keeping quality has been to discover a simple chemical that might be added to the water for extending the vase life of flowers (1, 4, 6, 10, 11, 19, 27, 28, 30, 40, 49, 53, 54, 88, 98, 101, 102, 109). In general, the function of these additives is to either conserve or replenish the carbohydrate supply present at time of harvest, or to assist in maintaining water uptake.

<u>Sugars</u>

In 1930, Arnold (4) showed that 5 per cent glucose was beneficial in prolonging the cut flower life of a wide variety of flowers. Working with carnations, Knoppenberger (40) was able to increase cut flower life two to six days with the addition of ammonium or potassium alum - 1/2 teaspoon per gallon. Sugar, at the rate of 2 teaspoons per gallon, added to the alum solution, increased flower keeping another two to four days. Tinga (102) reported in 1956 the fact that the amount of sugar required for post-harvest treatment to provide maximum vase life, varies with the season of the year. Dahl (19), working with the rose variety "Pearl of Aalsmeer", tested a range of sugar concentrations and recommended a 4 per cent solution, with 30 ppm $AgNO_3$ and 0.1 per cent $Ca(NO_3)$.

Aarts (1) reports that glucose was slightly better than sucrose as a carbon source for roses, while maltose, in low concentrations also has a favorable effect. The literature generally agrees that sugar has an indirect action on keeping quality by supplying the necessary respiratory substrates.

In his thorough investigation of chemical additives, Aarts came to the conclusion that aside from "vascular blocking", the addition of sugar was the only factor that had a general influence on the keeping quality of cut flowers.

He demonstrated that: 1) the favorable influence of light on the keeping quality of stocks could be replaced by the addition of sugar; 2) the influence of the leaf is mainly due to the formation of assimilation products; and 3) water uptake is limited by sugar. The addition of sugar protects the plasmo proteins. The colloidal structure of the plasma is directly protected by the sugar so that the plasma is not involved in the metabolism.

Respiratory Inhibitors

In addition to supplying additional carbohydrates, another approach to extending vase life is to conserve the available supply by slowing down the rate of respiration. Siegelman (92) measured the rate of respiration of cut heads of roses and reported that at time of commercial harvest, they are either at a post-climacteric stage or do not exhibit a climacteric rise. His charts emphasized the influence of temperature on the rate of utilization of accumulated sugars. Mastalerz (54) reported that roses placed in water before storage were found to have a lower rate of respiration in storage than those packed without being placed in water.

Coorts (16), working under a more elaborate experimental set-up, reported a respiration drift downward, until the third day after cutting. The rate then climbs, climaxing on the sixth day. He found, too, that a much greater rate of respiration is obtained when rose stems are placed in a floral preservative as compared with roses in tap water.

Laurie (47, 49) considered a respiratory inhibitor an important means of extending keeping quality. Bennett (7), Griesel (28) and Weinstein (109) have reported positive results in using maleic hydrazide to extend the vase life of flowers. Bennett found that dipping in solutions varying from 200 to 1,000 ppm enhanced the keeping quality of roses. The major problem encountered with this procedure was the development of molds after treatment and storage at 40°F.

Aarts, on the other hand, cound find no positive results during further investigations with maleic hydrazide (0.0005 to 0.025 per cent) using *Rosa* var. Pearl of Aalsmeer.

Kinins

This group of growth regulator substances, due to their involvement in maintaining protein synthesis in detached plant parts, has attracted the interest of recent workers in the field of post-harvest physiology. One in particular, Verdan (N-6-benzyladenine) has produced spectacular results in slowing down the aging process in lettuce. Although Wesenberg (113) reported that this compound influenced the flower longevity when sprayed on potted chrysanthemums, and Link (51) produced positive results in retarding loss of leaves and bracts on poinsettias with Verdan sprays, limited research on this material at Missouri (86) did not result in any beneficial effects on the keeping quality of snapdragons.

Recently, Uota (107) produced a significant increase in storage life of stock through the use of Verdan.

E. Color Changes in Roses.

Some red rose varieties, notably "Better Times", characteristically undergo a distinct color change two to three days after being placed at room temperature in tap water. This is commonly called "bluing", and can result in an unsalable product while still firm and turgid. There are several good reviews of research on this phenomenon of bluing (18, 45, 52, 104, 108). As a basis of understanding the references to the influence of various factors on the pigments of the rose, attention is directed to two excellent sources: Bonner (9) on the biochemical nature of anthocyanins and Blank (8) for a review of the occurrance, physiology, morphology and genetics of anthocyanins. Twigg (104) reported that the Better Times rose had an anthocyanin, having an absorption peak at 515μ in an acid extract, and an anthoxanthin, having an absorption peak at 355μ in an ethyl acetate extract. He suggested the anthoxyanin pigment was a cyanin, which was supported by Ahiya (2) in 1962 when he identified the anthocyanin in "Pink Coronel" and "Happiness" as cyanidin.

Curry (18), studied the relationship between the quantity of anthocyanin pigment and tannin present in a rose variety, "Hadley" that blued easily, and "Lady Maureen Stewart" that seldom blued. He reported in 1927 that a combination of low tannins, plus low pigment concentration, resulted in bluing. His explanation was that the tannin acted to stabilize the red color and that the bluing was caused by the alkalinity in the cell sap, due to the low concentration of tannins. Twigg (104), however, 24 years later, suggested that the change in tannin content was a result and not a cause of bluing. He determined that a high potassium concentration in the petals played a direct role in bluing and suggested the possibility of the formation of an additional complex between the potassium and anthocyanin pigment. He listed three factors associated with bluing in the Better Times rose: higher pH values, higher potassium content of petals and higher concentrations of an anthoxanthin pigment.

Weinstein (108) operating on a grant to the Boyce-Thompson Institute from Roses, Incorporated, made a thorough investigation of the physiological changes that occurred in cut Better Times roses as they aged. With reference to the color change, his results indicated this sequence of events. First, the content of various sugars falls sharply. Next proteins are broken down gradually into their component parts, the amino acids. Free amino acids there begin to accumulate for a period of time and then they are broken down because of the lack of sugars for energy. The breakdown of amino acids liberates free ammonia into the tissue, which becomes toxic and causes bluing.

Kuc (45), in 1964, confirmed and amplified this sequence of events. The changes in total ammonia, amide and organic acid content were measured throughout the cut life of Better Times roses, and compared with similar measurements for every stage of development in roses allowed to age on the plant. In aging cut flowers, ammonia levels increased rapidly after 3 days. On the plant, ammonia accumulation was more gradual and never reached the level of that in cut flowers.

Measurements indicated increased amino acid oxidation was the source of the increased ammonia content in the maturing cut flowers. Amide synthesis increased for two days in cut flowers, while it continued into senescence in flowers remaining on the plant. Kuc presents evidence that amide synthesis is partially effective in ammonia detoxification, suggesting neutralization of the excess ammonia by the organic acid as an explanation.

Her data confirms the hypothesis that color change in aging cut roses is directly related to the ammonia nitrogen levels in excess of the acid equivalence. This excessive ammonia level is reached 4 to 5 days after cutting. In flowers aged on the plant, the ammonia level never surpasses the acid equivalence and the rose does not blue.

Bluing is so characteristic of approaching senescence that it is generally accepted as the best indication of keeping quality (88). Water relations (39, 55), light (63), excessive carbon dioxide (100) and ethylene oxide (5, 10, 106) have all been shown to have a direct effect on the expression of this color change.

The influence of metallic ions on keeping quality should also be considered. The beneficial effects of silver (87, 88) and zinc (12) are related to their bacteriacidal action. Aluminum, on the other hand, has been shown to form additive complexes with anthocyanins, resulting in a change of color (3, 13). The unnatural color of petals, associated with the use of preservatives in Better Times rose, is indicative of an additive complex formed in the petals with a material found in the preservative (108).

F. Commercial Preservatives.

Fourten (27) was one of the earliest authors to report on the successful extension of cut flower keeping quality, in 1906. During the ensuing years there have been many such reports (10, 11, 15, 30, 32, 40, 42, 49, 60, 76, 82, 83, 101, 109). Investigations have usually centered on bacteria and fungus inhibitors, sugars, metallic salts and respiratory inhibitors. In the mid forties, a new group of proprietary compounds began to appear on the commercial market, called floral preservatives. In 1948, Laurie (49) reported two formulations to reduce respiration, destroy bacteria and increase vase life of flowers. Weinstein (108, 109) developed a floral preservative specifically for extending the vase life of cut roses. Patents were applied for but difficulties were encountered in finding a manufacturer (112). Mastalerz (60), commenting on the specificity of some compounds noted that preservatives effective for roses are also very effective for chrysanthemums, but compounds designed for carnations are not usually as effective with roses or chrysanthemums.

Rogers (71), in summarizing the role of preservatives, said that most of the commercial preparations are composed primarily of sugar, usually either dextrose or sucrose; an acidic substance to reduce the pH of the water; metallic salts to help maintain better petal color; and substances to control the growth of microorganisms in the solution. Some of them in addition may contain a chemical respiratory inhibitor. There still seems to be some area of doubt on the minimum time period required for cut flowers to be in preservative solutions in order to produce beneficial results. Most reports agree that any absorbtion of preservatives after the flower is cut is useful, but for maximum results, continuous use is required (59, 83, 98). Tayama (98) varied the number of treatment days in preservatives, after which the flowers were placed in tap water. His data ranged from 7.3 days in water to 17.1 days, continuously in preservatives. Mastalerz (59) reported that 50 per cent of the effectiveness of floral preservatives can be lost in the first 14 to 48 hours if flowers are placed in water first. Bancroft (6) suggested that there was too little absorption in refrigeration to justify the use of preservatives. Weinstein (108) went even further by classifying two types of preservatives to be used at different stages of handling. He proposed a "Grower Type" preservative, composed of metabolic inhibitors to slow down rate of food consumption and complexed metal salts to retard breakdown of pigments, and a "Consumer Type" preservative. This would substitute sugar (succrose or dextrose) for the metabolic inhibitor, and add an acidic substance, and a substance to prevent the growth of bacteria.

IV. Need for Dissemination of Information

MiKesell (61) reported that no other segment of the agricultural industry is as lax and negligent with their end product as the florist industry. Moore (62) in discussing the possibilities of expanding the retail market for floral products, claimed that there was an urgent need for information on how to care for cut flowers both in the marketing channels and in the home. In a Texas consumer panel, Sorensen (93) reported that a need for information on the care of cut flowers in the home was cited as a major obstacle to expanded usage of flowers. Pfahl (70) made recommendations on how retail florists could process flowers in advance of sales, and Mastalerz (59), in 1960, came out with a strong plea that all segments should become concerned with the importance of their handling practices on the salability of their product.

As has been pointed out, basic information on the response of cut flowers to various chemicals and environmental factors has been available for many years. The economic crises faced by the rose growers in 1960 emphasized the need for a compilation of available research and a further investigation of current handling practices and new materials.

Projects were designed to develop data upon which a sound educational program could be launched with the goal of improving the keeping quality and image of the rose in the hands of the consumer.

STUDY I: THE EFFECT OF CHEMICAL PRESERVATIVES ON THE KEEPING QUALITY OF THE BETTER TIMES ROSE

Screening Trials

Screening trials were conducted from 1960 through 1963 in order to evaluate the experimental formulations becoming available as well as the modifications of commercial products.

Materials and Methods, 1960

In June, 1960, nine chemical formulations intended to extend the vase life of cut flowers were obtained. Three of them: Bloomlife, Floralife, and Petalife, were commercially available, nine: Roselife, Boyce Thompson rose preservative, and codes 681.3, 908.4, 1135.5, and 1362.6 were still in the experimental stage. Concentrations used followed manufacturer's recommendations. Two solvents were used in the preparation of the solutions: tapwater, and "ionized" water. The latter was produced by drawing water through a "Sil-A-Zin Ionizer." This device, made by the Omaha Chemical Co., is designed to electrolytically dissolve the preservative metals to the proper concentration in the water stream as it passed over metal electrodes sealed in a section of aluminum tubing.

The test solutions were carried to Floral Avenue Greenhouses, Mount Clemens, Michigan, the source of the roses used in these studies. The commercial grade, 15-18 inches, of Better Times rose was used. As the roses were cut, they were graded, divided into treatment lots of 40 roses each, placed directly into the various test solutions, and transported, in solution, to East Lansing for a 24-hour storage period at 40°F. They were then removed, stems recut, each lot subdivided into three uniform replications of ten roses each, and placed at room temperature in 2-quart waxed cartons, containing 48 oz. of freshly prepared preservative solution. Temperature and relative humidity recordings were made on a 7-day recording hydrothermograph.

There were 10 roses used in each of three replications of the 20 treatments, making a total of 600 roses under observation. Beginning with the third day at room temperature, the relative effectiveness of various treatments was measured daily by a panel of judges, drawn from the staff of the department. By means of indexing the judges scores, ranking each replication per judge, assigning points based on each judge's ranking, and adding up the total ranking per treatment based on the assigned points, the relative performance of each treatment was recorded.

Results

The results of the initial screening trial are shown in Table 1. Although there was a difference in the response of Better Times rose to the various treatments, one factor was uniform--the effect on bluing. All of the chemical treatments were effective in retarding the appearance of the undesirable bluish cast. Relatively speaking, on the sixth day of vase life, seven treatments looked better than the rest: Roselife and Floralife in ionized and tapwater, Bloomlife and Petalife in ionized water, and Code 681.3 in tapwater. On the seventh day, all treatments were discarded except the Roselife treatments which were still quite acceptable. These treatments were discarded on the eighth day.

Materials and Methods, 1961

In November, 1961, two new experimental preservatives, Fl-S-X and Fl-S-XX, were tested and the results compared with the effect of 3

Table 1. Preservative screening trials - 1960, treatments ranked according to relative effectiveness.

Treatment		No. days judged "acceptable"[a]
Preservative	Solvent	
Roselife	ionized water	7
Roselife	tapwater	7
Floralife	ionized water	6
Floralife	tap water	6
Bloomlife	ionized water	6
Code 681.3	tap water	6
Petalife	ionized water	6
Code 1362.6	ionized water	5.5
Code 681.3	ionized water	5.5
Code 908.4	ionized water	5.5
Code 1135.5	ionized water	5.5
Code 1362.6	tap water	5.5
Code 908.4	tap water	5
Code 1135.5	tap water	5
Petalife	tap water	5
Check	ionized water	4
Check	tap water	3.5
Boyce Thompson	ionized water	2.5
Boyce Thompson	tap water	2.5

[a]Each figure represents average of three replications, 10 roses each.

commercial preparations, Floralife, Petalife-H, and Roselife on the keeping quality of Better Times roses. Only plain water was used as a solvent and check.

The roses were cut on the morning of November 23, and within 1 hour, had been graded, divided into treatments and placed in warm (110°F) solutions of the appropriate chemical. They were transported to East Lansing and placed in the laboratory for vase life determinations without refrigeration. The temperature during transit and first day averaged 60°F. Daily temperature readings made during the remainder of the trial showed variations from 64°-71°F. Due to the large amount of uptake of the initial solutions by the roses, fresh solutions were prepared and added on the morning of the fourth day of vase life, November 27.

Ten roses, 15 to 18 inches long, were used for treatment and each treatment was replicated three times. Data from a total of 180 roses was taken for this test. Each day the number of "acceptable" flowers, based on the criteria of color, substance, turgidity, general freshness of appearance and resistance to shattering, was recorded for each treatment. At the conclusion of the trial, the average number of days of vase life was determined by totaling the daily readings and dividing by the number of flowers in the treatment. This method is explained in detail by Tayama and Kiplinger (98).

Results

Table 2 lists the treatments used, with the average number of days of vase life obtained per replication and an average figure per treatment. The value of using a good preservative was again demonstrated, with an increase in vase life of 3.5 days reported between the water

Table 2. Preservative screening trials, 1961.

Treatment	Average Days Vase Life			
	Replication No.[a]			
	1	2	3	Treatment
Floralife	7.9	8.0	7.7	7.9
Fl-S-X	8.0	8.2	8.1	8.1
Fl-S-XX	7.5	7.6	7.8	7.6
Petalife-H	4.7	4.5	4.7	4.6
Roselife	7.9	7.9	7.5	7.8
Water	4.4	4.7	4.6	4.6

[a]Average of ten roses per replication.

"check" and Fl-S-X. The specificity of response was also indicated. For example, Petalife, a carnation preservative, had no effect on Better Times roses vase life, although there was an improvement in color over the water check.

There was little difference between the Floralife preparations and Roselife. All of them produced good results. Some differences were observed between these preparations in the effect on the rose. Roses opened more quickly in Floralife. On the sixth day of vase life, nine out of thirty roses in Roselife were from 1/4 to 3/4 open. The remainder were fully open. While only four in Fl-S-X were 3/4 open, all were fully open in Floralife and two had shattered in Fl-X-XX.

The color clarity was similar in all of the chemical treatments. The most obvious difference in response was that when the roses in Floralife were finally discarded it was due to shattering. The petals maintained a crisp turgid appearance. When the roses in Roselife were discarded, it was due to a general softness or wilting. In neither case did these symptoms appear until after the eighth day.

Materials and Methods, 1962

Due to the increasing interest from formulators of preservative preparations, it was necessary to schedule two screening trials in 1962, one in January, one in July. Roses were obtained from a large commercial grower in Mount Clemens, Michigan. The roses were cut, graded, put into the test solutions within one hour and transported to East Lansing for 24 hours of conditioning at 40°F. They were then removed, divided into three replications of each treatment and placed into warm (110°) freshly prepared solutions in 1-quart cylindrical cartons for vase life determinations as described for the 1961 trials. Ten roses, 15 to 18 inches long, were used for each replication.

The first test began January 2. Two experimental formulations, Fl-S-X and "Brite Flower" were tested against three commercial preparations, Bloomlife, Floralife and Roselife, and water.

The second test began July 26. Two different experimental formulations were tested, O.F.P. and 362-X. Their effect on the vase life of roses was compared with the effect of Floralife and Roselife and a water check treatment. A total of 11 treatments were run in 1962, with three replications of each treatment, ten roses per treatment, totaling 330 roses under observation.

Results

These trials proved once again the value of a good preservative in extending the vase life of Better Times roses. None of the experimental formulations tried in 1962 were better than products currently available. Table 3 combines the results of both the January and July trials.

Roses in water developed the characteristic muddy blue color by the second day in winter and third day in summer. Preservative treatments maintained a clear red throughout the life of the rose.

Materials and Methods, 1963

In April, 1963, the final screening trials of this project were conducted. The source and grade of roses, method of collecting, transporting and conditioning, were the same. After 24 hours at 34°F, the stems were recut and placed in fresh solutions of 70°F. They were subdivided into lots of ten roses per replication, three replications per treatment.

For vase life determinations, a constant 74°F. temperature room was used with 12 hours of light, 1200 foot candles intensity per day. Data was collected as before.

Table 3. Preservative screening trials, 1962.

Treatment	Average days vase life			
	Replication[a]			
	1	2	3	Treatment Average
January Trials				
Bloomlife	6.2	5.6	5.1	5.9
Briteflower	4.8	4.8	4.9	4.8
Floralife	6.4	6.3	5.2	6.0
Fl-S-X	5.6	6.0	6.2	5.9
Roselife	6.2	5.9	6.2	6.1
Water	2.3	2.0	2.6	2.3
July Trials				
Code 362-X	4.0	4.0	4.0	4.0
Floralife	6.1	5.8	6.2	6.0
OFP	5.0	5.2	5.1	5.1
Roselife	6.4	6.2	5.9	6.2
Water	4.0	4.1	4.1	4.1

[a]Each figure represents average of data taken on ten roses.

Three experimental formulations, 187-X and 330-4801 from General Foods Corporation and CU-X from Cornell University were tested. For comparison, six commercial preparations were used: Bloomlife, Burpee Everbloom, Flora Magic, Floralife, Petalife and Roselife.

Ten roses were used per replication, three replications of ten treatments equaled 300 roses under observation for this trial.

Results

The effect of these preservatives on the vase life of Better Times roses is shown in Table 4. It is important to remember the difference in environmental conditions surrounding the roses in this test as compared with previous trials. The 1963 trials were conducted at a constant temperature of 74°, while other trials had been subjected to fluctuating diurnal variations from lows of 62°F to highs of 78° to 80°F.

Relatively speaking, the story is the same. Bluing showing up the third day in water treatments, no bluing in preservative treatment. The other observation repeated here is that although bluing was repressed in the preservative treatments, some, such as Burpee Everbloom and Flora Magic, shattered upon touch at 3.4 and 3.2 days.

Influence of Quality of Water on Action of Preservatives

Materials and Methods

In order to produce data showing the influence of pH on the action of preservatives in extending the vase life of roses, a test using distilled water adjusted to an alkaline and an acid level, was designed. At the same time, a test was run using local well water, before and after it had been run through a Culligan sodium exchange water softening system. An analysis of the water determined the mineral content.

Table 4. Preservative screening trials, 1963.

	Average days vase life			
	Replication[a]			
Treatment	1	2	3	Treatment Average
Bloomlife	4.7	4.8	5.0	4.8
Burpee Everbloom	3.6	3.4	3.3	3.4
Code 187-X	4.7	4.7	5.0	4.8
Code 330-4801	4.0	4.3	4.0	4.1
CU-X	4.3	4.5	4.6	4.5
Flora Magic	3.1	3.2	3.4	3.2
Floralife	4.1	4.4	4.2	4.2
Petalife	3.1	3.0	3.4	3.2
Roselife	5.0	5.2	5.4	5.2
Water	3.7	3.9	4.0	3.9

[a]Each figure represents average of data taken on ten roses.

Aluminum sulfate was used to adjust the pH to 4.2, a series of mono and di-basis phosphates were used to adjust the pH to 5.0 and 6.2, while calcium carbonate was used to adjust the pH to 8.0.

A Beckman pH meter was used to measure the pH of the various solvents, before and after addition of the preservative, and again five and seven days after vase life determinations were begun.

Better Times roses, 15 to 18 inches long, were taken from the grading table and put into the various test solutions within an hour of cutting on November 17, 1960. They were transported to East Lansing and placed in 40°F storage for 24 hours. They were then removed, stems recut and divided into three replications of each treatment, with ten roses per replication. Room temperatures in the laboratory varied from 64°F at night to a high of 77° during the day. Days of vase life were determined as detailed by Tayama and Kiplinger (98). Three replications, ten roses each, of ten treatments, resulted in a total of 300 roses used in this test.

Results

The treatments, pH values and days of vase life are shown in Table 5.

Roses in distilled water at a pH of 7.0, with no preservatives added, lasted an average of 3.5 days at room temperature before excessive bluing and wilting made them unacceptable.

Roses in the same water, to which a preservative had been added (lowering the pH to 3.6) lasted 6.4 days.

Roses in distilled water with the pH adjusted to 8.0 (simulating an alkaline water supply) to which preservatives were added (lowering the pH to about 4.0) lasted 5.3 days - cutting 1 day off their vase life.

Table 5. The effect of water quality on vase life of roses.

Treatment	Initial pH	pH values of solutions: After adding preservative[a]	5 days later	7 days later	Average days vase life[b]
Distilled water	7.0	7.0[e]	6.4	-	3.5
Distilled water	7.0	3.6	3.7	3.7	6.4
Distilled water adjusted to	8.0	4.0	4.0	4.2	5.3
Distilled water adjusted to	6.2	4.2	4.2	4.0	5.6
Distilled water adjusted to	5.0	4.3	4.2	-	2.7
Distilled water adjusted to	4.2	4.0	4.2	4.1	6.0
"Hard" water[c]	7.1	7.1[e]	7.0	-	2.3
"Hard" water[c]	7.1	5.8	6.5	6.2	5.3
"Soft" water[d]	7.1	7.1[e]	6.9	-	3.0
"Soft" water[d]	7.1	5.5	6.2	6.2	5.7

[a]Floralife.

[b]Each figure represents an average of 3 replications, 30 roses.

[c]57 ppm Iron.

[d]10 ppm Iron.

[e]Check treatment, no preservative added.

Roses in distilled water with the pH adjusted to 4.2 (simulating an acid water supply) to which preservatives were added (altering the pH to about 4.0) lasted 6 days.

Roses in deep well water, pH 7.1, lasted 2.3 days.

Roses in the same water to which a preservative had been added (lowering the pH to 5.8) lasted 5.3 days.

Roses in this well water, "softened" by the Culligan process, pH 7.1, lasted 3.0 days.

Roses in "softened" water to which preservatives had been added (lowering the pH to 5.5), lasted 5.7 days.

Influence of Time and Duration of Application of Preservatives

Materials and Methods

After the 1960 screening trial, two of the preservative formulations were chosen as most effective on Better Times roses. The next step was to study the interaction of the use of plain water and preservative solutions at various stages in the movement of cut roses through the marketing channels, from growers, through the wholesalers, retailers and to the customer. Three "handling periods" were devised, extending over a 4-day period, and various combinations of using water and preservative solutions in each period were established.

The method of handling the roses during each of the periods was as follows:

1. Grower. Roses were graded, bunched and placed in various solutions within one hour of cut on September 13, 1960. They were transported to East Lansing and placed in 40°F storage for a total of 48 hours from time of cut.

2. Wholesaler. At the start of this handling period, the roses were removed from refrigeration, taken from the solutions and placed on a table at a room temperature of approximately 75°F for four hours. They were then placed in containers of fresh solution, according to the specified treatment, and returned to the refrigerator for 20 hours, making a total of 24 hours.

3. Retailers. At the start of this period, the roses were removed from the refrigerator, stems recut, and the roses placed into fresh solutions indicated by treatment number. The temperature of the solutions was 100°F. The roses were then returned to refrigeration for 24 hours at 40°.

At the conclusion of the simulated retailer handling period, the roses were brought out into room temperatures of approximately 75°F, placed in containers of fresh solutions of the same formulation in which they were last stored. Vase life determinations were made according to the method already detailed. Ten Better Times roses, 15 to 18 inches long, were used per replication, three replications per treatment, with thirteen treatments totaling 390 roses used in this test.

Results

The list of treatments and average days vase life is presented in Table 6.

Under the conditions of this test, the roses in nothing but water lasted an average of four days. Little effect could be noted in treatments using Floralife first, followed by water, which resulted in an average of 3.86 days. Roselife, on the other hand, used only at the grower level, resulted in 5 days vase life. The longest period resulted

Table 6. The effect of time and duration of application of preservatives.

Handling Period			Days vase life			
			Replication No.			Treatment
Grower	Wholesaler	Retailer	1	2	3	Average
Floralife	Floralife	Floralife	6.6	6.0	6.9	6.5
Roselife	Roselife	Roselife	6.5	6.9	7.0	6.8
Floralife	Floralife	Water	5.0	4.4	5.0	4.8
Roselife	Roselife	Water	5.3	4.5	5.0	4.9
Floralife	Water	Floralife	6.5	6.1	6.2	6.5
Roselife	Water	Roselife	6.5	6.8	6.3	6.5
Floralife	Water	Water	4.2	3.2	3.8	3.8
Roselife	Water	Water	5.1	4.7	5.6	5.1
Water	Floralife	Water	5.2	5.3	4.5	5.0
Water	Roselife	Water	4.5	5.3	5.2	5.0
Water	Water	Floralife	5.9	7.3	5.9	6.4
Water	Water	Roselife	6.9	6.9	6.2	6.7
Water	Water	Water	3.2	4.5	4.3	4.0

[a]Average of data from ten roses.

from treatments using the preservatives in all stages of handling, with Roselife producing 6.8 days and Floralife 6.5 days, no significant difference.

STUDY II. EFFECT OF "FOAM" MATERIALS ON KEEPING QUALITY OF ROSES

Due to widespread use by retail florists of "foam" materials to hold the stems of roses, it was necessary to study the relationship of water-holding capacity, the relative rates of water uptake and loss through various foam materials, and the effect of wetting agents used in some foams on the vase life of roses.

Ratio of Quantity of Solution to Foam

Materials and Methods

In September 1960, three levels of solutions were set up with two foam materials, Sno-pac and Hydrafoam. The "minimum" moisture condition was arranged by using plastic "O" bowls that were 1 inch deep. The "medium" and "maximum" conditions were arranged in glass bowls, 6 inches in diameter. The medium moisture treatments were in bowls 2.75 inches deep and the maximum moisture treatments in bowls 6.0 inches in depth. One-third of a commercial block of foam material, having 72 square inches of surface area was used. Each was saturated in a preservative solution. In treatment #1, only the bottom inch of the block was in the solution. In treatment #2, the medium treatment, approximately one-half of the block was submerged. In treatment #3, the maximum moisture treatment, the block was totally submerged. Ten roses were used in each replication. The bases of the stems in the minimum and medium moisture treatments were inserted to within one-quarter inch of the solution level, so that the liquid had to move up through the foam to reach the stem. Levels of solution were maintained daily.

Roses were cut September 10, 1960, graded and placed into preservative solutions. They were placed in 40°F for 24 hours, brought out and divided into treatments. Two different "foams" in which the preservative solutions were held at three levels, plus a check treatment of water in a glass bowl, resulted in seven treatments. With three replications, 210 roses with 15 to 18 inch stems were used for vase life determinations.

Results

The average number of days of vase life per replication and for each treatment is shown in Table 7. Since the solution levels were maintained, the results were the same, regardless of the ratio of solution to "foam." The minimal moisture treatments had to be refilled on the average of two times a day, while the medium moisture treatment only once every two days. The maximum moisture treatments did not have to be touched.

Retailer Handling Practices

Foams are generally used by retail florists in two ways: in a container to which a solution can be added, or saturated initially, then wrapped in foil or plastic to act as an independent reservoir supplying moisture to the stems of flowers inserted at any angle.

In order to study the effect of retailers' handling practices on the keeping quality of roses in "foam" materials, tests were conducted in July 1962 and July 1963.

Materials and Methods, 1962

The purpose of this test was to compare the action of six foam materials under two conditions: 1) minimal water and 2) maximum water, using both tapwater and preservative solutions.

Table 7. The effect of quantity of solution to "foam."[a]

Treatment		Average days vase life			
		Replication No.[b]			
Moisture	"Foam"	1	2	3	Treatment
Minimum	Hydrafoam	7.1	7.5	7.0	7.2
Minimum	Sno-pac	6.1	7.6	7.0	6.9
Medium	Hydrafoam	7.8	7.9	7.9	7.9
Medium	Sno-pac	7.1	7.1	6.6	6.9
Maximum	Hydrafoam	7.3	7.5	7.3	7.4
Maximum	Sno-pac	3.5	4.3	3.2	3.7[c]

[a]Stems in "minimum" and "medium" moisture treatments within 1/4 inch of solution level.

[b]Average of data from ten roses, each replication

[c]Not adequately pre-soaked

Better Times roses were cut in a commercial range July 26, 1962. They were graded dry and placed in either a Floralife solution or tap-water and transported to East Lansing where they were conditioned at 40° for 48 hours.

Weights were taken of all "foam" materials both dry and after initial saturations, to determine amount of water uptake. At the end of vase life period, dry block treatments were re-weighed to determine amount of water lost during test.

On July 28, roses were removed from refrigeration and placed in appropriate "foam" treatment at room temperature which ranged from 67° to 78°F for vase life determinations.

The individual treatments are listed in Table 8. Conventional sized blocks were cut into half, and weighed. The "minimum water treatment" consisted of soaking the foam according to the manufacturer's recommendation, wrapping in foil and inserting stems of 10 roses. The "maximum water treatment" consisted of saturating the "foam", placing it in a 6-inch glass bowl to which an additional quart of the appropriate solution was added. Each treatment was replicated twice. A total of 440 roses was used.

Results

The effect of two handling methods on six foam materials as compared with "no foam" checks is shown in Table 8.

Roses lasted longest in the open vase of preservative solution, Treatment No. 21 - 6.1 days, as compared with the water, check, Treatment No. 22 - 3.3 days.

To better comprehend the data, the two moisture conditions are separated out.

Table 8. The effect of type of "foam" and solutions on keeping quality, 1962. (Average of 2 replications, expressed in Average Days Vase Life)

Treat. No.	Foam Material	Solution	Treatment	Average days vase life
1	Aquafoam	Water	In bowl	2.8
2	"	"	Foil wrapped	2.3
3	"	Preservative	In bowl	3.3
4	"	"	Foil Wrapped	3.0
5	Hydrofoam	Water	In bowl	3.2
6	"	"	Foil Wrapped	2.8
7	"	Preservative	In bowl	4.3
8	"	"	Foil Wrapped	3.6
9	Quickee	Water	In bowl	3.0
10	"	"	Foil Wrapped	2.6
11	"	Preservative	In bowl	3.3
12	"	"	Foil Wrapped	3.1
13	Speediblock	Water	In bowl	3.0
14	"	"	Foil Wrapped	2.8
15	"	Preservative	In bowl	4.0
16	"	"	Foil Wrapped	2.9
17	Aquatainer	Water[a]	Man'f. Recom.	3.0
18	Camelets	Water[a]	Water Added Daily	2.8
19	"	Water[a]	Initial Filling Only	2.8
20	Camelfoam	Water[a]	Man'f. Recom.	2.4
21	Check, Open Vase	Preservative	Open Vase	6.1
22	" " "	Water	Open Vase	3.3

[a]Preservative included in foam by manufacturer.

A. Minimal Moisture

Table 9 presents the "foil wrapped" foam treatments, with their weights and days of vase life.

Several items of interest arise from a study of this data.

1. Under minimal moisture conditions, roses lasted longest in preservative saturated Hydrofoam - 3.6 days.

2. Up to a full day can be added to the life of roses in dry block situations by using preservatives instead of water for the initial saturation (3.6 days in preservatives vs. 2.75 days in water).

3. There may be a correlation between the increased release of moisture with a wetting agent such as a preservative and the extra vase life. Both of the Hydrofoam treatments started out with approximately the <u>same</u> amount of moisture:

When Hydrofoam was saturated with water, it took up 833 to 854 gms of moisture. When Hydrofoam was saturated with preservative, it took up 846 to 862 gms.

Ranked according to vase life, the foil wrapped treatments provided the following results:

1.	Hydrofoam + preservative	3.6 days
2.	Quickee + preservative	3.1 days
3.	Aquafoam + preservative	2.95 days
4.	Speediblock + preservative	2.95 days
5.	Hydrofoam + water	2.75 days
6.	Speediblock + water	2.75 days
7.	Quickee + water	2.65 days
8.	Aquafoam + water	2.30 days

Table 9. Gms. liquid lost from various foil wrapped foams, ten roses per block.

Treatment	Initial weights in Gms Dry(Gms)	Wet(Gms)	Gms H_2O	Final Weight (Gms)	Gms H_2O released	Days vase life
Aquafoam+Water	18	738	720	620	110	2.3
	17	759	742	642	117	2.3
Aquafoam+Preservative	17	715	698	562	153	3.1
	17	719	702	549	170	2.8
Hydrofoam+Water	25	858	833	740	113	2.7
	26	880	854	745	135	2.8
Hydrofoam+Preservative	24	870	846	666	204	3.7
	25	887	862	696	191	3.5
Quickee+Water	257	901	644	791	110	2.6
	246	898	652	778	120	2.7
Quickee+Preservative	286	955	669	824	151	3.2
	275	916	641	790	126	3.0
Speediblok+Water	19	895	874	772	121	2.8
	19	889	870	795	94	2.7
Speediblok+Preservative	19	900	881	773	167	3.1
	19	917	902	745	172	2.8

B. Maximum Moisture

Table 10 presents the results of the treatments where the "foam" material was placed in a bowl with additional solutions, ranked according to vase life.

In all cases, roses lasted longer when the foams were saturated with preservative solution. Any foam in preservative is better than any foam in water. But the longest vase life was still obtained when the roses were placed in an open vase of water containing a good preservative.

Materials and Methods, 1963

In July 1963, a second screening trial of two new "foam" materials, "Fill-Foam-Fast" and "Jiffy", plus the current modifications of Hydrofoam, Oasis, Quickee and Sno-pac were conducted. The experimental set-up was the same as detailed for 1962 with the exception that Roselife was used as the preservative treatment. There were 780 roses used in vase life determinations.

Results

The effect of two handling methods on six "foam" materials as compared with "no foam" checks is shown in Table 11. The 1963 trials confirm the 1962 trials on general concepts with individual "foams" responding differently. The longest vase life was obtained by the use of adequate preservative solutions. In these trials, the use of "Jiffy" foam in a container filled with preservative solution equaled the vase life of the roses used in water to which a preservative had been added. The Fill-Fast-Foam used in these trials evidently contained some chemical that was harmful to roses unless soaked in preservatives. Following these trials the company made adjustments in the formulation of this material

Table 10. Performance of foams in maximum moisture, 1962.

Treatment		
Foam	Solution	Average days vase life[a]
Hydrofoam	Preservative	4.3
Speediblok	Preservative	4.0
Aquafoam	Preservative	3.3
Quickee	Preservative	3.3
Hydrafoam	Water	3.2
Quickee	Water	3.0
Speediblok	Water	3.0
Aquafoam	Water	2.8

[a]Average of two replications, twenty roses.

Table 11. The effect of type of foam and solutions on keeping quality, 1963.

Foam material	Solution	Treatment	Average days vase life[a]
Fill-Fast-Foam	Water	In container	1.6
Fill-Fast-Foam	Water	Foil wrapped	1.2
Fill-Fast-Foam	Preservative	In container	4.6
Fill-Fast-Foam	Preservative	Foil wrapped	1.8
Hydrafoam	Water	In container	3.6
Hydrafoam	Water	Foil wrapped	2.2
Hydrafoam	Preservative	In container	4.4
Hydrafoam	Preservative	Foil wrapped	3.2
Jiffy	Water	In container	3.3
Jiffy	Water	Foil wrapped	2.9
Jiffy	Preservative	In container	5.0
Jiffy	Preservative	Foil wrapped	3.9
Oasis	Water	In container	2.6
Oasis	Water	Foil wrapped	1.2
Oasis	Preservative	In container	3.0
Oasis	Preservative	Foil wrapped	1.0
Quickee	Water	In container	3.1
Quickee	Water	Foil wrapped	2.5
Quickee	Preservative	In container	3.4
Quickee	Preservative	Foil wrapped	3.1
Sno-Pac	Water	In container	3.7
Sno-Pac	Water	Foil wrapped	2.9
Sno-Pac	Preservative	In container	4.6
Sno-Pac	Preservative	Foil wrapped	4.3
Check	Preservative	In container	5.0
Check	Water	In container	3.3

[a]Average of three replications, of ten roses each.

which resulted in much better results. In water, roses wilted in the Fill-Fast-Foam within 1.6 days, while in preservative solution, they lasted 4.6 days.

According to the manufacturer, the only difference between Oasis and Hydrofoam is the wetting agent in Oasis, permitting uptake of moisture by submersion of the block. In order to wet Hydrofoam, moisture must be drawn into the foam by a partial vacuum. The difference in effect on vase life was striking:

Treatment	Average days vase life	
	Oasis	Hydrofoam
Foil wrapped + water	1.2	2.2
Foil wrapped + preservative	1.0	3.2
In container + water	2.6	3.6
In container + preservative	3.0	4.4

This emphasizes the significant influence various handling practices can have upon the keeping quality of uniformly grown roses.

The effect of various "foams" under conditions of maximum moisture are shown in Table 12, and under conditions of moisture from original saturation only (foil wrapped) in Table 13. The "foams" are ranked in descending order of effect on vase life.

Table 12. Performance of foams in maximum moisture, 1963.

Treatment		Average days vase life[a]
Foam	Solution	
Jiffy	Preservative	5.0
Sno-pac	Preservative	4.6
Fill-Fast-Foam	Preservative	4.6
Hydrafoam	Preservative	4.4
Sno-pac	Water	3.7
Hydrafoam	Water	3.6
Quickee	Preservative	3.4
Jiffy	Water	3.3
Quickee	Water	3.1
Oasis	Preservative	3.0
Oasis	Water	2.6
Fill-Fast-Foam	Water	1.6

[a]Average of three replications, ten roses each replication.

Table 13. Performance of foams in minimum moisture, 1963.

Treatment		Average days vase life[a]
Foam	Solution	
Sno-pac	Preservative	4.3
Jiffy	Preservative	3.9
Hydrafoam	Preservative	3.2
Quickee	Preservative	3.1
Sno-pac	Water	2.9
Jiffy	Water	2.9
Quickee	Water	2.5
Hydrafoam	Water	2.2
Fill-Fast-Foam	Preservative	1.8
Oasis	Preservative	1.0

[a]Average of three replications, ten roses per replication.

STUDY III: PACKAGING FOR SHIPMENT

Two major complaints have been raised concerning the physical movement of roses to the retailer. One involved the adverse effects of lying on wholesalers' tables without moisture, and the other involved mechanical injury and bruising of the petals in shipment. Two areas of investigation were conducted.

Effect of Polyethylene Shipping Bags on Keeping Quality

Materials and Methods

Treatments were devised in September 1960, to determine the effect of bagging roses in polyethylene with and without "foams". A commercial bunch of 25 roses was used for each treatment. Each treatment was repeated three times using either 12, 15 or 18 inch Better Times roses.

After cutting and grading, the roses were placed either in water or a preservative solution, as the treatment dictated, then placed in the refrigerator at 40°F for 24 hours. The roses were then transported to East Lansing where they were bunched, packaged according to treatment and packed in a commercial shipping container with ice. They were held in this container for 24 hours to represent period of shipment, after which time they were removed and laid on the table at room temperature for 4 hours, in the bags. After the period on the table, they were returned to the refrigerator for approximately 24 hours. The bagged treatments were placed in an empty can for support, the unbagged treatments were placed in water. This represented the wholesale period. Next, the roses were unpacked, stems recut, and placed in solutions of warm preservative. They were refrigerated for 24 hours to represent the retail period. They were then removed and placed in 2-quart milk cartons at room temperature in preservative solutions to determine vase life. There were 450 roses used in this test.

<u>Results</u>

Table 14 lists the individual treatments and their effect on subsequent keeping quality. An inspection of the data reveals little justification for recommending that growers should ship in plastic bags, if the roses are treated in preservative solutions when they are finally set out at room temperatures.

Vertical Shipping Carton

<u>Materials and Methods</u>

In order to investigate the possibility of designing a carton that would permit roses to be shipped vertically and reduce handling at the wholesale level, the following procedure was followed. Conferences with representatives of the Floriculture Section, Michigan State University, and prominant Michigan rose growers were held to outline the basic packaging requirements of the commodity. Next, these requirements were sketched and presented to the Packaging Department, Michigan State University, for their suggestions and improvements. Finally, a representative of the Research and Development Department, Hinde and Dauch Division of West Virginia Pulp and Paper Company, took over the plans for final modification and supplied a series of cartons for evaluation trials. These cartons were shown to the growers' and wholesalers' sections of the 1961 Michigan State Florist Association meeting in Detroit. Suggestions for further improvement were incorporated into another version which was shown to the Board of Directors of Roses, Incorporated, April 8, 1961.

Table 14. The effect of various treatments on roses in plastic bags.

Treatment	"foam" saturated in solution	Average days vase life by stem length[a] 18 inch	15 inch	12 inch
Rose stems in:				
Hydrafoam	Preservative	5.4	4.6	3.9
Hydrafoam	Water	4.8	5.3	4.2
Shredded Sno-pac	Preservative	5.3	4.2	5.1
Shredded Sno-pac	Water	4.9	5.2	4.5
Check treatment, bagged	No foam used	5.0	5.2	5.0
Check treatment, no bag	Paper wrap	4.8	4.8	5.0

[a]Average based on vase life of twenty-five roses per grade.

Since no further modifications were suggested at the April 8 meeting, negotiations were begun to prepare a test carton to meet shipping standards and to conduct a shipping test to compare the experimental design with a vertical container already in use for another commodity on the West Coast.

Results

The experimental vertical carton that was tested by shipping roses from California to Michigan differed from the Crown-Zellerbach carton primarily in that the test carton contained interior cross supports, dividing the area into cells, holding one bunch of roses each. Both cartons had the side zip tab feature, with water-proof tray in the base, allowing the wholesaler to zip off the top one-third of the carton, add solution to the base and display the product in the carton without further handling.

Roses were packed in the Crown-Zellerbach and experimental cartons in Redwood City, California, by Enomoto and Company on September 13, 1961. They were shipped that afternoon, arriving in East Lansing the night of September 14. Cartons were photographed and notes taken on the condition of boxes and contents. The roses were placed in vase life trials, reported in Study V. There was no difference in keeping quality of roses shipped in either carton.

In general, the test indicated the need for internal support to prevent shifting. The primary problem encountered with this test shipment was accomodations for ice. Water from the melting crushed ice around the stems produced weakening of the carton walls. No provisions had been made in the design for holding bagged ice in place.

Recommendations based on this test for improvement of future experimental designs include:

1. Make adequate provision for icing.

2. Modify the design to permit shipping mixed grades of roses, i.e., different stem lengths, and mixed shipments of floribundas and hybrid teas.

3. Provide for the adaptation of small experimental models to larger shipping cartons, keeping internal sub-divisions.

STUDY IV: EFFECTS OF N^6-BENZYLAMINOPURINE ON KEEPING QUALITY OF ROSES

Since there were references in the literature of the effect of a kinin called Verdan (N^6-Benzylaminopurine) in extending the life of leafy vegetables, and a preliminary report by Mac Lean indicated promising results on carnations, an investigation of its use on roses seemed feasible. A preliminary trial was conducted in March 1961 to study its effect at various concentrations as a dip and in a preservative solution on the vase life of Better Times roses.

Materials and Methods, 1961

Fifteen treatments were designed as detailed in Table 15. Ten roses, 15 to 18 inches long, were used in each treatment. Roses were cut, February 27, 1961 at the Plant Science Greenhouse, Michigan State University, conditioned in water at 40°F for 48 hours and graded. Treatments were applied as indicated, and the roses were set out at room temperature in the laboratory for vase life determination. The preservative used was Floralife, at manufacturer's recommendation of 1 teaspoon per quart. One hundred and fifty roses were used.

Results

The vase life of roses, subjected to the fifteen treatments listed, is shown in Table 15. Vase life determination began on March 1, two days after cutting. Roses in preservative solution alone lasted 5.4 days, while roses in water alone lasted 2.6 days. Verdan was ineffective when placed in the preservative solution for absorbtion by the stem. Dipping the roses for 60 seconds in a 100 ppm concentration of Verdan then placing them in preservative solutions added almost a day

Table 15. The effect of N^6-benzylaminopurine on vase life, 1961.

Treatment	Average days vase life[a]
Check - water	2.6
Check - preservative solution	5.4
N^6, 25 ppm in water	3.0
N^6, 200 ppm in water	2.1
N^6, 10 ppm in preservative solution	3.9
N^6, 25 ppm in preservative solution	4.6
N^6, 50 ppm in preservative solution	4.4
N^6,100 ppm in preservative solution	4.1
N^6,200 ppm in preservative solution	3.7
N^6, 10 ppm 60 sec. dip, then in preservative	5.9
N^6, 25 ppm 60 sec. dip, then in preservative	5.9
N^6, 50 ppm 60 sec. dip, then in preservative	5.6
N^6 100 ppm 60 sec. dip, then in preservative	6.4
N^6 200 ppm 60 sec. dip, then in preservative	6.2
N^6, 25 ppm daily spray, stems in preservative	6.2

[a]Average of ten roses per treatment.

to the vase life as compared to those that were placed directly in the preservative solution without the dip.

Materials and Methods, 1962

RESPIRATION STUDY. As the basic research on the effect of N^6-Benzylaminopurine increased in the Horticulture Department, it was possible to cooperate with other workers in order to study the effect of this kinin on the rate of respiration of roses.

Roses were cut February 6, 1962, graded, placed in water at 100°F, and conditioned at 35°F for 2 hours. They were then removed, packed in a box with crushed ice and transported to East Lansing where they were placed in cool (60°F) water and stored at 40° for 6 hours. Total time from cut until removal for treatment was 10 hours.

The stems were cut to an overall length, including the flower, of 8 inches to fit in the respiration chambers. The stems were placed either in 250 ml of plain water or the same quantity of a Roselife (1 tablespoon per quart) solution. For the "dry" treatments, the roses were leaned against the side of the respirometers. All roses were dipped prior to placing in jars, either in a 10 ppm solution of N^6-Benzylaminopurine, or water. Six roses were used per unit with three respiration units per treatment, totaling 162 roses in this test.

Treatment list:

1. N^6 dip, stems in water.
2. H_2O dip, stems in water.
3. N^6 dip, stems in preservative.
4. H_2O dip, stems in preservative.
5. N^6 dip, stems dry.
6. H_2O dip, stems dry.

7. Rose flower only, N^6 dip, dry.

8. Rose flower only, H_2O dip, dry.

Carbon dioxide evolution was determined by the Claypool-Keefer method at 8 hour intervals for 144 hours.

METHOD OF APPLICATION STUDY. A test to determine the best method of getting N^6 into the rose was conducted in May, 1962. Seven treatments were set up:

1. N^6 in solution for uptake by stem.
2. N^6 forced into stem by partial vacuum in bell jar.
3. N^6 used as a daily dip.
4. N^6 used as an initial dip only.
5. N^6 used as a single dip, when flower one-half open.
6. Control - water dip.
7. Control - no dip.

Ten Better Times roses, 15 to 18 inches long, were used for each of three replications. The roses were cut May 16, treated and placed in water in a 70° constant temperature room for vase life determinations.

Results

RESPIRATION STUDY. Carbon dioxide evolution was measured every eight hours for over six days. Each of the eight treatments was replicated three times, making a total of 456 individual measurements. Treatment averages for each sampling period for the CO_2 evolved are presented in Table 16.

Figure 1 indicates with smooth curves the effect of an N^6 dip on rates of respiration of roses, in water.

Figure 2 indicates the effect of an N^6 dip on rates of respiration of roses in preservative solution.

Table 16. The effect of N^6 on rate of respiration of roses. (Expressed as mg CO_2/kg/hr evolved[a])

Hour measured	Treatment Number[b]							
	1	2	3	4	5	6	7	8
2400	629	613	646	681	620	603	694	682
0800	479	450	453	520	452	444	509	491
1600	502	468	550	556	411	402	520	490
2400	471	450	553	533	440	400	498	491
0800	421	391	444	424	305	305	383	380
1600	366	387	472	419	328	360	401	397
2400	390	383	439	414	328	396	418	426
0800	434	387	446	431	368	356	430	411
1600	408	402	420	385	328	340	459	433
2400	320	357	336	347	308	310	374	374
0800	465	443	534	497	495	434	515	474
1600	358	324	382	386	359	314	401	440
2400	376	322	401	419	329	346	457	477
0800	394	354	419	409	369	360	456	409
1600	379	344	411	394	341	361	436	408
2400	334	303	383	372	354	336	416	409
0800	341	293	350	362	326	338	413	390
1600	291	314	364	371	361	354	405	366
2400	279	278	317	306	304	307	352	350

[a]Each value is average of three respiration units.

[b]Key to treatment code listed on pages 60 and 61.

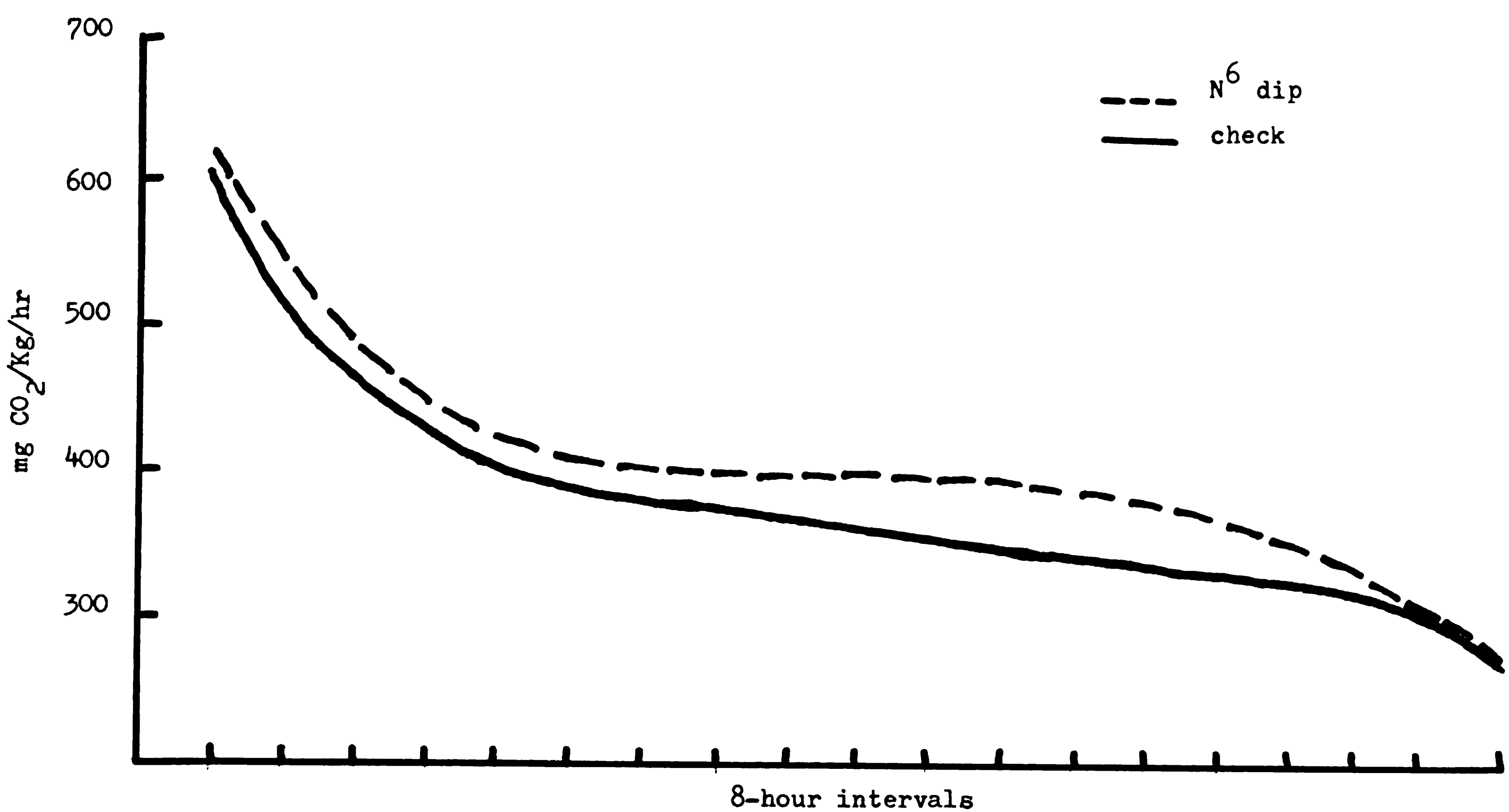

Figure 1. Rate of rose respiration, stems in water, with and without N^6 dip.

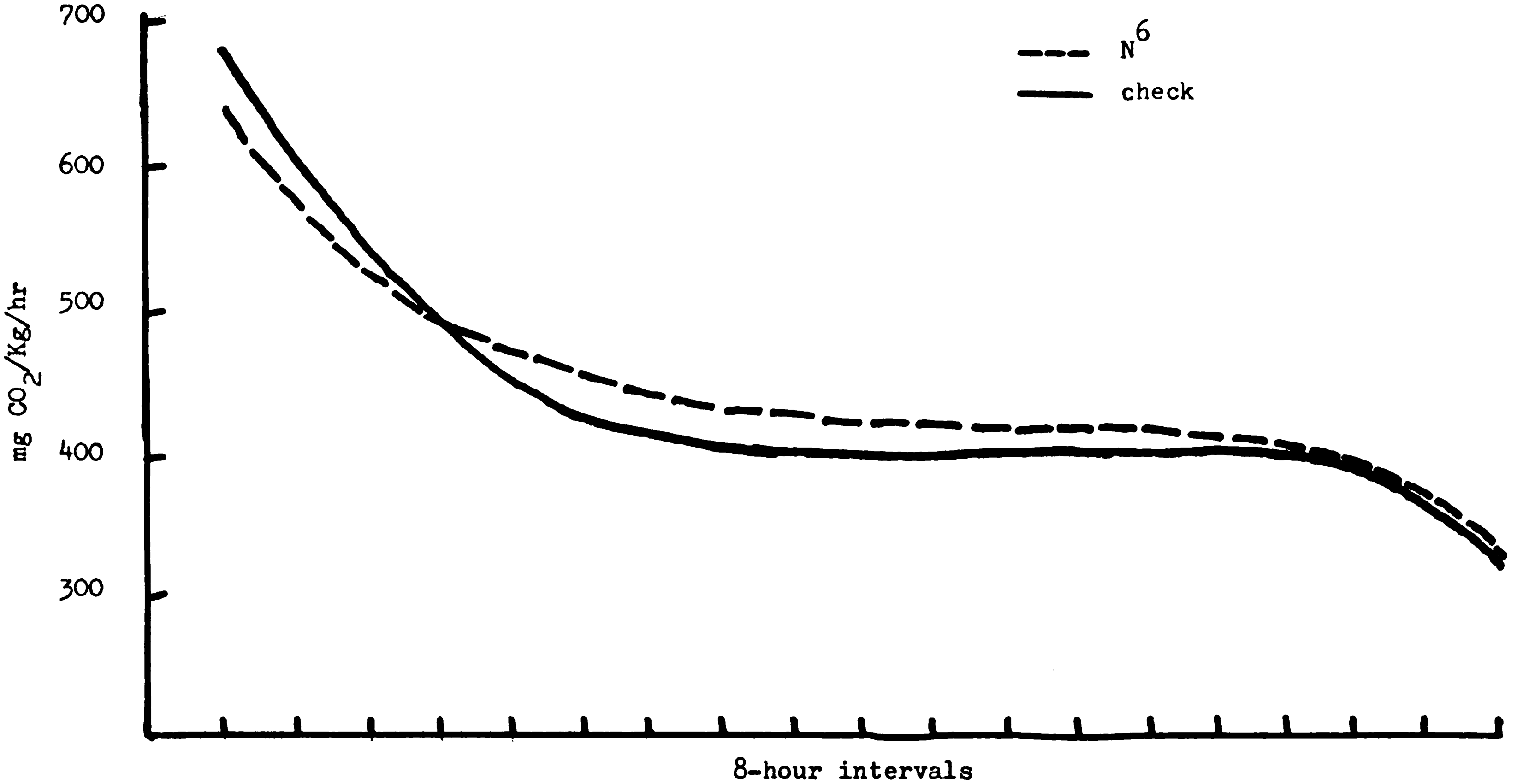

Figure 2. Rate of rose respiration, stems in preservative solution, with and without N^6 dip.

The data clearly indicates that under the conditions of this test, a 10 ppm concentration of N^6 used as a dip did not inhibit respiration, but apparently stimulated it.

Figure 3 shows the effect of a preservative solution on the rate of respiration of roses, as compared with water. The preservative solution, with added sugars, enables the roses in that treatment to maintain a higher rate of respiration for a longer period of time.

METHOD OF APPLICATION STUDY. The effect of various methods of trying to get N^6-Benzylaminopurine into the rose on its vase life is reported in Table 17. The roses were all in water for vase life determinations, and the data confirms the 1961 test. N^6 had no apparent effect on vase life under the conditions of this test.

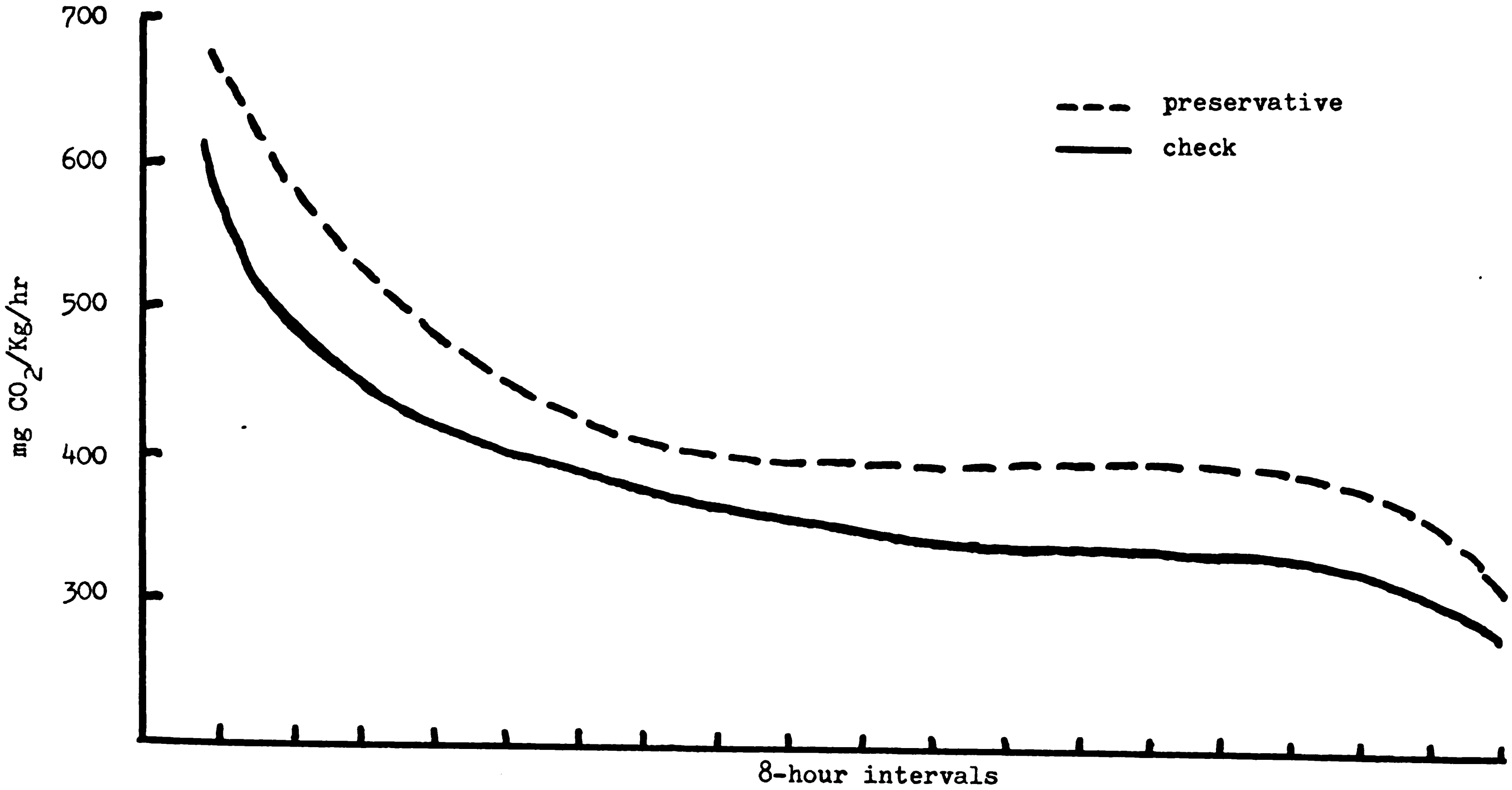

Figure 3. Rate of rose respiration, stems in water and preservative solutions.

Table 17. The effect of method of application of N^6 on vase life.

Treatment	Average days vase life[a]
N^6 in vase for stem uptake	4.0
N^6 absorbed under vacuum	3.5
N^6 as a daily dip	3.8
N^6 as an initial dip only	4.0
N^6 dip when rose half opened	3.8
Control - water dip	3.9
Control - no dip	3.6

[a]Average of three replications, thirty roses.

STUDY V: INTERACTION OF THREE-STAGE HANDLING PRACTICES ON "BENT NECK".

After studying many aspects of factors affecting the keeping quality of roses, this fifth and final study was organized. While the first four studies had as their goals, the general extension of vase life with roses opening and developing normally, this one was designed to investigate handling practices that affected the incidence of the premature wilting called "bent neck". In order to combat this problem it is necessary to understand what produces the symptoms.

Preliminary investigations suggested four handling practices should be studied.

Phase 1. Effect of Variables at the Grower Level

Materials and Methods

In order to observe the effect of various methods of handling roses by the grower, the following treatments were set up:

1. Time out of water. Five time periods were used, ranging from minimum, (in which buckets of solution and plain water were placed in the greenhouse and as roses were cut, they were placed in these buckets instead of the usual dry racks at the end of the benches) to 1, 2, 3 and 4 hours dry after cutting, before placing into water or preservatives.

2. Temperature of solution. Roses from each of the five time periods were placed in warm water and preservative solutions at 110° and cool water and solutions at 60°F.

3. Water vs. Preservatives. Half of the roses from each treatment were placed in tapwater, the other half in Roselife.

4. <u>Conditioning vs. Non-conditioning</u>. The fourth variable divided all the other treatments into two lots. One group was placed directly into vase life determinations at room temperature (which varied from 62° to 70°F) while the other group was placed in refrigerated storage at 34°F for 24 hours, and then brought out into room temperatures, which varied from 60° to 72°F, for vase life determinations.

Roses were cut May 17, 1961. Each treatment consisted of ten Better Times roses, 15 to 18 inches long and each treatment was replicated twice. Seven hundred and twenty roses were used.

<u>Results</u>

The effect of the 36 combinations of the four variables under investigation, on vase life are shown in Table 18.

For easier interpretation, the same data is summarized in Tables 19, 20 and 21 using the average days vase life per treatment grouped under treatment headings. A study of this data reveals that:

Up to 3 hours out of water, there were only slight differences between hot and cold water, and conditioned and non-conditioned treatments. The longer the roses were out of water, the shorter the vase life.

Under the conditions of severe water deficiency, (4 hours out of water) hot water was more effective than cold and 24 hours refrigeration materially increased the keeping quality.

The same general response was noted in treatments using preservatives, i.e., little benefit was derived from heating the preservative in treatments up to 3 hours, but in severe dessication, the action of the preservative was greatly enhanced by use of hot water and 24 hours of low temperature conditioning.

Table 18. The effect of grower treatment on keeping quality.

Treatment	Hours refrig.	Average days vase life: Replication 1	Replication 2	Treatment average
Directly in water in GH	24	5.0	4.7	4.85
" " preservative in GH	24	7.9	7.8	7.85
" " water in GH	0	4.7	4.7	4.70
" " preservative in GH	0	7.7	7.1	7.40
Dry 1 hour, into cold water	24	3.8	3.5	3.65
" " " " " preservative	24	7.4	7.4	7.40
" " " " " water	0	3.4	3.4	3.40
" " " " " preservative	0	6.2	6.5	6.35
" " " " hot water	24	3.6	4.0	3.80
" " " " " preservative	24	7.5	7.6	7.60
" " " " " water	0	3.6	3.5	3.55
" " " " " preservative	0	7.1	7.1	7.10
Dry 2 hours, into cold water	24	2.4	2.3	2.35
" " " " " preservative	24	7.2	7.4	7.30
" " " " " water	0	2.2	2.2	2.20
" " " " " preservative	0	6.7	7.0	6.85
" " " " hot water	24	2.6	2.6	2.60
" " " " " preservative	24	7.9	7.9	7.90
" " " " " water	0	2.4	2.4	2.40
" " " " " preservative	0	6.9	7.0	6.95

Table 18. The effect of grower treatment on keeping quality. (Continued)

Treatment	Hours refrig.	Average days vase life: Replication 1	Replication 2	Treatment average
Dry 3 hours, into cold water	24	2.3	2.3	2.30
" " " " " preservative	24	7.8	7.8	7.80
" " " " " water	0	2.0	2.3	2.15
" " " " " preservative	0	6.8	7.2	7.00
" " " " hot water	24	2.6	2.5	2.55
" " " " " preservative	24	7.9	7.8	7.85
" " " " " water	0	2.3	2.3	2.30
" " " " " preservative	0	7.0	7.2	7.10
Dry 4 hours, into cold water	24	1.6	1.4	1.50
" " " " " preservative	24	7.8	7.8	7.80
" " " " " water	0	1.1	1.6	1.35
" " " " " preservative	0	3.7	3.4	3.85
" " " " hot water	24	3.3	3.3	3.30
" " " " " preservative	24	7.7	7.9	7.80
" " " " " water	0	2.1	2.5	2.30
" " " " " preservative	0	4.8	5.2	5.00

Table 19. Interaction of water vs. preservative and temperature of solution - retailer level. (Expressed in average days vase life.)

Treatment	Water		Preservative	
	cold[a]	hot[b]	cold[c]	hot[b]
Non-conditioned[d]				
Solution in greenhouse		4.7		7.4
Roses out of sol. 1 hour	3.4	3.6	6.4	7.1
Roses out of sol. 2 hours	2.2	2.4	6.8	7.0
Roses out of sol. 3 hours	2.2	2.3	7.0	7.1
Roses out of sol. 4 hours	1.4	2.3	3.8	5.0
Conditioned[e]				
Solution in greenhouse		4.8		7.8
Roses out of sol. 1 hour	3.6	3.8	7.4	7.6
Roses out of sol. 2 hours	2.4	2.6	7.3	7.9
Roses out of sol. 3 hours	2.3	2.6	7.8	7.8
Roses out of sol. 4 hours	1.5	3.3	7.8	7.8

[a] - 58 degrees F.

[b] - 110 degrees F.

[c] - 60 degrees F.

[d] - Roses placed out for "vase-life" determinations directly after grading.

[e] - Roses placed in 34 degree refrigerator for 24 hours after grading.

Table 20. Interaction of water vs. preservative and conditioned vs. non-conditioned roses. (Expressed in average days vase life.)

Treatment	Water		Preservative	
	Non-cond.[a]	Cond.[b]	Non-cond.[a]	Cond.[b]
Solution in greenhouse	4.7	4.8	7.4	7.8
Roses out 1 hour then in cold sol.	3.4	3.6	6.4	7.4
Roses out 1 hour, then in hot sol.	3.6	3.8	7.1	7.6
Roses out 2 hours, then in cold sol.	2.2	2.4	6.8	7.3
Roses out 2 hours, then in hot sol.	2.4	2.6	7.0	7.9
Roses out 3 hours, then in cold sol.	2.2	2.3	7.2	7.8
Roses out 3 hours, then in hot sol.	2.3	2.6	7.1	7.8
Roses out 4 hours, then in cold sol.	1.4	1.5	3.8	7.8
Roses out 4 hours, then in hot sol.	2.3	3.3	5.0	7.8

[a]Roses placed out for "vase life" determinations directly after grading.

[b]Roses placed in 34°F refrigerator for 24 hours after grading.

Table 21. Interaction of water vs. preservatives and time out of solutions. (Expressed in average days vase life.)

Treatment	Greenhouse		Out 1 Hour		Out 2 Hours		Out 3 Hours		Out 4 Hours	
	water	presev.	water	presev.	water	presev.	water	presev.	water	presev.
Non-Conditioned[a]										
Cold solutions[b]			3.4	6.4	2.2	6.8	2.2	7.2	1.4	3.8
Hot solutions[c]	4.7	7.4	3.6	7.1	2.4	7.0	2.3	7.1	2.3	5.0
Conditioned[d]										
Cold solutions[b]			3.6	7.4	2.4	7.3	2.3	7.8	1.5	7.8
Hot solutions[c]	4.8	7.8	3.8	7.6	2.6	7.9	2.6	7.8	3.3	7.8

[a]Roses placed out for "vase life" determinations directly after grading.

[b]58 degrees - 60 degrees F.

[c]110 degrees F.

[d]Roses placed in 34 degrees F refrigerator for 24 hours after grading.

The greatest differences existed between the use of water and the use of the preservative.

Effect of California Handling on Vase Life of Roses Shipped to Michigan

Materials and Methods

In order to provide more realistic data on the grower handling effects on subsequent keeping quality, a shipping test was arranged with a California rose grower.

The grower applied five treatments to six varieties of roses. All roses were shipped on the afternoon of September 13, 1961.

Treatment I. Cut on the morning of September 9, placed in 31°F dry storage for approximately 80 hours. Removed on the afternoon of September 12 and placed in 65°F water. Held overnight in 38°F refrigerator; shipped September 13. Varieties used:

1. Baccara
2. Happiness
3. Red Delight

Treatment II. Cut September 11, roses were placed in water at 65°F and into 38°F storage refrigeration for approximately 48 hours. They were removed and shipped September 13. Variety used:

1. Christian Dior

Treatment III. Roses cut on September 12 were placed in water at 65°F, then into 38°F storage overnight. They were shipped September 13. Varieties used:

1. Baccara
2. Happiness
3. Red Delight

4. Mayday
5. Honeygold
6. Gold Top

Treatment IV. The roses were treated in a manner similar to those in Treatment III, except that Roselife was used instead of water. They were cut September 12, then placed in Roselife at 65°F and stored at 38° overnight and shipped September 13. Varieties used:

1. Baccara
2. Happiness
3. Red Delight
4. Mayday
5. Honeygold
6. Gold Top

Treatment V. The roses were cut on the morning of September 19, placed in water at 40°F. Stored for 3 hours in a 40°F refrigerator and shipped the same day. Varieties used:

1. Happiness
2. Gold Top

The roses were packed in two vertical shipping cartons and shipped Air Express, arriving in Lansing, Michigan approximately 30 hours later. Each bunch of roses was wrapped in newspaper with crushed ice in the paper and with bags of ice attached to the top and bottom of the boxes.

Upon receipt of the roses in East Lansing, it was noted that the cartons had begun to collapse due to wetting, but much ice still remained unmelted inside the individual bunches. The layer of fiberglass insulation apparently was highly effective in maintaining a low internal temperature.

Each bunch of roses was divided, so that one-half of the roses were placed in hot (110°F) water and one-half were placed in a hot (110°F) solution of Roselife. The roses were unpacked near midnight, Thursday, September 16, and after being placed in the appropriate solutions, were placed in 40°F storage over Friday for conditioning. They were removed from storage Saturday morning, September 16 and placed in freshly prepared solutions of the same composition in which they had been conditioned over the past 32 hours. They were then placed at room temperature (67° to 79°F) for vase life determinations.

A total of 21 bunches of roses were received, each one being split into two lots at East Lansing--one lot was placed in water and the other one in Roselife, making a total of 42 lots of 10 roses each, or 420 roses under observation.

Results

Table 22 presents a list of the various treatments administered in California and Michigan, and the average number of days vase life resulting from each treatment.

There was no observable difference between any bunches of roses when they were unpacked in Michigan. They all were apparently crisp, firm and turgid. The same was true upon removal from refrigeration on the morning of September 16. All lots were of comparable quality, which is substantiated by other studies, which indicated that it is difficult to detect differences between treatments on roses still under the influence of refrigeration. At this time, the rate of respiration is too low to show differences in keeping quality. BUT, differences can show up quickly under higher temperatures. At the end of 24 hours at room temperature, 8 out of 10 Happiness roses that had been improperly

Table 22. Effect of five grower treatments on keeping quality. (Expressed in average days vase life.)

California Treatment (Prior to shipment)		Treatment after arrival in Michigan: Water	Preservative
I. Three days - 31°F Dry One day - 38°F WATER Varieties:			
	1. Baccara	2.3	4.5
	2. Happiness	1.3	4.1
	3. Red Delight	1.2	3.6
II. Two days - - 38°F WATER Variety:			
	1. Christian Dior	3.9	5.6
III. One day - - 38°F WATER Varieties:			
	1. Baccara	2.6	5.9
	2. Happiness	2.2	3.7
	3. Red Delight	2.5	3.3
	4. Mayday	4.6	5.7
	5. Honeygold	4.3	5.3
	6. Gold Top	3.3	5.3
IV. One day - - 38°F PRESERVATIVE Varieties:			
	1. Baccara	4.5	6.2
	2. Happiness	1.1	4.7
	3. Red Delight	2.3	3.9
	4. Mayday	5.1	5.5
	5. Honeygold	4.4	5.2
	6. Gold Top	3.5	4.8
V. Three hours - 40°F WATER Varieties:			
	1. Happiness	0.2	3.9
	2. Gold Top	3.3	5.5

conditioned (Treatment No. V-1) had collapsed, while roses of the same variety, picked 24 hours earlier and conditioned overnight in preservatives were still in good condition 5 days later (Treatment No. IV-2).

Effect of Method of Reconditioning Roses Stored at 41° on Subsequent Vase Life

Materials and Methods

Another important handling practice at the grower level which can influence the expression of "bent neck" at a later date is the storing of roses dry for a 24 hour period at 31°F. This test was set up to determine the effect of preservatives vs. water in reconditioning Better Times roses stored dry for three days at 31°F. The treatments applied are outlined in Table 23. One hundred Better Times roses were used in this test.

Results

The data proves the importance of using preservatives at the grower level when handling roses stored dry for extended periods at 31°F. The vase life for each treatment is listed in Table 23.

Phase 2. Effect of Variables at the Wholesaler Level

Materials and Methods

The next step was to prepare a quantity of roses at the grower level in an optimum manner, so that they could be expected to give maximum vase life, and determine the effects of various handling methods by the wholesaler on their subsequent keeping quality.

Roses were cut August 10, 1961 and within one hour, placed in hot (100°) water containing a commercial preservative. They were then

Table 23. Effect of water and preservative on conditioning roses stored dry for 24 hours at 31°F.

Grower handling	Wholesaler handling	Retailer handling	Vase life determination	Average days vase life[a]
All roses stored dry at 31°, then:				
24 hours - 35°F in hot[b] water	24 hours - 37°F in cool[c] water	24 hours - 37°F in cool water	into hot water	1.8
24 hours - 35°F in hot water	24 hours - 37°F in cool water	25 hours - 37° in cool water	into hot preservatives	3.0
24 hours - 35°F in hot preservatives	24 hours - 35°F in hot preservatives	24 hours - 37°F in cool preservatives	into hot water	4.0
24 hours - 35°F in hot preservatives	24 hours - 37°F in cool preservatives	24 hours - 37°F in cool preservatives	into hot preservatives	5.8

[a] Average of two replications, twenty roses.

[b] 110°F.

[c] 54°F.

refrigerated at 34°F for 24 hours. At the end of this time, they were loaded on a wholesaler's refrigerated truck, along with the rest of the shipment, and transported in the solution to East Lansing. Four hours after leaving the grower, they were delivered to the local wholesaler where they were taken over by the investigators for various treatments.

The major variable in this phase was the effect of time out of water (simulating the laying out of roses at a commission house). The other three variables studied in the grower phase were also included to determine their action on overcoming the adverse effects of being out of water.

The time out of water at this level consisted of 0 hours, (roses placed directly into solution) 2, 4 and 6 hours on the table, dry, then into solutions and either refrigerated or put out for vase life. In another treatment the roses were placed in solution, then placed at room temperature for 6 hours, then refrigerated.

The temperatures of the solutions were the same as before, and the other variables were also the same.

After the treatments were completed, the roses were placed at room temperature (62° - 76°F) for vase life determinations. Each treatment contained 10 Better Times roses, 15 to 18 inches long, with 2 replications. Six hundred roses were used.

Results

Table 24 presents the 30 combinations of treatments used, and shows the average days of vase life resulting from each treatment and the average keeping quality of the two replications combined.

Table 24. Effect of wholesaler treatment on keeping quality.

Treatment	Hours Refrig.	Average days vase life Replications 1	2	Treat. Ave.
Roses placed:				
Directly into hot water	24	4.5	4.1	4.3
" " " "	0	4.5	4.3	4.4
" " " presv.	24	5.8	5.3	5.6
" " " "	0	6.2	6.3	6.3
In hot water, left on table 6 hrs.	24	3.8	3.7	3.8
" " presv. " " " " "	24	6.6	6.3	6.5
Dry 2 hrs. - into cold water	24	3.9	4.4	4.2
" " " - " " "	0	5.0	4.7	4.8
" " " - " " presv.	24	7.0	6.3	6.7
" " " - " " "	0	7.2	7.2	7.2
" " " - " hot water	24	4.2	4.2	4.2
" " " - " " "	0	4.2	4.5	4.4
" " " - " " presv.	24	6.4	6.0	6.2
" " " - " " "	0	5.8	6.1	6.0
Dry 4 hrs. - into cold water	24	4.3	4.5	4.4
" " " - " " "	0	4.6	4.8	4.7
" " " - " " presv.	24	6.1	6.8	6.5
" " " - " " "	0	6.3	6.5	6.4
" " " - " hot water	24	3.9	4.1	4.0
" " " - " " "	0	4.6	4.8	4.7
" " " - " " presv.	24	6.4	6.5	6.5
" " " - " " "	0	5.7	6.1	5.9
Dry 6 hrs. - into cold water	24	4.0	4.0	4.0
" " " - " " "	0	4.6	4.8	4.7
" " " - " " presv.	24	6.3	6.7	6.5
" " " - " " "	0	5.7	6.0	5.9
" " " - " hot water	24	4.0	4.0	4.0
" " " - " " "	0	4.5	4.7	4.6
" " " - " " presv.	24	5.9	6.1	6.0
" " " - " " "	0	5.9	6.6	6.3

For easier interpretation, the same data is summarized in Table 25 using the average days of vase life per treatment grouped under treatment headings.

In examining the Table, it is well to remember that the figures presented represent the average number of days roses in each treatment lasted at room temperatures which varied from 62°F to 76°F. The "conditioned" roses were 24 hours older than the "non-conditioned" ones. All roses arrived in excellent shape at the wholesalers. They had been chilled and placed in preservatives.

Phase 3. Effect of Variables at Retailer Level

The third phase of this study used uniformly treated roses handled in an optimum manner by the grower and wholesaler in order to determine the effect of various handling methods by the retailer on subsequent keeping quality.

Materials and Methods

Roses were cut September 8, 1961, and within an hour, placed in solutions of hot preservatives. They were refrigerated at 34°F for 24 hours. They were then transported to the wholesaler in East Lansing via refrigerated truck. They were then taken over by the investigators. At this point, the "wholesaler" treatment consisted of placing them in cold preservatives and storing at 40°F for 24 hours. The roses were then removed from refrigeration and various treatments applied at the "Retail" level. Five variables were used:

1. Time Out of Water. The treatments here consisted of 0 hours (roses placed directly into solution) and 3 hours on the table at room temperature (74°F).

Table 25. Interaction of water vs. preservative and temperature of solution - wholesaler level. (Expressed in average days vase life.)

Treatment	Water Cold[a]	Water Hot[b]	Preservative Cold[a]	Preservative Hot[b]
I. Non-conditioned[c]				
1. dry 0 hours		4.4		6.3
2. dry 2 hours	4.8	4.4	7.2	6.0
3. dry 4 hours	4.7	4.7	6.4	5.9
4. dry 6 hours	4.7	4.6	5.9	6.3
II. Conditioned[d]				
1. dry 0 hours		4.3		5.6
2. dry 2 hours	5.2	4.2	6.7	6.2
3. dry 4 hours	4.4	4.0	6.5	6.5
4. dry 6 hours	4.0	4.0	6.5	6.0
5. in sol. 6 hours		3.8		6.5

[a] 60°F.

[b] 110°F.

[c] Placed directly out for vase-life trials from treatment. No refrigeration.

[d] Placed in 40°F for 24 hours after treatment, then out for vase life.

2. Cut vs. Not-Cut. After the above treatments, and before placing in water or preservative solutions, stems of one-half of the roses were cut in a slanting manner so as to remove approximately 1/2 inch. The others were placed in appropriate solutions without cutting.

3. Temperature of Solution. The same temperatures were used as in the other phases - cold, 60°F, hot, 110°F.

4. Water vs. Preservatives. The treatments were the same as those described in the other phases - Tapwater and Roselife.

5. Conditioned vs. Non-conditioned. Conditioning treatments consisted of 24-hour storage at 40°F, after the other treatments had been applied.

Results

Table 26 presents the 32 combinations of treatments used with the average days vase life resulting from each replication and the average keeping quality of the two replications combined.

For easier interpretation, the same data is summarized in Table 27 using the average days vase life per treatment, grouped under treatment heading.

In examining the data presented in Table 27 it is well to keep in mind that the figures represent the average number of days roses in each treatment lasted at room temperature, which varied from 64°F to 70°F. The "conditioned" roses were 24 hours older than the "non-conditioned" roses and all roses arrived in excellent shape, chilled and in a preservative solution.

Table 26. Effect of retailer treatment on keeping quality.

Cut vs. Not-Cut	Temp. of Solution	Water vs. Preserv.	Time out of Water	Conditioned vs. N-C	Average Days Vase Life[a] Replications 1	2	Treat. Ave.
C	Hot	W	0 Hrs.	C	2.6	2.7	2.6
C	H	W	0	N-C	2.5	2.3	2.4
C	H	P	0	C	4.2	4.3	4.2
C	H	P	0	N-C	3.8	3.8	3.8
C	Cold	W	0	C	2.5	2.7	2.6
C	C	W	0	N-C	3.1	2.7	2.9
C	C	P	0	C	4.9	4.7	4.8
C	C	P	0	N-C	4.2	4.1	4.2
N-C	H	W	0	C	2.6	2.6	2.6
N-C	H	W	0	N-C	2.9	2.7	2.8
N-C	H	P	0	C	5.5	5.3	5.4
N-C	H	P	0	N-C	3.6	3.8	3.7
N-C	C	W	0	C	2.5	2.6	2.6
N-C	C	W	0	N-C	3.6	3.5	3.6
N-C	C	P	0	C	3.9	3.7	3.8
N-C	C	P	0	N-C	4.2	4.0	4.1
C	H	W	3 Hrs.	C	3.0	3.0	3.0
C	H	W	3	N-C	3.4	3.1	3.2
C	H	P	3	C	4.1	4.3	4.2
C	H	P	3	N-C	3.4	3.0	3.2
C	C	W	3	C	2.9	2.8	2.8
C	C	W	3	N-C	2.6	3.0	2.8

(Continued)

Table 26. Effect of retailer treatment on keeping quality. (Cont'd)

Cut vs. Not-Cut	Temp. of Solution	Water vs. Preserv.	Time out of Water	Conditioned vs. N-C	Average Days Vase Life[a] Replications 1	2	Treat. Ave.
C	C	P	3	C	4.0	4.1	4.0
C	C	P	3	N-C	4.2	4.1	4.2
N-C	H	W	3	C	2.9	2.8	2.8
N-C	H	W	3	N-C	3.2	3.0	3.1
N-C	H	P	3	C	3.0	3.2	3.1
N-C	H	P	3	N-C	3.7	3.7	3.7
N-C	C	W	3	C	2.6	2.4	2.5
N-C	C	W	3	N-C	2.3	2.5	2.4
N-C	C	P	3	C	5.9	6.3	6.1
N-C	C	P	3	N-C	4.5	4.1	4.3

[a]Conditioned roses were 24 hours older than non-conditioned ones.

The results emphasize the importance of handling practices on the retail level. Using roses that had been well conditioned, turgid and filled with preservatives, results of vase life trials ranged from 2.4 to 6.1 days, depending upon the handling practices.

The poorest results, 2.4 days, came from non-conditioned roses in water. The best results, 6.1 days, came from roses that were conditioned in cool preservative solutions. On these well-conditioned roses, no correlation was found between cutting and not cutting the stem. The three hour "dry" period was not enough to induce cell collapse or mechanical blocking of the conductive tissue.

The interactions, presented in Table 27, also show little influence of cutting the stem, and under the conditions of this experiment, would suggest that the cool preservative treatment is best.

Table 27. Interaction of water vs. preservative and temperature of solution - retailer level. (Expressed in average days vase life.)

	Water				Preservative			
	Cold[a]		Hot[b]		Cold[c]		Hot[b]	
Time Out of Water	N-C[d]	C[e]	N-C	C	N-C	C	N-C	C
I. 0 Hours[f]								
a. Non-Conditioned[g]	3.6	2.9	2.8	2.4	4.1	4.2	3.7	3.8
b. Conditioned[i]	2.6	2.6	2.6	2.6	3.8	4.8	5.4	4.2
II. 3 Hours[g]								
a. Non-Conditioned[h]	2.4	2.8	3.1	3.2	4.3	4.2	3.7	3.2
b. Conditioned[i]	2.5	2.8	2.8	3.0	6.1	4.0	3.1	4.2

[a] 58°F.

[b] 110°F.

[c] 60°F.

[d] Stems not cut.

[e] Stems cut before placing in solution.

[f] Roses placed directly in solution from Wholesaler.

[g] Roses held dry at Retailer for 3 hours.

[h] No refrigeration at retailer - placed out for vase life immediately after being placed in appropriate solution.

[i] Refrigerated 24 hours at 40°F after being placed in appropriate solution, then removed for vase life determinations.

Phase 4: Effect of Interaction of Three Levels of Handling

Materials and Methods

The fourth phase of this study was designed to investigate the effects of "good" and "bad" treatments in interaction with each other at various stages of handling. In the three previous phases, treatments were uniform in all but the handling stage under study. This was done to isolate the effects of various factors at that specific stage. For the purposes of providing data for more general recommendations, this interaction study was designed.

By using data on vase life from each of the other three phases, treatments were chosen that could be expected to produce a maximum and a minimum number of days of "acceptable" keeping quality. Then treatments were set up that combined all combinations of the "good" and "bad" treatments at each handling stage. After the retail level treatments were administered, the roses were placed out for vase life determinations. Table 28 lists the treatments used in each handling stage. The preservative at the manufacturer's recommended concentration was used where treatments called for preservative solutions. Roses were cut October 13, 1961.

Each treatment consisted of 10 Better Times roses, 15 to 18 inches long, and each treatment was replicated twice. Four hundred and twenty roses were used in total.

Results

Table 29 presents the 21 combinations of treatments used, with the average day's of vase life that resulted from each replication. It also shows the average days of vase life resulting from the combination of the two replications.

Table 28. Treatments used in interaction study.

Handling stage	Treatment symbol used in Tables	Treatment
Grower level	P	Roses graded and placed in hot (110°) preservative solution within 1 hour of cutting, then refrigerated for 24 hours at 35°F.
	4w	Roses held dry 4 hours after cutting then graded and placed in cold (60°) water and refrigerated 20 hours at 35°F.
Wholesaler level	p	Roses placed in cold (60°) preservative solution immediately upon receipt and refrigerated for 24 hours at 36°F.
	P	Roses placed in hot (110°) preservative solution immediately upon receipt and refrigerated 24 hours at 36°F.
	6w	Roses held dry 6 hours at room temperature (76°), then put in cold (60°) water and refrigerated 18 hours at 36°F.
Retailer level	p	Stems cut and put in cold (60°) preservative solution as soon as received and refrigerated 24 hours at 36°F.
	P	Stems cut and put in hot (110°) preservative solution as soon as received and refrigerated 24 hours at 36°F.
	3p	Held dry for 3 hours, stems not cut, placed in cold preservative (60°) solution and refrigerated for 21 hours at 36°F.
	3w	Held dry for 3 hours, stems not cut, placed in cold (60°) water and refrigerated for 21 hours at 36°F.
	w	Stems cut and placed in cold (60°) water and refrigerated for 24 hours at 36°F.

Table 29. Effect of interaction of treatments on keeping quality. (Symbols used refer to treatments detailed in Table 28.)

Grower - Wholesaler - Retailer			Average days vase life		
			Replications		Treatment
			1	2	Average
P	p	p	6.7	6.6	6.6
P	p	P	5.7	5.7	5.7
P	p	3p	6.5	6.6	6.6
P	p	3w	3.0	3.2	3.1
P	p	w	3.1	3.1	3.1
P	6w	p	6.1	6.1	6.1
P	6w	P	5.3	5.2	5.2
P	6w	3w	3.4	3.3	3.4
P	6w	w	3.0	3.2	3.2
4w	p	p	5.5	5.8	5.6
4w	p	P	5.0	4.7	4.8
4w	p	3w	3.6	3.5	3.6
4w	p	w	3.4	3.2	3.3
4w	P	p	6.1	6.2	6.2
4w	P	P	3.0	3.1	3.0
4w	P	3w	3.7	3.7	3.7
4w	P	w	3.0	3.0	3.0
4w	6w	p	5.9	5.5	5.7
4w	6w	P	4.2	4.5	4.4
4w	6w	3w	3.1	3.4	3.2
4w	6w	w	3.1	3.3	3.2

P - Hot (110°) preservative solution.
p - Cold (60°) preservative solution.
w - Cold (60°) water solution.
3, 4, 6, - Hours held dry.

This study shows the influence of post-harvest handling practices on the vase life of roses. Starting off with as uniform a group of roses as possible, vase life trials showed a range of keeping quality from 3.0 to 6.6 days. Roses, left to dry four hours in the greenhouse, then placed in cold water and conditioned at 35°F for 20 hours, shipped to the wholesaler where they were left dry for 6 hours, then placed in cold water and conditioned for another 18 hours at 36°F, and finally left to dry at the retailer's for 3 hours before being sent out in water, lasted less than one-half as long as the best treatment.

The treatment resulting in the best keeping quality was the one involving the use of preservative solutions throughout the marketing channels.

The influence of the preservative solution after the rose is removed from refrigeration is also emphasized. When preservatives were used in vase life trials, the influence of mistreatment earlier in the marketing channels was marked. Roses left to dry at the grower and wholesaler levels lasted 3.2 days in water, while roses similarly treated, yet placed in preservatives, lasted 5.7 days.

Effect of Various Handling Techniques on Transcontinentally Shipped Roses

Materials and Methods

To test the validity of recommendations based on the interaction study, this shipping test was used.

In order to focus attention upon the effects of handling at the Grower, Wholesaler and Retailer levels, all variables used in former work were eliminated except for the "good" treatment, following recommended procedures, and the "bad" treatment, which had been modeled after undesirable practices being used in the industry. Each treatment consisted of 10 roses, 15 to 18 inches long, and each treatment was replicated twice. A total of 180 roses of each variety were used. Three varieties of roses were included in this test: Better Times, Red Delight and Gold Top strain of Golden Rapture.

The roses were cut in California on the morning of August 18, 1962, treated and conditioned overnight at 35° and shipped August 19. They were received in Lansing, Michigan on August 20, at which time they entered their "Wholesaler" treatments. The next day the "Retail" treatments commenced and on the afternoon of August 22, the roses were placed out for vase life determinations, approximately four days after being cut. Temperatures ranged from 60° to 82°F in the room during the period of vase life determinations.

Results

Table 31 presents the nine treatments used, with the average day's vase life of the two replications of each treatment combined for each of the varieties used. Symbols refer to treatments detailed in Table 30.

Table 30. Treatments used in shipping study.

Handling stage	Treatment symbol used in Tables	Treatment
Grower level	P	Roses graded and placed in hot (90°) preservative solution immediately after cutting then refrigerated 24 hours at 35°F.
	4w	Roses held dry 4 hours after cut, graded and placed in cold (65°) water and refrigerated 20 hours at 35°F.
	w	Roses placed immediately into cold (60°) water and refrigerated 24 hours.
Wholesaler level	P	Roses placed in hot (110°) preservative solution immediately upon receipt and refrigerated 25 hours at 40°F.
	5w	Roses held dry 5 hours at room temperature (80°), then put in cold (60°) water and refrigerated 19 hours at 40°F.
	w	Roses placed immediately into cold (60°) water and refrigerated 24 hours.
Retailer level	p	Stems cut and put in cool (75°) preservative solution as soon as received and refrigerated 24 hours at 40°F.
	w	Stems cut and placed in cold (60°) water and refrigerated for 24 hours at 40°F.

Table 31. Effect of handling during shipment on keeping quality.

Variety	Handling stage			Average days vase life
	Grower	Wholesaler	Retailer	
Better Times	P[a]	P	p	5.2
Gold Top				4.6
Red Delight				5.9
Better Times	P	P	w	2.5
Gold Top				2.0
Red Delight				2.1
Better Times	P	5w	P	4.0
Gold Top				4.1
Red Delight				3.7
Better Times	P	5w	w	3.0
Gold Top				2.2
Red Delight				2.0
Better Times	4w	P	p	4.4
Gold Top				4.1
Red Delight				5.4
Better Times	4w	P	w	2.7
Gold Top				2.5
Red Delight				1.9
Better Times	4w	5w	P	4.1
Gold Top				3.6
Red Delight				3.8
Better Times	4w	5w	w	2.1
Gold Top				2.0
Red Delight				1.3
Better Times	w	w	w	2.6
Gold Top				2.3
Red Delight				2.2

P - Hot preservative solution.
p - Cool preservative solution.
w - Cool water.
4, 5 - Hours held dry.

[a]Treatments detailed in Table 30.

DISCUSSION

Over a four-year period, twenty chemical formulations, intended to extend the vase life of cut flowers, were tested. Two thousand roses were used in the keeping quality determinations.

One of the most striking aspects of the four-year preservative screening trials was the manner in which all of the chemical mixtures used prevented bluing of Better Times roses. The roses in water changed color, expressing the characteristic bluish cast in the petals within 2.5 days.

There was a definite difference in effect on vase life between the formulations tested, confirming Mastalerz's work (60). Consistently, though, throughout the screening period, two formulations, "Roselife" and "Floralife", produced the maximum extension in vase life. The average vase life increase through the use of these preservatives varied with the season of the year, from 25 per cent in April (Table 4) to approximately 165 per cent in January (Table 3).

The screening trials produced ample evidence of the value of appropriate chemical additive in improving the keeping quality of roses. In like manner, the initial study on the influence of time and duration of application of preservatives provided the direction for the major four-phase handling study.

Under the conditions of this test, roses in water in all three stages lasted an average of four days. Little effect could be noted in the treatments using a preservative first, followed by water in the last two stages. The longest vase life resulted from treatments using preservatives in all stages of handling which resulted in over six and one-half days vase life.

Perhaps the most interesting results of this trial concerned the effect of preservatives when applied only at the final stage. It was to be expected that good results could be produced by using the chemicals on the grower and retailer levels, but it was encouraging to see that even when used in only the final phase, two and one-half days vase life could be added when compared to similar treatments in water.

An important source of retail florists' complaints on the keeping quality of roses was the poor results obtained in the popular "foam" products. Basically, foams are used in two ways: 1) in a container and 2) foil or plastic wrapped - without a container. The ability of the rose to hold up satisfactorily under either of these conditions is due, in part, to the ability of the rose to compete with the physical structure of the "foam", for the available moisture supply. Obviously this "competition" is most serious under the second condition, where no additional moisture is available to replace that which is lost.

The data produced by these tests also showed that the use of certain "foams" can drastically reduce the keeping quality of roses.

Using ten different "foam" materials and a total of over 1,800 roses, data was produced showing that the keeping quality of roses with stems inserted in a preservative-saturated, foil-wrapped block of foam varied from 1.0 days (Oasis) to 4.3 days (Sno-pac), Table 13. Eliminating the factor of minimum moisture, immersing the "foam" in containers of solution showed the importance of the proper choice of "foam". Table 12 lists a range of vase life from 1.6 days to 5.0, depending on the choice of foams.

Respiration studies on roses dipped in N^6-Benzylaminopurine confirmed reports from Mastalerz that he had been unable to reduce the rate of respiration of roses with this material.

The higher respiration rates of roses in preservatives as compared with roses in water (Figure 3) supports the work of Coorts (16). The increased rate is apparently due to the presence of elevated levels of respiratory substrates. There was a direct correlation between the appearance of the blue color and the time at which the CO_2 evolution fell below a level of approximately 390 mg/kg/hr. In the water treatment, both factors occurred about two days after treatments started when the rose stems were in water, and on about the fifth day when roses were in preservative solutions.

The studies of effect of various handling practices at the grower, wholesaler and retailer level, produced interesting and useful data.

<u>Grower Handling</u>

One of the most striking responses to grower handling practices was the masking effect of refrigeration. Although wilted roses in the non-conditioned treatments were slow to revive, if at all, all of the treatments, regardless of time out of water, seemed quite turgid and firm when removed from the 24-hour hardening period, substantiating the florist's claim that he couldn't tell from external appearances, which would collapse. Those treatments which had developed a water deficit, and were then placed in cold water, went down rapidly after being brought out to room temperature, while the identical treatments, except for the substitution of preservative solutions for water, held up as well as roses that were never out of solution.

The results of this study of four variables of handling on the grower level emphasized the importance of proper handling to obtain subsequent consumer satisfaction.

The most important single factor reflected in these keeping quality trials was the outstanding benefit derived from using a good preservative solution. Roses put directly into hot water in the greenhouse and hardened overnight lasted 4.8 days, while roses that had been left out of water for four hours, and then placed in preservatives and conditioned overnight, lasted 7.8 days and showed markedly better color quality.

Proper conditioning adds materially to the life of a rose at this stage of handling, and is of particular importance in helping preservative action overcome severe water deficits. If it is not possible to condition the roses after cutting, then it is very important to get the freshly cut roses into hot preservatives as soon as possible.

In general, longer vase life can be expected, especially in non-conditioned roses, if they are placed in 110°F solutions. Table 20 shows that there is little difference between the action of cold and hot preservatives if properly conditioned.

In general, the longer roses are held dry after cutting, the shorter time they will last in the consumer's home.

<u>Wholesaler Handling</u>

In evaluating the role of the wholesaler in the handling of roses, it might be well to put "rapid turnover" at the top of the list. This is a highly perishable item, and, unlike the grower, the wholesaler can do little to improve the keeping quality <u>IF</u> he is handling well-conditioned roses from the grower that are chilled, turgid, and filled with preservatives.

Using well-conditioned roses fresh from the grower, the time that they were out of water had little effect on the vase life of roses subsequently placed in water. The same is generally true for roses in preservatives. The keeping quality of roses put in cold preservatives and not conditioned is directly proportional to time out of water. The differences were less when warm preservatives were used.

Within each "time out of water" treatment, conditioning reduced vase life slightly if preservatives were not used. This is understandable when we remember that all roses in this trial were properly conditioned by the grower, so at the wholesale stage, conditioning merely involved adding another 24 hours to the age of the flower before placing in vase life trials.

As in the grower trials, under adverse conditions (4 and 6 hours out of water) the beneficial effects of the preservative were enhanced by refrigeration.

In water, temperature of solution has little effect on lasting qualities. The same is generally true for the preservative treatments with the exception of the treatment in which the roses were kept dry for 2 hours. Here, the use of cold preservative added almost a day to the life of these roses.

A possible explanation might involve the fact that the roses arrive in excellent condition, turgid, filled with preservative and chilled, most probably had a low rate of respiration. Two hours were not long enough to induce a serious disbalance internally and so the use of <u>hot</u> preservatives tended to speed up the respiratory rate hastening maturation, while the cold preservative tended to maintain the lowered rate of respiration with resulting increase in vase life.

The use of water vs. preservatives proved again to be the most significant variable of all at the wholesale level. The data shows that as much as two and one-half days can be added to the vase life of roses with the use of a good preservative at this stage.

Retailer Handling

Data presented in Tables 26 and 27 show that if the retailer puts his well-handled and conditioned roses in water, he can expect an average of 2.8 days vase life. Cold water is better than hot water on turgid roses. Conditioning is of questionable value if preservatives are not used, due to the short period they will last. If the retailer puts his well-handled and conditioned roses directly into preservative solutions, he can expect an average of 4.8 days vase life, an increase of 2 days over those in water. Cold preservatives yielded better results than hot preservatives on turgid roses. Combinations of hardening and preservatives produced the best results. No clearly defined evidence can be produced at this time to support the value of recutting stems when roses have been well handled all along the line. Obviously from a practical standpoint, it would be better not to assume ideal prior handling, and to cut stems to insure better uptake.

Interaction Study

Considering the final interaction study, reported in Tables 30 and 31, it can be stated that for roses subsequently well-handled by the wholesaler and retailer, the grower can add from one-half to a full day's vase life through the use of preservatives as compared with water, depending upon the variety (treatments 1 and 5, Table 30).

Where the retailer uses water, the effect of the grower's treatment does not show up in additional days vase life, but there was a difference in quality. When the grower started the roses in preservative, the roses maintained a firmer substance than roses started in water (treatments 2 and 6, Table 30).

As before, little effect can be determined in wholesaler handling when roses end up in water at room temperature, <u>but</u> the wholesaler can add from one-half to over two days to the vase life of the roses, depending on variety, by using recommended handling practices on subsequently well-handled roses (treatments 1 and 3, 5 and 7, Table 30).

The most striking beneficial effects of the use of a preservative in the handling of cut roses occurs at the stage where the flower is no longer under refrigeration. Low temperatures are highly effective in reducing the rate of respiration. The use of a preservative in conjunction with refrigeration is even better. But when flowers are removed from refrigeration and set out at the higher temperatures experienced in the average home, then the use of preservatives is <u>most</u> important. They can greatly prolong the life of roses, increasing their keeping quality and customer satisfaction.

For example, in Table 30, treatments 1 and 2 show that the use of a preservative solution <u>can more than double</u> the vase life of roses at room temperature. (From 2.1 to 5.9 days in the case of Red Delight.)

Not all varieties of roses react the same to the use of preservatives. We have never found any variety that did not benefit in some manner, but some types respond more dramatically than others.

For example, in treatment 9, Table 30, which depicts roses kept in water throughout their handling, the vase life was quite similar for all three varieties. But when compared with treatment 1, using preservatives throughout, varietal differences are obvious.

Since the literature is filled with references to the influence of pre-harvest factors on keeping quality, it would have been advisable to analyze samples of roses used for their mineral and carbohydrate levels. In this series of studies, no analysis was run, and the only attempt at uniformity was securing each group from a single cut of a given greenhouse, produced under uniform growing conditions.

It also would have been better to have analyzed the "commercial products" (foams and preservatives) in order to know the materials with which we were working. Since the formulations were considered propriatary secrets, the decision was made to accept the materials as presented by the manufacturers.

CONCLUSIONS

As a result of the five studies reported here, covering a period of four years and utilizing over 9,500 roses, it is possible to provide the following recommendations for handling roses by growers, wholesalers and the retailers in order to avoid "bent neck" and insure maximum keeping quality and consumer satisfaction.

Grower

For maximum keeping quality, it is recommended:

1. Roses should be cut at the proper stage of maturity. Immature stems and buds are highly susceptible to wilting and bending. The "proper stage" varies with the variety and must be determined by experimentation. Generally, it is at the stage when the first outer petals are starting to unfold.

2. Avoid bruising at all stages.

3. Place freshly cut roses in containers of hot (100° - 110°F) solutions of a good preservative and refrigerate at 34° as soon as possible. The importance of proper handling in the period immediately after cutting the rose cannot be over-emphasized. A well-conditioned rose can survive much more mistreatment enroute than an improperly handled one. In order to rapidly reduce the rate of respiration, roses should be left in the preservative solution under refrigeration for at least 3 to 4 hours before grading. The subsequent period on the grading table will then have little effect so long as they are returned to the preservative solutions and refrigerated for an additional 12 to 24 hours after grading prior to shipping.

Wholesaler

For maximum keeping quality, the following practices are recommended, depending upon the appearance of the roses on arrival:

1. If roses are received in buckets of preservative solution from the grower, leave them in that solution and refrigerate immediately at 33° to 40° until sold.

2. If roses arrive in boxes, well iced, firm and turgid, place them in a cool preservative solution and refrigerate at 33° to 40° until sold.

3. If roses arrive in boxes that have been delayed enroute, the ice has melted and they appear slightly wilted or not firm and turgid, place them in a warm (100°) preservative solution and refrigerate at 33° to 40° until sold.

4. It is important to unpack roses and place in preservative solution upon arrival. Laying dry on the table for long periods adversely affects their keeping quality.

5. Avoid jamming too many roses into a single container. Iced roses will snap off at the neck easily, and all can be bruised by over-crowding or rough handling.

6. Use clean containers. Stems are clogged by bacteria found in dirty containers and cannot absorb the necessary solutions for hardening.

Retailer

It is fortunate that the retailer, who has closest contact with the customer, can so greatly influence the keeping quality of the roses he sells. The data derived from this study indicates that by using the recommended practices, the retailer can double the life of his roses as compared with the same roses in plain water. For maximum keeping quality, it is recommended that the retailer should, upon receipt of his roses:

1. Cut the stems with a slanting cut, remove the lower foliage, and place immediately in freshly prepared cool preservative solution.

2. Condition them 6 to 12 hours in COLD refrigerator (35° to 40°) unless direct shipments are received in solution.

3. MOST IMPORTANT OF ALL - Add a preservative solution to all rose arrangements. If "foam" material is used to secure flowers in vases or arrangements, it should be saturated with preservative solution.

4. Allow sufficient space in the container for the customer to replace the water lost through evaporation. When foam materials completely block the container, it isn't convenient to replace the liquid. Therefore, as they dry out, the roses wilt and die.

5. Place an Add Water Daily card on all rose arrangements before delivery. Roses absorb and transpire a surprising amount of water, which must be replaced.

6. If the roses are delivered loose or boxed, include an envelope of preservative powder along with a "rose care folder" telling the customer how to get maximum satisfaction from the roses.

The results of this project clearly show that by the use of recommended handling procedures all along the line from the grower, through the wholesaler and retailer, to the ultimate consumer, the effective keeping quality can be doubled with resulting increase in customer satisfaction and confidence in the rose.

Based on this research, Roses, Incorporated launched a massive educational program on the "Care and Handling of Roses". The handling practices listed above were reported at meetings of all segments of the industry, on a local, regional and national basis. Color pictures of roses undergoing treatment were a part of full-page advertisements announcing the association's "Quality Control" program and a complete report of the effects of handling on keeping quality of roses appeared in the major trade publications in April 1961. Specific recommendations were distributed to growers and posters were prepared for posting in wholesale and retail establishments.

A measure, then, of the effects of post-harvest handling practices on the marketability of Better Times roses would be the trend in sales. Using the U.S.D.A.'s crop reports for six selected states (94, 95), representing 45 per cent of the national production, it is seen that from the decrease in sales of $1 million experienced from 1959 to 1961, rose sales increased $500,000 from 1961 to 1962, and increased approximately $1 million from 1962 to 1963. The outstanding changes in promotional activities for roses during this period, was the inauguration of the "Care and Handling" program by Roses, Incorporated, based on this research.

Appendix A. Analysis of water samples used in tests showing the effect of water quality on preservatives.

Element	Sample 1	2	3	4
P - %	.004	.005	.007	.003
Ca - %	.080	.050	.070	.050
Mg - %	.050	.035	.040	.055
Mn - ppm	3	2	4	0.5
Fe - ppm	57	24	10	9
Cu - ppm	0.7	1.0	2.0	0.2
B - ppm	1.5	1.3	1.9	1.3
Zn - ppm	10	6	6	2
Mo - ppm	*	0.10	0.15	*
Al - ppm	5.0	1.2	5.0	5.0

*Not detectable

Code:

Sample No.	Volume	Water Type
1	5 cc	Hard
2	2.5 cc	Hard
3	2.5 cc	Softened
4	5.0 cc	Softened

Appendix B. Changes in rose production and sales, 1959 - 1963, in six states.[a]

Year	Plants in production	Blooms sold	Value of sales at wholesale
1959	6,989,000	161,597,000	$12,581,000
1961	6,752,000	148,059,000	$11,600,000
1962	7,175,000	153,988,000	$12,164,000
1963	7,257,000	162,697,000	$13,092,000

[a]Figures from Sp Cr 6 - 1 (62) and (64), U.S.D.A.

Appendix C. Effect of retailer handling methods on roses properly handled by grower and wholesaler.

Treat.#1: Preservatives used in all stages of handling.
Treat.#2: Handling at grower and wholesaler levels the same as #1, cool water without preservative used at retailer level.

Appearance when removed from refrigeration.

Appearance after five days vase life.

Appendix D. Effect of retailer handling on roses improperly handled by grower and wholesaler.

Treat.#7: Grower: 4 hrs.dry, cool water. Wholesaler: 6 hrs. dry, cool water. Retailer: warm preservative solution.

Treat.#8: Handling at grower and wholesaler levels the same as #7, cool water without a preservative used at retailer level.

Appearance when removed from refrigeration.

Appearance after five days vase life.

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