EFFECTS OF ACACIA GUM ON POST-HARVEST QUALITY OF

CUT FLOWERS

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EFFECTS OF ACACIA GUM ON POST-HARVEST QUALITY OF CUT FLOWERS

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THESIS ABSTRACT

EFFECTS OF ACACIA GUM ON POST-HARVEST QUALITY

OF CUT FLOWERS

Rachel Elaine Creel

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The U.S. cut flower market has shifted from domestically grown to imported products. Because of the extended time between harvest and reaching the consumer, there is need for improved post-harvest handling methods, especially in less developed countries. Acacia gum appeared to be promising in its use as a floral preservative.

A first experiment evaluated a range of concentrations and application methods of Acacia gum for its effectiveness in extending the vase life of fresh cut flowers. 'Maryland True Pink' and 'Maryland Dark Red' snapdragons (*Antirrhinum majus)* along with 'Guardian White' and 'Guardian Mid Blue' delphiniums (*Delphinium elatum)* were grown in a greenhouse, harvested, and treated with 5%, 10%, or 20% concentration of Acacia gum mixed in water using eight different application methods. The vase life of 'Maryland True Pink'

snapdragon was extended by dipping flowers in 10% or 20% Acacia gum. Results for 'Maryland Dark Red' and delphiniums were variable.

A second experiment screened widely used cut flowers for the efficacy of Acacia gum in extending vase life. Twelve cut flower species were acquired from a local wholesale floral supplier. Flowers were treated by dipping in 5% or 10% Acacia gum and placed in reverse osmosis water or Floralife preservative. Results of this study show that Acacia gum treatments were at best comparable too, but not better than the Floralife standard. Acacia gum showed no benefit as a floral preservative over what is currently used.

A third experiment tested the effects of Acacia gum applied before or after storage in a cooler, and with or without Floralife, on vase life of two cut flower species. 'ABC 1-3 Purple' lisianthus (*Eustoma grandiflorum*) and 'Super Parfait Raspberry' dianthus (*Dianthus chinensis*) were grown in a greenhouse, harvested, and treated with Acacia gum (5% or 10%) before or after storage in a cooler. Storage times were 0, 4, 8, or 12 days. Dianthus treated with Acacia gum showed varied results. Regardless of preservative treatment, the longer flowers were stored, the longer they kept their aesthetic value after removal from cooler. Acacia gum had no effect on the number of days to aesthetic loss of lisianthus.

This research indicates that overall, Acacia gum is at best comparable to Floralife, and showed no benefit over currently used floral preservatives.

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CHAPTER I

LITERATURE REVIEW

The cut flower industry is a continuously growing global market with ample opportunity for improvement in the area of delivering high quality products. A significant amount of the cut flower's life is spent in transportation from one place to the next. For maximum longevity of flower quality, it is crucial that the product is properly managed from the time of harvest until it arrives at the consumer.

Cut Flower Industry

The U.S. cut flower market has changed dramatically over the past 30 years. In the 1970's, a large percentage of the cut flowers consumed in this country were produced domestically. During the 1980's and 1990's, the majority of growth in cut flower sales per U.S. household came from imports of cut flowers. Domestically-grown cut flower sales decreased per household. Most cut flowers are currently imported from Colombia, Ecuador, the European Union, and Mexico (12). In 2002, about 36% of U.S. cut flower imports were fresh roses, followed by carnations at 13%, and chrysanthemums at 11% (1).

Imports continue to account for roughly two-thirds of the U.S. cut flower market due to the strength of the dollar and U.S. income growth as increasing global exports

drive prices down, according to the U.S. International Trade Commission (ITC) (4). Over the last two decades, imports have increasingly supplied the U.S. market with fresh cut flowers. Flower producers in developing countries have a significant advantage over domestic growers because of low wage rates, smaller climate control investments, and cheaper currencies. As a result of the amplified global supply of fresh cut flowers since the early 1990's, fresh cut flower import prices have fallen significantly, especially for roses. Because of the increasing competition with low-priced imports, many U.S. growers have converted production to specialty cut flowers, which are not imported in significant volumes. Consequently, U.S. production of roses and other major flowers has fallen significantly.

In 2004, U.S. domestic cut flower production's wholesale value was $422 million (1). The largest category of cut plant material was cut cultivated greens at $92.4 million. These products are largely produced in Florida and California. In terms of dollar value, the top three domestically produced cut flowers were lilies, roses, and tulips at $78.2, $43.1, and $36.2 million, respectively. As with cut greens, California and Florida were the top producers by a wide margin compared to other states (1).

The most significant capacity of international cargo imported through U.S. airports is handled by John F. Kennedy International Airport (JFKIA) and Miami International Airport (MIA). MIA receives the highest volume of flowers, with over 11 million boxes loaded with 342,000 tons of flowers shipped through each year. This accounts for two-thirds of the U.S.'s $13 billion in annual cut flower retail sales (20). The majority of Central American cut flowers are imported by air, mostly through MIA. Flowers generally arrive in Miami 24-48 hours after harvest. There, wholesalers handle

customs inspections and other agriculture formalities, and re-cool the flowers. Flowers are stored at floral importers for at least one to two days before they are shipped by airplane and /or truck to their destination (14, 23). Flowers shipped by non-stop flights typically arrive in good condition if they are handled properly throughout their transport. Flowers shipped on airlines that require transfers and stops are exposed to more temperature extremes (24). Even flowers of the highest quality, after lengthy transportation time and variable temperature exposure in the air, are of secondary quality by the time they reach the retail stage, and can be poor quality once they reach the customer (23). In a study conducted on the transport of Colombian cut roses, it was four to six days from harvest until the flowers arrived at the University of Florida (14).

Refrigerated truck transport of cut flowers is an efficient method of shipment because of lower cost and temperature regulation. Flowers shipped in a refrigerated truck for two to four days can be in better condition upon arrival than those shipped overnight in an airplane that lacks temperature control. Cut flowers are also shipped by marine refrigerated containers. This shipment method gives flowers comparable vase life to those shipped by air even though it can take days to transport by water and hours by air (24).

Cut flowers are sold at the retail level through a range of outlets including traditional florists, garden centers, supermarkets, and market and street vendors, the market share of each depending on the country. All principal markets have in common increasing supermarket shares. In some countries the increase is higher than in others. The two main supermarket chains in Switzerland, Migros and Coop, together account for 60% to 70% of all cut flower sales. In the UK, the portion of supermarket sales is almost

40%. It is certain that in every major cut flower market in the world, supermarkets are targeting the flower trade as an area for expansion (30).

Buying cut flowers directly from known producers is the shortest route from the grower to the shop and the best way to ensure a fresh product with longer vase life. Supermarkets usually buy large quantities of cut flowers using long-term contracts, directly from known producers. It is critical for supermarkets to have a vase life guarantee, or the grower's code that is marked on a written guarantee so that problems can be traced back to the producer. Shortening the chain of intermediaries between growers and retailers gives supermarkets more control over who their suppliers are; gives more information on the conditions of work at these suppliers; lowers cost; and reduces delay, thus lengthening vase life. However, buying directly and regularly through long-term contracts makes it difficult to import from the Netherlands, which is the leading cut flower exporter, where growers must sell their produce through auctions. Producers in less developed countries in Africa have the capability to produce large volumes and are willing to sell directly at an agreed price. This fact makes these sources appealing to supermarkets. Consequently, these growers must have optimal production methods, including greenhouses, forced ventilation and heating, and greater attention to quality to provide a competitive product (30).

Reid (22) reported that because of the globalization of the cut flower market, average time between harvest and delivery to the customer's home has increased significantly. Escalated time in the marketing channels has major implications for the eventual life of the flower, and places increased weight on the factors that affect the post harvest life of the flower. World wide over-production of cut flowers puts more pressure

on the industry to increase consumption. Over the past 16 years, U.S. cut flower consumption has dropped, mainly as a result of unsatisfactory cut flower vase life (22). Poor vase life results from extended transportation times, long storage durations, and poor temperature management during shipment. U.S. consumption can only be increased by providing high quality products with a high degree of consumer satisfaction (23).

Post-harvest Handling

Superior post-harvest care results in more flowers being sold, despite the origin. Furthermore, increased flower sales result in higher public visibility and a perceived necessity of the product (2).

Post-harvest handling is the stage of production directly after harvest, that involves cooling, cleaning, sorting and packing. Immediately after a flower is cut from its parent plant, it begins to deteriorate. Post-harvest treatment largely determines final quality (10). A fresh cut flower remains a living specimen regardless of its removal from the mother plant. Its potential vase life, even at its peak harvest quality, is short (3). The quality of flowers at harvest is set and can only stabilize or decrease. Post-harvest management starts at the beginning of production and continues from cultivar selection, cultivation, harvest, to handling by the retailer. Because flowers are very sensitive to treatment once they have been cut, the post-harvest time period is extremely critical to prolonging the life of cut flowers. Because every flower is different, it is important to know for each crop what the main quality reducing variables are and how to manage them (32).

There are a series of tasks required after flowers are harvested, commonly referred to as handling, that are performed in order to prepare the flowers for market.

These steps include: immediate hydration, grading, leaf removal, bunching, re-cutting, hydration, special treatments, packing, pre-cooling, cold storage, and delivery to market. The specific steps required for each flower depend on the flower market being sold to. The location and exact procedures for each step depends on the market and the grower's facilities (10).

There are many factors that can interact to reduce fresh flower vase life. Ten of the most common reasons for vase life decline include 1) carbohydrate depletion, 2) attack by bacteria and fungi, 3) normal maturation and aging, 4) wilting caused by water stress and xylem blockage, 5) bruising and crushing, 6) temperature fluctuations between storage and transit, 7) color change (bluing), 8) accumulation of ethylene, 9) poor water quality, and 10) sub-optimal cultural practices or conditions. Growers must be aware of these obstacles and be prepared to address them with correct post-harvest handling procedures. Cold storage at the proper temperature helps to delay normal senescence, bacterial and fungal attack, and bluing. Floral preservatives, meticulous handling, and proper sanitation practices help prevent carbohydrate depletion, poor water quality, bruising or crushing, wilting, and incursion of microorganisms (10).

Vase life is often limited by a decrease in water uptake that can result from several factors. When flowers are harvested, they are placed directly in water to avoid wilting (29). Poor water quality often exposes the flower to microorganisms and dissolved solids that block xylem vessels and limits water absorption. Xylem blockage can also result from chemicals in the stems that change to a gum-like substance when the stem is cut (3, 32). This physiological blockage is highly species dependent and is thought to be a mechanism to prevent attack by microorganisms. Occlusion by emboli,

or cavitation, can also occur in the xylem and thus reduce water uptake. Blockage can be repaired by adding a surfactant to the water or by re-cutting the stem (29).

Cold storage is an imperative step in bringing fresh cut flowers from the producer to the marketplace. Low temperatures, in the range of 33-40º F, help extend vase life by reducing respiration, thus conserving carbohydrates; decreasing water loss and wilting; diminishing disease organism growth; reducing ethylene production; and providing time for proper handling, packaging and marketing (9). Higher temperatures are associated with rapid utilization of carbohydrates stored in plant tissues (19). Lower temperatures reduce respiration and restrict the quality loss as a result of the consumption of reserves. The period of time between harvesting and arrival at final destination should also be as short as possible (32).

Ethylene gas, found commonly in storage, causes adverse effects on the longevity and quality of cut flowers. Ethylene, known as the ripening, senescence, or wound hormone, is a naturally occurring plant hormone. It is a substantial part of the reproductive cycle, and prompts ripening and senescence of flowers and fruit (10). In cut carnations, small amounts of ethylene are produced after harvest. Levels then increase sharply a few days after harvest and just prior to wilting. Other flowers that senesce faster than carnations begin a more rapid increase of ethylene. Exposure to ethylene accelerates the flower's own ethylene production, resulting in wilting and growth of ovaries. Advancing senescence increases a flower's sensitivity to ethylene. Some flowers are more sensitive to ethylene than others (19). To avoid the effects of ethylene, flowers should be kept in a cool, well ventilated area, away from aging or injured flowers, plant debris or ripening fruit (2). Silver thiosulfate (STS) is used to reduce the harmful effects

of ethylene on cut flowers. STS protects the flower from ethylene and stops it from producing ethylene (10). 1-MCP is another anti-ethylene compound that is used as an alternative to STS. 1-MCP blocks the attachment of ethylene to the plant's ethylene receptor (18).

Many critical factors must be considered for quality cut flowers, from planning of the harvest stage, to regulating factors such as temperature, light, humidity, air circulation, and water quality, all of which play important roles in sustaining cut flower freshness. One of the key factors is the application of a floral preservative, which is highly effective in prolonging quality and increasing longevity. Floral preservatives typically double vase life of cut flowers when compared to water alone (3). In a study conducted on the shipment of roses and carnations, the use of floral preservatives after shipment had a greater effect on longevity than any pre-shipment conditioning, cooling, or shipping method (7). Floral preservatives should be used at every stage of distribution (16). The average floral preservative solution contains water, a simple sugar that serves as a food source, a biocide, an ethylene inhibitor, and an acidifying ingredient (25, 15).

Biocides are important in the preservative solution to control microorganisms such as bacteria, yeasts, and molds. Microorganisms in the vase water can physically plug the stem, produce toxic metabolites and enzymes, release damaging levels of ethylene, and cause a hypersensitive response to low temperatures (26). Bacterial counts of 10 to 100 million per milliliter can reduce water and nutrient uptake, while counts of 3 billion per milliliter caused wilting.

Carbohydrates provide food to the flower and are an important addition to cut flower preservatives. Low carbohydrate supply, or food depletion, is a primary reason for

vase life decline in cut flowers. Nowak, Rudnicki, and Duncan (19) stated that "Carbohydrates are the main source of nutrition of flowers and the source of the energy necessary for maintaining all biochemical and physiological processes after separation from the mother plant." To maintain metabolic activities in cut flowers, especially respiration, it is necessary to supply an adequate energy source in the flower to achieve a reasonable vase life. When stored carbohydrate levels are low, leaves and flowers quickly senesce and petals develop a pale color (11). Sucrose is the most widely used food source in cut flower preservatives. It provides energy that gives cut flowers more longevity and helps open flowers that are in the bud stage (10).

Acids or acid salts are added to floral preservatives to adjust the pH of the water to a range of 3.5 to 5.5, which is a pH level less conducive to microbial growth (10). Municipal water supplies are typically more alkaline and have the potential to reduce cut flower vase life. An acidifier also helps stabilize cut flower color (17). Vase water that is slightly acidic increases water uptake and prevents bent neck (8). Citric acid is a frequently used acidifier in preservative solutions (11).

Other characteristics of water affect the vase life of cut flowers, including total dissolved solids (TDS), alkalinity, and hardness. TDS is important because high levels of certain salts have the potential to reduce vase life. The alkalinity level of water describes its buffering capacity, or ability to neutralize acid. A higher level indicates that the water holds a combination of higher amounts of carbonates, bicarbonates, and hydroxides, which oppose the lowering of the pH and make floral preservatives ineffective. Water hardness measures the positive ion salts in the water, particularly Mg and Ca, which can be harmful at high levels and can provoke differing reactions with the preservative

solution (8). Fluoride, found in most tap water sources, can be harmful to certain cut flower species. It is for this reason that de-ionized water is recommended for cut flowers (16).

Transportation of cut flowers from the field to the consumer is a process that takes particular care and planning. Many important decisions must be made, one of which is whether to ship the flowers in water or dry-packed. Dry-packing leaves out the weight of water in buckets, but allows for greater risk of water stress. This method is used often by commercial growers that ship flowers all over the world. Because it is important to keep low temperatures within the dry-pack boxes, ice chips are packed along with the flowers. Climate controlled trucks are also useful in maintaining low temperatures. Dry packed cut flowers should be fully hydrated and pulsed. Pulsing is placing flowers in a preservative solution for a short period of time to extend vase life. Special care should be taken when handling flowers to keep from bruising the petals. When transporting flowers short distances, it may be possible to ship them in buckets of water. Unlike dry-packing, there is little risk of water stress when this transport method is used. Buckets of water are more difficult to move, which would increase shipping costs (13).

In less developed countries where refrigeration may be far from the production area, an efficient method is needed to preserve cut flowers while in transit. In Brazil, for example, sanitation, packaging, and logistical issues are some of the many difficulties faced by producers (28). Even in developed countries where handling methods are more modern, losses in the marketing chain can be high. Colombian cut roses en route to the U.S. are exposed to varying temperatures during transport and a prolonged transport time. It is often 4 to 6 days before flowers reach the consumer (14). Despite the handling

procedures outlined above, little major advancement has been made in extending the vase life of cut flowers in many years.

Acacia Gum

Research at Auburn University, has lead to a method of utilizing Acacia gum in the reversible preservation of biological samples. The Acacia gum is used to isolate and preserve a biological specimen in a prolonged dormant condition without damage to the specimen. The specimen can later be restored to its previous state (31). Acacia gum, an exudate obtained from the acacia tree (*Acacia senegal* Willd.), is also used in pharmaceutical preparations, inks, pottery pigments, water colors, wax polishes, food emulsifying agents, flavor fixatives, and many other applications. Acacia gum is soluble at a very high concentration in water (21). It is comprised of polysaccharides and calcium, magnesium, and potassium salts, which upon hydrolysis generates glalactose, arabinose, rhamnose and glucuronic acid (27). Its pH in a 25% solution in water is 4.1-4.8. The acacia species is widespread in tropical Africa and cultivated in India, Nigeria, Pakistan, and Sudan (6). Acacia gum is processed in several forms, including grains, milled powder, spray-dried powder, or roller-dried powder (5). Because of its success in the preservation of microorganisms, it is possible that Acacia gum can be used to preserve larger specimens, such as cut flowers. Acacia powder can be dissolved in a solution that can be applied to cut flowers by dip or spray at a specified stage of post-harvest handling. The Acacia gum has the potential to prolong flower quality from the time the flower is cut, far beyond the time it reaches the consumer's vase.

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CHAPTER II

ENHANCING POST-HARVEST QUALITY OF FRESH CUT FLOWERS USING ACACIA GUM

Abstract

The purpose of this study was to test a range of concentrations and application methods of Acacia gum for efficacy in preserving fresh cut flowers. 'Maryland True Pink' and 'Maryland Dark Red' snapdragons (*Antirrhinum majus)* along with 'Guardian White' and 'Guardian Mid Blue' delphiniums (*Delphinium elatum)* were grown in a greenhouse, harvested, and treated with 5%, 10%, or 20% concentration of Acacia gum by one of eight different methods. Vase life of 'Maryland True Pink' snapdragon was extended by dipping flowers in 10% or 20% Acacia gum. Results for 'Maryland Dark Red' and delphiniums were variable.

Index words: floral preservative, vase life

Species used in this study: 'Guardian Mid Blue' delphinium (*Delphinium elatum* L.), 'Guardian White' delphinium (*Delphinium elatum* L.), 'Maryland True Pink' snapdragon (*Antirrhinum majus* L.), 'Maryland Dark Red' snapdragon (*Antirrhinum majus* L.)

Significance to the Industry:

Cut flower quality is highly dependent upon post-harvest handling. A major component of post-harvest handling is the application of floral preservatives, which are highly effective in prolonging quality and increasing longevity. Acacia gum, a naturally occurring bio-polymer, has been successfully used in the reversible preservation of microorganisms and has shown promise in the preservation of cut flowers. Acacia powder can be dissolved in a solution that can be applied to cut flowers by dip or spray at a specified stage of post-harvest handling. The responses of snapdragon and delphinium to Acacia gum treatments varied by species and cultivar. Vase life of 'Maryland True Pink' snapdragons dipped in Acacia gum was extended beyond that of Floralife. Results were variable with delphinium and 'Maryland Dark Red' snapdragon.

Introduction

Due to the globalization of the cut flower market, average time between harvest and arrival to the customer has increased significantly. Escalated time in the marketing channels has significant implications for the eventual life of the flower, and places increased pressure on the factors that affect the post harvest life of the flower (4).

Many critical factors must be considered for quality cut flowers, from planning of the harvest stage, to factors such as temperature, light, humidity, air circulation, and water quality, all of which play important roles in sustaining cut flower freshness. One of the key factors is the application of a floral preservative, which is highly effective in prolonging quality and increasing longevity. Floral preservatives typically double the vase life of cut flowers when compared to water alone (1). In less developed countries

where refrigeration may be far from the production area, an efficient method is needed to preserve cut flowers while in transit. In Brazil, for example, sanitation, packaging, and logistical issues are some of the many difficulties faced by producers (5). Even in developed countries where handling methods are more modern, losses in the marketing chain can be high. Colombian cut roses en route to the U.S. are exposed to varying temperatures and a prolonged transport time. It is often 4 to 6 days before flowers reach the consumer (2). Acacia gum has been effectively utilized in the reversible preservation of biological samples. Specifically, the Acacia gum is used to isolate and preserve a biological specimen in a prolonged dormant condition without damage to the specimen. The specimen can later be restored to its previous state (6). Because of its success in the preservation of microorganisms, it is possible that Acacia gum can be used to preserve larger specimens, such as cut flowers. The objective of this study was to test a range of concentrations and application methods of Acacia gum for efficacy in preserving fresh cut flowers.

Materials and methods

On January 19, 2005 transplants of 'Guardian Mid Blue' delphinium, 'Maryland True Pink' and 'Maryland Dark Red' snapdragon were obtained from a plug grower (Ball Horticultural Company, West Chicago, IL). 'Guardian White' delphinium arrived on February 2, 2005. Plants were received in 384 plug flats and transplanted upon arrival into 606 jumbo market flats containing Fafard 52 potting media (Fafard, Inc., Anderson, SC). Plants were grown in an unshaded, polycarbonate covered greenhouse with a heating set point of 18C (62F) and ventilation at 24C (75F). Delphiniums were placed under 400 watt metal halide lamps that were turned on from 0600 hours to 2000 hours to

supplement natural light. When plants reached a transplantable stage in the plug flats, they were transplanted to #5 squat nursery containers containing Fafard 52 mix. Snapdragons were planted five per pot and delphiniums were planted four per pot. 'Guardian Blue' and 'Maryland Dark Red' snapdragons were transplanted on February 10, 2005. 'Maryland True Pink' was transplanted on February 14, 2005, and 'Guardian White' on March 2, 2005. Delphiniums were removed from lighting upon transplanting. The plants were supported by tomato cages (106.7 cm, 4 ring, 4 leg) from which the bottom ring was removed. Delphiniums were fertilized using a 14-4-14 (14N-1.8P-11.6K) water soluble fertilizer applied two out of every three times the plants required water at a rate of 150 ppm nitrogen. Flowers were harvested according to common practice (3).

Experiment 1

In the first experiment, 'Maryland True Pink' was harvested when six to eight florets were fully open. Flowers were cut at a length of 70 cm (24 in) and the lower 20.3 cm (8 in) of foliage was removed. Hand pruners were sterilized (10% Clorox solution) between cutting each flower. Flowers were immediately placed in reverse osmosis water. The Acacia gum, Instantgum AS, (CNI, Normandy, France) solution was prepared prior to the beginning of the experiment. The Acacia gum was mixed at a concentration of 5% (100g/ 1900mL), 10%, (200g/ 1800mL), or 20% (400g/ 1600mL) in reverse osmosis water. The powder was mixed using stir plates (Fisher Scientific International, Inc., Hampton, NH) and left to dissolve overnight. Prior to use, the Acacia gum was stored in a cooler set at 4.4C (40F).

Flowers were treated with the Acacia gum at 5%, 10%, or 20%, using eight methods: 1) stems placed directly in Acacia gum solution. 2) foliage and stems only,

sprayed one hour prior to harvest. 3) foliage and stems only, sprayed one hour after harvest. 4) entire cut flower sprayed after harvest. 5) flowers only sprayed one hour prior to harvest. 6) flowers only sprayed after harvest. 7) entire cut flower sprayed one hour prior to harvest. 8) entire cut flower dipped in the solution after harvest. Flowers treated by spray treatments were sprayed with a fine mist to the point at which dripping occurred. The control and standard for the experiments were cut and placed immediately in individual sterilized 22.9 cm (9 in) glass bud vases (Syndicate Sales, Inc., Kokomo, IN) filled with either 300 mL of reverse osmosis water or 300mL of reverse osmosis water with 40g/ 3.79L Floralife (Floralife, Inc., Waterboro, SC) preservative, respectively. Cut flowers in Acacia gum treatments were placed in reverse osmosis water except those placed directly in Acacia gum solutions. After treatment, flowers were placed in a simulated indoor environment room under continuous fluorescent lighting with temperatures maintained at 20-21.1C (68-70F). Vases were completely randomized within the room. There were ten single stem replications per treatment.

Data recorded included date the lowermost floret on a flower spike wilted, and date the lowermost six florets wilted. Fresh weight was taken for both species on the date the lowermost six florets wilted.

The experiment was a completely randomized design with Acacia gum concentration and application method in a factorial treatment arrangement. The data were analyzed using PROC GLM in PC-SAS (SAS Institute, Cary, NC). Differences in application method were determined using the Waller/Duncan mean comparisons at $P = 0.05$. Linear and quadratic trends over Acacia gum concentration were determined using

orthogonal contrasts, $P = 0.05$. Comparison with the control and standard were determined using Dunnett's comparison to a control, $P = 0.05$.

The second part of the experiment used 'Guardian Mid Blue' which were harvested when five to seven florets were fully open. Stems were cut at 71.1 cm (28 in) lengths and the lower 20.3 cm (8 in) of foliage was removed, using sterilized hand pruners. Flowers were placed directly into bud vases filled with 300 mL of reverse osmosis water. They were then weighed and treated with the Acacia gum (5%, 10%, or 20%), using 6 methods. Treatment methods included: 1) foliage and stems only, sprayed one hour prior to harvest. 2) entire cut flower sprayed after harvest. 3) flowers only sprayed one hour prior to harvest. 4) flowers only sprayed after harvest. 5) entire cut flower sprayed one hour prior to harvest. 6) entire cut flower dipped in the solution after harvest. Aquagro surfactant (Aquatrol, Cherry Hill, NJ) was added to the Acacia gum in treatments 2, 3, 5, and 6 at a rate of 0.6mL/L. The control and standard were placed directly in 300 mL reverse osmosis water or in 300 mL reverse osmosis water containing Floralife preservative, respectively. The flowers were placed in simulated indoor environment rooms after treatment.

Data recorded included the date the lowermost floret on the flower spike wilted and the date the whole flower spike wilted. Fresh weight was taken on the date the whole delphinium flower wilted.

The experiment was a completely randomized design with Acacia gum concentration and application method in a factorial treatment arrangement. The data were analyzed using PROC GLM in PC-SAS (SAS Institute, Cary, NC). Differences in application method were determined using the Waller/Duncan mean comparisons at $P =$

0.05. Linear and quadratic trends over Acacia gum concentration were determined using orthogonal contrasts, $P = 0.05$. Comparison with the control and standard were determined using Dunnett's comparison to a control, $P = 0.05$.

Experiment 2

In a second experiment, 'Maryland Dark Red' were cut, using sterilized pruners, at 70 cm (24 in) length and the lower 20.3 cm (8 in) of foliage was removed. Flowers were treated with the Acacia gum at concentrations of 5%, 10%, or 20%, using two application methods, at 3 harvest stages for each method. Flowers were harvested at 3, 6, or 9 fully open florets and treated with the Acacia gum by either spraying the entire cut flower after harvest or spraying the foliage and stem only after harvest. Flowers were placed directly in indoor environment rooms after treatment.

Data recorded included date the lowermost floret on the flower spike wilted, and date the lowermost six florets wilted. Fresh weight was taken for both species on the harvest date and the date the lowermost six florets wilted.

The experiment was a completely randomized design with Acacia gum concentration, floret open stage, and application method in a factorial treatment arrangement. The data were analyzed using PROC GLM in PC-SAS (SAS Institute, Cary, NC). Differences in application method were determined using the Waller/Duncan mean comparisons at $P = 0.05$. Linear and quadratic trends over Acacia gum concentration and floret open stage were determined using orthogonal contrasts, $P = 0.05$. Comparison with the control and standard determined using Dunnett's comparison to a control, $P = 0.05$.

In a second part of the experiment, 'Guardian White' were used. Flowers were harvested at three stages; ¼, ½, or ¾ open florets. Stems were cut at 55.8 cm (22 in) lengths and the lower 20.3 cm (8 in) of foliage was removed. Stems were then weighed and treated with the Acacia gum at concentrations of 5%, 10%, or 20% using two methods (three stages for each method). Treatment methods consisted of spraying the entire cut flower after harvest or dipping the entire cut flower after harvest. Aquagro surfactant was added to the spray treatments (0.9mL/L). After treatment, flowers were transferred to simulated indoor environment rooms. The control and standard were placed directly in vases of 300 mL reverse osmosis water, or 300 mL Floralife preservative.

Data recorded consisted of the date the lowermost floret on the flower spike wilted and the date the whole flower spike wilted. Fresh weight was taken on the date the whole delphinium flower wilted.

The experiment was a completely randomized design with Acacia gum concentration, floret open stage, and application method in a factorial treatment arrangement. The data were analyzed using PROC GLM in PC-SAS (SAS Institute, Cary, NC). Differences in application method were determined using the Waller/Duncan mean comparisons at $P = 0.05$. Linear and quadratic trends over Acacia gum concentration and floret open stage were determined using orthogonal contrasts, $P = 0.05$. Comparison with the control and standard were determined using Dunnett's comparison to a control, $P = 0.05$.

Results and discussion

Experiment 1

Snapdragon 'Maryland True Pink'. In the first part of this experiment, observation was made on the effects of AG rate and application methods on longevity of cut snapdragon 'Maryland True Pink' (Table 1). There was an interaction between Acacia gum (AG) rate and application method for number of days to first wilted floret and number of days to six wilted florets.

Days to first wilted floret. All cut flowers placed directly in AG wilted and died in several hours. At an AG rate of 5%, the greatest number of days to first wilted floret occured when AG was sprayed on flowers only 1 hr. before harvest. However, this method was not different from AG sprayed on foliage only 1 hr. before harvest or spray entire cut flower at harvest. The least number of days to first wilted floret occurred when the entire cut flower was sprayed one hr. before harvest. At an AG rate of 10%, the greatest number of days to first wilted floret when AG was sprayed entire cut flower at harvest, sprayed only on foliage at harvest, and when the entire stem was dipped in AG at harvest. The least number of days to first wilted floret were with entire cut flower sprayed 1 hour before harvest and flowers only sprayed 1 hr. before harvest. At an AG rate of 20%, the greatest number of days to first wilted floret occured when entire stem was dipped at harvest. This method was not different from AG sprayed only on foliage at harvest, sprayed on entire cut flower at harvest, or sprayed only on flowers at harvest. The least number of days to first wilted floret occurred with spraying flowers only 1 hr. before harvest and entire cut flowers 1 hr. before harvest.

There was a linear decrease in the number of days to first wilted floret with increasing Acacia gum concentration when flowers only were sprayed 1 hr. before harvest. The reverse trend was observed when the entire stem was dipped. In that instance, there was a linear increase in days to first wilted floret from lowest to highest AG concentration.

Flowers treated with 5% AG sprayed on the entire cut flower 1 hr. before harvest had fewer days to first wilted floret compared to reverse osmosis water. Treatments of 10% AG sprayed only on flowers 1 hr. before harvest and 10% AG sprayed on the entire stem 1 hr. before harvest, also had fewer days to first wilted floret compared to reverse osmosis water. Similarly, treatments of 20% AG sprayed only on flowers 1 hr. before harvest and sprayed on entire cut flower 1 hr. before harvest, had fewer days to first wilted floret than reverse osmosis water.

When compared to Floralife, 5% AG sprayed only on foliage at harvest, sprayed only on flowers at harvest, sprayed on entire stem 1 hr. before harvest, and entire stem dipped at harvest, had fewer days to first floret wilted. At 10% AG, most treatments had fewer days to first wilted floret than Floralife, with the exception of when the entire cut flower was sprayed at harvest, and the entire stem dipped at harvest. At 20%, AG sprayed on foliage 1 hr. before harvest, sprayed only on flowers 1 hr. before harvest, sprayed only on flowers at harvest, and sprayed on entire cut flower 1 hr. before harvest, had fewer days than Floralife to first wilted floret.

Generally, stems that were dipped at harvest at 10% and 20% AG showed the most days to the first wilted floret, followed by entire cut flowers that were sprayed at harvest. Flowers only that were sprayed at harvest resulted in fewer days than Floralife

to first wilted floret at 5%, 10%, and 20% AG rates. Entire cut flowers that were sprayed one hr. before harvest, at 5%, 10%, and 20% rates, had fewer days to first wilted floret than Floralife and reverse osmosis water.

Days to six wilted florets. At the 5% AG rate, spraying the entire cut flower 1 hr. before harvest resulted in the most days to six wilted florets. This treatment was only different from the entire cut flower sprayed 1 hr. before harvest. At 10% AG, the most days to six wilted florets occurred when the entire stem was dipped at harvest. The entire cut flower sprayed 1 hr. before harvest and only flowers sprayed 1 hr. before harvest showed the fewest days to six wilted florets. At an AG rate of 20%, the entire stem dip method had the most days to six wilted florets. The least days to six wilted florets occurred when only flowers were sprayed 1 hr. before harvest and when the entire cut flower was sprayed 1 hr. before harvest.

There was a linear increase in days to six wilted florets with increasing AG concentration when only foliage was sprayed at harvest and when entire stem was dipped at harvest. There was a linear decrease in number of days to six wilted florets with increasing AG when only flowers were sprayed 1 hr. before harvest.

Compared to reverse osmosis water, entire stems sprayed 1 hr. before harvest with 10% AG had fewer days to six wilted florets. In comparison to Floralife, entire stems sprayed 1 hr. before harvest with 5% AG had fewer days to six wilted florets. Flowers only that were sprayed 1 hr. before harvest and entire stem sprayed one hr. before harvest at a rate of 10% AG had fewer days to six wilted florets than Floralife. Flowers only that were sprayed one hr. before harvest and entire stem sprayed one hr. before harvest with

20% AG had fewer days to six wilted florets than Floralife. Entire stems dipped in 10% and 20% AG had more days to six wilted florets than reverse osmosis water.

Generally, at AG rates of 10% and 20%, the entire stem dip treatment resulted in the most days to six wilted florets. At all three AG rates, entire cut flowers sprayed one hr. before harvest resulted in the least days to six wilted florets.

Only the main effect application method was significant for fresh weight. Treatments that resulted in the highest fresh weight were those in which the foliage was sprayed 1 hr. before harvest and flowers only were sprayed at harvest. All treatments, including the reverse osmosis water control, had lower fresh weights than the Floralife standard. Stems dipped in AG had lower fresh weights than reverse osmosis water and Floralife.

Overall, sprays of Acacia gum only to the flowers 1 hr. before harvest decreased the number of days to first and six wilted florets with an increase in AG rate. Dipping the entire stem in AG increased days to first wilted floret and six wilted florets with increase in AG concentration by 23% and 58%, respectively. AG sprayed on the entire cut flower one hr. before harvest showed the least days to first and six wilted florets. The results of this study indicate that dipping cut flowers in 10% or 20% AG has potential application in post-harvest handling procedures because of its favorable comparison to Floralife. Results of other application methods were not as promising.

Delphinium 'Guardian Mid Blue'. The objective of this part of the experiment was to observe the effects of Acacia gum application methods on the longevity of cut delphinium 'Guardian Mid Blue' (Table 2). There was no effect of AG rate on cut flower longevity, nor was there an effect of treatments on fresh weight. Cut delphiniums that

were dipped at harvest had the most days to first wilted floret, but were not different from entire cut flowers sprayed at harvest, only flowers sprayed at harvest, or entire cut flower sprayed 1 hr. before harvest. Treatments of only foliage sprayed at harvest resulted in the least days to first wilted floret.

Cut flowers placed in Floralife and those treated by dipping the entire stem resulted in 38% and 37% increase in number of days to first wilted floret compared to those placed in reverse osmosis water.

The treatment in which only the flowers were sprayed at harvest had the highest number of days to all wilted florets. This treatment resulted in 25% and 31% increase in days to all wilted florets compared to Floralife and reverse osmosis water, respectively.

Experiment 2

Snapdragon 'Maryland Dark Red'. In the first part of this experiment, observation was made on the effects of Acacia gum rate, application method, and harvest stage on cut flower longevity of 'Maryland Dark Red' (Table 3). Cut flowers treated with Floralife had the most days to first wilted floret and six wilted florets compared to other application methods. Cut flowers treated with Floralife also had the highest fresh weight of all treatments. There was a linear decrease in number of days to first wilted floret with increasing AG concentration.

Flowers harvested at three, six, and nine open florets resulted in a quadratic change in number of days to first wilted floret. There was a linear decrease in number of days to six wilted florets with an increase in number of open florets. Fresh weight increased with increasing open florets.

Delphinium 'Guardian White'. The second part of this experiment focused on the effects of Acacia gum rate, application method, and harvest stage on longevity of cut delphinium 'Guardian White' (Table 4). There was an interaction between application method and harvest stage for the number of days to first wilted floret. Only the main effect application method was significant for fresh weight. There was no effect of AG concentration on cut flower longevity.

At a harvest stage of three open florets, Floralife had more days to first wilted floret than reverse osmosis water, but flowers treated by spraying entire stem at harvest or spraying only foliage at harvest performed as well as Floralife. In flowers harvested at six open florets, those treated by spraying only foliage at harvest and those placed in Floralife had more days to first wilted floret than those in reverse osmosis water. At nine open florets, flowers placed in Floralife had the most days to first wilted floret.

There was a linear decrease in number of days to first wilted floret in flowers treated by placing them in reverse osmosis water and by spraying the entire stem at harvest, with increase in number of florets open at harvest. Cut flowers treated with Floralife and by spraying foliage only at harvest resulted in a quadratic change in number of days to first wilted floret with increasing number of florets open at harvest.

Overall, the dip treatment showed the most promising results in comparison to Floralife in snapdragon 'Maryland True Pink'. Dipping the stems in AG resulted in drying of florets while stems and foliage remained alive. Poor performance of sprays may have been caused by beading. Placing the stems directly in AG appeared to cause blockage of xylem, therefore rapid death. There were mixed responses from delphiniums

and ‘Maryland Dark Red’ snapdragons. The varied results shown by different cut flowers prompted screening of other cut flower species.

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Table 1. Effect of Acacia gum rate and application method on cut flower longevity of snapdragon 'Maryland True Pink'.

Application method	First wilted floret (days) Acacia gum (%)[z] 5	10	20	Sig.[y]	Six wilted floret (days) Acacia gum (%)[z] 5	10	20	Sig.	Fresh weight (g)[x]
Stems in Acacia gum solution	dead	dead	dead	–	dead	dead	dead	–	dead
Spray foliage only 1 hr. before harvest	7.7ab[w]	6.2bc[2]	6.6b[2]	ns	9.6ab	9.2b	8.9d	ns	0.68ab[2]
Spray foliage only at harvest	6.5c[2]	6.8ab[2]	7.3ab	ns	8.6ab	9.8b	10.8bc	L*	0.63bc[2]
Spray entire cut flower at harvest	7.3abc	8.0a	8.1ab	ns	11.4a	10.1b	11.3b	ns	0.63bc[2]
Spray flowers only 1 hr. before harvest	8.1a	5.1cd[12]	4.4c[12]	L***	10.5ab	8.2bc[2]	7.5e[2]	L**	0.60c[2]
Spray flowers only at harvest	6.9bc[2]	6.3bc[2]	7.0ab[2]	ns	9.0ab	9.3b	9.8cd	ns	0.70a[2]
Spray entire cut flower 1 hr. before harvest	4.8d[12]	4.6d[12]	4.3c[12]	ns	8.0b[2]	6.3c[12]	7.1e[2]	ns	0.61c[2]
Dip entire cut flower at harvest	6.4c[2]	7.8a	8.3a	L**	10.4ab	16.8a[12]	25.0a[12]	L***	0.49d[12]
Reverse osmosis water[v]	7.5				9.8				0.67
Floralife[v]	9.1				11.5				0.82[1]

[z] There was an interaction of Acacia gum rate × application method, $P = 0.05$.
[y] Non-significant (ns) or significant linear (L) trends at $P = 0.05$ (*), 0.01 (**), or 0.001 (***).
[x] Main effect application method significant only, $P = 0.05$.
[w] Means within columns followed by the same letter were not different according to Waller/Duncan Multiple Range Test, $P = 0.05$.
[v] Treatment different from reverse osmosis water ([1]) or treatments different from Floralife ([2]) according to Dunnett's Comparison to a control, $P = 0.05$.

Table 2. Effect of Acacia gum application method on cut flower longevity of delphinium 'Guardian Mid Blue'.

Application method	First wilted floret (days)[z]	All wilted floret (days)[z]
Spray foliage only at harvest	3.6c [y 2]	14.3b
Spray entire cut flower at harvest	4.5ab	13.4bc
Spray flowers only 1 hr. before harvest	3.8bc[2]	14.2b
Spray flowers only at harvest	4.6ab	16.6a[12]
Spray entire cut flower 1 hr. before harvest	4.5ab	13.7bc
Dip entire stem at harvest	5.2a[1]	12.4c
Reverse osmosis water[x]	3.3	11.5
Floralife[x]	5.3[1]	12.5

[z] Main effect application method significant only, $P = 0.05$.
[y] Means within columns followed by the same letter were not different according to Waller/Duncan Multiple Range Test, $P = 0.05$.
[x]Treatment different from reverse osmosis water ([1]) or treatments different from Floralife ([2]) according to Dunnett's Comparison to a control, $P = 0.05$.

Table 3. Effect of Acacia gum rate, application method, and harvest stage on cut flower longevity of snapdragon 'Maryland Dark Red'[z].

Application method	First wilted floret (days)	Six wilted floret (days)	Fresh weight (g)	Acacia gum rate (%)	First wilted floret (days)
Spray entire stem at harvest	7.5b[y]	10.8b	0.67b	5	7.9
Spray foliage only at harvest	7.3b	11.3b	0.66b	10	7.3
Reverse osmosis water	7.8b	11.1b	0.63b	20	7.0
Floralife	10.1a	13.5a	1.00a	Signif.[x]	L**

Harvest stage[w]	First wilted floret (days)	Six wilted floret (days)	Fresh weight (g)
3	8.3	12.5	0.63
6	7.9	11.3	0.67
9	6.1	9.3	0.70
Significance	Q**	L***	L**

[z] Main effects significant only, $P = 0.05$.
[y] Means within columns followed by the same letter were not different according to Waller/Duncan Multiple Range Test, $P = 0.05$.
[x] Non-significant (ns) or significant linear (L) trends at $P = 0.01$ (**), or 0.001 (***).
[w] Number of fully open basal florets.

Table 4. Effect of Acacia gum rate, application method, and harvest stage on cut flower longevity of delphinium 'Guardian White'[z].

	First wilted floret (days)				
	Harvest stage[y]				
Application method	3	6	9	Sig.[x]	Fresh weight (g)
Reverse osmosis water	4.9b[w]	3.6b	3.3c	L**	0.28b
Floralife	6.4a	4.9a	6.9a	Q***	0.38a
Spray entire stem at harvest	5.6ab	4.4ab	4.1bc	L*	0.36a
Spray foliage only at harvest	5.5ab	4.6a	4.4b	Q**	0.41a

[z] There was an interaction of application method × harvest stage. Main effect application method only was significant for fresh weight, $P = 0.05$.
[y] Number of fully open basal florets.
[x] Significant linear (L) or quadratic (Q) trends at $P = 0.05$ (*), 0.01 (**), or 0.001 (***).
[w] Means within columns followed by the same letter were not different according to Waller/Duncan Multiple Range Test, $P = 0.05$.

CHAPTER III

EFFICACY OF ACACIA GUM IN EXTENDING VASE LIFE OF 12 CUT FLOWER SPECIES

Abstract

The objective of this experiment was to screen widely used cut flowers for the efficacy of Acacia gum in extending vase life. Twelve cut flower species were acquired from a local wholesale floral supplier. Flowers were treated by dipping in 5% or 10% Acacia gum solutions and placement in reverse osmosis water or Floralife preservative. Controls were placed directly in reverse osmosis water and standards were placed directly in Floralife. Results of this study indicate that Acacia gum treatments were at best comparable, but not better than the Floralife standard. Acacia gum showed no benefit as a floral preservative over what is currently used.

Index words: floral preservative

Species used in this study: 'Rosita Cherry 'alstroemeria (*Alstroemeria sp.* L.), 'Nelson' carnation (*Dianthus caryophyllus* L.), 'Factor' daisy mum (*Dendranthema* ×*grandiflora* Ramat.), rose (*Rosa* sp. L.), 'Monte Casino' aster (*Callistephus chinensis* Nees), 'Deep Red' gladiolus (*Gladiolus* ×*hortulanus* Bailey), blazing star (*Liatris spicata* Nilld), stock

(*Matthiola incana* L.), 'Sprengeri' asparagus fern (*Asparagus densiflorus* Kunth*)*, 'Stargazer' lily (*Lilium sp.* L.), dutch iris (*Iris xiphium* L.), gerbera daisy (*Gerbera spp.* L.)

Significance to the Nursery Industry

Cut flower quality is highly dependent upon post-harvest handling. A major component of post-harvest handling is the application of floral preservatives, which are highly effective in prolonging quality and increasing longevity. In less developed countries where refrigeration may be far from the production area, more efficient methods are needed to preserve cut flowers while in transit. Even in developed countries where handling methods are more modern, losses in the marketing chain can be high. Acacia gum, a naturally occurring bio-polymer has shown potential in the preservation of cut flowers. However, results of this study indicate that Acacia gum shows no benefit over Floralife in extending the vase life of cut flowers.

Introduction

Post-harvest treatment largely determines final quality of cut flowers. Specific post-harvest procedures depend on the flower species, the market, and the size of the operation (1). The quality of flowers at harvest is set and can only stabilize or decrease. Post-harvest management starts at the beginning of production. It continues from cultivar selection, cultivation, harvest, to handling by the retailer. Because flowers are very sensitive to treatment once they have been cut, the post-harvest period is extremely

critical to prolonging the life of cut flowers. Because flower species can vary in their care requirements, it is important to know what the main quality problems are for each crop and how to prevent them (3). Although different flower species require different post harvest treatments, most species benefit from cooling and use of floral preservatives (2). In 2003, a method of reversible preservation of biological samples using Acacia gum was discovered. The Acacia gum was used to isolate and preserve a microscopic biological specimen in a prolonged dormant condition without damage to the specimen. The specimen was later restored to its previous state (4). Because of its success in the preservation of microorganisms, it is possible that Acacia gum could be used to preserve larger specimens, such as cut flowers. In Chapter II, cut snapdragon vase life was extended using the Acacia gum; however, results were variable with delphinium. The objective of this experiment was to screen widely used cut flowers for the efficacy of Acacia gum in extending vase life.

Materials and methods

Acacia gum, Instantgum AS, (CNI, Normandy, France) solutions were prepared before the start of the experiment. The Acacia gum was mixed at concentrations of 5%, and 10%. The powder was mixed using stir plates (Fisher Scientific International, Inc., Hampton, NH) and left to dissolve overnight. Prior to use, the Acacia gum was stored in a cooler set at 4.4C (40F). Acacia gum was not re-used once contaminated.

Twelve species of fresh cut flowers were obtained from a local wholesale floral supplier (Hall's Wholesale Florist, Opelika, AL). They were purchased and treated in 3 groups of 4 over a period of 16 weeks.

On September 6, 2005, 'Rosita Cherry 'alstroemeria (*Alstroemeria sp.* L.*)*, 'Nelson' carnation (*Dianthus caryophyllus* L.), 'Factor' daisy mum (*Dendranthema ×grandiflora* Ramat.), and rose (*Rosa* sp. L.) were purchased from the wholesaler. Flowers were not re-cut, but immediately hydrated in buckets of water and then placed inside a walk-in cooler set at 4.4C (40F) over night. Alstroemeria was placed in an indoor environment room with a temperature maintained at 20-21.1C (68-70F) and constant fluorescent lighting to allow further opening of the florets. On September 7, 2005, flowers were removed from the cooler and re-cut using hand pruners and the bottom 22.9 cm (9 in) of foliage was removed. Roses were cut at a length of 50.8 cm (20 in), carnations at 45.7 cm (18 in), and daisy mum and alstroemeria were cut at 55.8 cm (22 in). Flowers were then weighed and treated by dipping in 5% or 10% Acacia gum. To simplify the dipping procedure, a 10.2 cm (4 in) diameter, 70 cm (2 ft) height tube was constructed of PVC with a base made of PVC 7.6-10.2 cm (3-4 in) toilet flange. The Acacia gum was poured into the tube to half full and the flowers were dipped, excluding the bottom 22.9 cm (9 in), until fully covered with Acacia gum. After treatment, flowers were inserted in 22.9 cm (9 in) glass bud vases (Syndicate Sales, Inc., Kokomo, IN) filled with 300 mL reverse osmosis water or Floralife solution (Floralife, Inc., Waterboro, SC) at 40g/3.79L, and placed in a simulated indoor environment room. Standard and control flowers for each species were placed directly in vases containing Floralife solution or reverse osmosis water, respectively, and placed in the indoor environment rooms. Beginning two days after treatment, vases containing reverse osmosis water were emptied and re-filled with fresh reverse osmosis water every other day, until flowers reached a

rating of 2. Floralife vases were topped off when needed. Data recorded for all species were visual ratings of flower quality. Alstroemeria and daisy mum were rated on a scale of 1 to 5; 5 = no damage (crinkling, wilting, or necrosis of petals), 4 = ¼ or less flower damage, 3 = ½ flower damage, 2 = ¾ flower damage, and 1 = dead. Roses were rated on a scale of 1 to 7; 7 = no damage, 6 = all petals noticeably darkened from red to purple, 5 = less than ¼ petals necrotic, 4 =¼ - ½ petals necrotic, 3 =½ or more petals necrotic, 2 = flower drooped, and 1 = dead. Carnations were rated on a scale of 1 to 4; 4 = no damage (crinkling, wilting, or necrosis of petals), 3 = less than ¼ flower damage, 2 = ¼ - ½ flower damage, and 1 = dead.

On October 17, 2005, 'Monte Casino' aster (*Callistephus chinensis* Nees*),* 'Deep Red' gladiolus (*Gladiolus* × *hortulanus* Bailey), blazing star (*Liatris spicata* Willd.), and stock (*Matthiola incana* L.) were obtained from the wholesaler. Upon receipt, flowers were not re-cut, but placed directly in water and inside a walk in cooler set at 4.4C (40F) over night. Gladiolus were placed in an indoor environment room to encourage further opening of the florets. On October 18, 2005, flowers were removed from the cooler and re-cut. Aster were cut at 70 cm (24 in), gladiolus at 71.1 cm (28 in), blazing star at 50.8 cm (20 in), and stock were cut at 45.7 cm (18 in). The bottom 22.9 cm (9 in) of foliage was removed from all stems. Flowers were then weighed and treated with either 5% or 10% Acacia gum. Flowers were treated by a method of dipping the flower, excluding the bottom 22.9 cm, in a tube half full of the Acacia gum. After treatment, flowers were inserted in 22.9 cm (9 in) glass bud vases filled with 300 mL reverse osmosis water or Floralife solution, and placed in simulated indoor environment rooms. The standard and

control flowers for each species were placed directly in vases containing Floralife solution or reverse osmosis water, respectively, and placed in an indoor environment room. Every other day, vases containing reverse osmosis water were emptied and re-filled with fresh reverse osmosis water. Floralife vases were topped off when needed. Data recorded for all species were visual ratings of flower quality every other day. Aster, gladiolus, and stock were rated on a scale of 1 to 5; 5 = no damage (crinkling, wilting, or necrosis of petals), 4 = ¼ or less flower damage, 3 = ½ flower damage, 2 = ¾ flower damage, and 1 = dead. Ratings for blazing star consisted of 5 = many florets fully open, 4 = few florets fully open, 3 = most florets partially open, 2 = florets partially open and dried, black stem, and 1 = dead.

On November 28, 2005, the last group of flowers was purchased from the wholesaler. The group consisted of 'Sprengeri' asparagus fern (*Asparagus densiflorus* Kunth*)*, 'Stargazer' lily (*Lilium sp.* L) , dutch iris (*Iris xiphium* L.), and gerbera daisy (*Gerbera spp.* L. *)*. Flowers were not re-cut, but placed directly in water and inside a walk in cooler set at 4.4C (40F) over night. Stargazer lilies were put in an indoor environment room to encourage further opening of the florets. On November 29, 2005, flowers were taken from the cooler and re-cut. Sprengeri were cut at 50.8 cm (20 in), stargazer lilies were cut at 7.6-12.7 cm (3-5 in), iris and gerbera were cut at 45.7 cm (18 in). The bottom 22.9 cm (9 in) of foliage was removed from all stems. Flowers were then weighed and treated with either 5% or 10% concentration of the Acacia gum. Flowers were treated by dipping the flower, excluding the bottom 22.9 cm, in a PVC tube half full of the Acacia gum. After treatment, flowers were positioned in 22.9 cm (9 in) glass bud vases filled

with 300 mL reverse osmosis water containing Floralife solution, and placed in a simulated indoor environment room. The standard and controls for each flower species were placed directly in vases of Floralife solution or reverse osmosis water, respectively, and in the indoor environment rooms. Every other day, vases containing reverse osmosis water were emptied and re-filled with fresh reverse osmosis water. Floralife vases were topped off when needed. Data recorded for all species were visual ratings of flower quality. Sprengeri were rated on a scale of 1 to 5; 5 = no damage, 4 = ¼ or less yellow leaves, 3 = ½ yellow leaves, 2 = ¾ leaves dead or yellow, and 1 = dead. Ratings for stargazer lily were 5 = no damage, 4 = petals slightly drooped / not shriveled, 3 = petals partially drooped / shriveled edges, 2 = fully drooped / shriveled / discolored, and 1 = dead. *Iris* ratings consisted of 5 = no damage, 4 = ¼ flower damaged necrotic, 3 = ½ flower damage / curled petals, 2 = ¾ petals damaged, and 1 = dead. Gerbera daisies were rated on a scale of 1 to 7, with 7 = no damage, 6 = bent over, but no damage, 5 = bent over / ¼ petals damaged, 4 = ¼ or less damaged / wilted, 3 = ½ petal damage, 2 = ¾ petal damage, and 1 = dead.

Flowers were considered to have lost all aesthetic value when they reached a rating of 2. The number of days from the date of treatment to the date that the flowers lost aesthetic value was calculated to determine vase life of the flowers.

The experiment was a completely randomized design with 10 single-stem replications (vases) in each treatment. Each cut flower species was analyzed separately. Treatment difference were determined using the Waller/Duncan mean separation of the GLM procedure in PC SAS (SAS Institute, Cary, NC), $P = 0.05$.

Results and Discussion

Alstroemeria. The number of days to aesthetic loss (DAL) ranged from 21 to 26.2 days, with AG5 and 5% Acacia gum (AG5) plus Floralife (FL), respectively (Table 1). Flowers showed little crinkling or wilting from AG, but foliar damage seemed to increase with higher concentrations of the Acacia gum. The highest fresh weights (FW) were found at AG10, RW, AG5, AG5+FL, and AG10+FL.

Carnation. Carnation cut flowers treated with FL showed the highest DAL followed by RW, AG5, AG10, and AG5+FL, and AG10+FL. RW and FL resulted in higher DAL than any of the Acacia gum treatments. The petals on treated flowers turned dark red and wrinkled. The highest FW was with FL and AG10+FL followed by RW, AG5, AG10, AG5+FL, and AG10+FL. The petals of the controls looked healthy until their final days, when they developed necrotic edges.

Daisy mum. Cut flowers treated with AG5 + FL, FL, RW, and AG10+FL had the highest DAL. Cut flowers treated with RW and AG10 had among the lowest DAL. Flowers demonstrated very little petal damage from the Acacia gum. Foliage had varying levels of chlorosis and necrosis.

Rose. Cut roses treated with RW, FL, AG5, and AG10 had the highest DAL. Treatments of AG5+FL and AG10+FL had the lowest DAL. Petals showed various degrees of necrosis and crinkling as a result of the AG treatments.

Aster. Cut flowers treated with FL had highest DAL, followed by RW, and AG5. The lowest DAL was with AG10+FL. Cut asters treated with FL, RW, and AG10 had

the highest FW. AG5+FL and AG10+FL had the lowest FW. There was some necrosis on foliage of all Acacia gum treated flowers.

Gladiolus. The AG5+FL treatment showed the highest DAL for cut gladiolus, but was not different from FL or AG10. The lowest DAL was with AG10+FL but this treatment was not different from RW. Florets that were not open when treated did not open after treatment. Some treated petals had necrotic edges.

Liatris. Cut liatris treated with FL had the highest DAL, followed by AG5. Flowers treated with AG10+FL showed among the least DAL, but were not different from RW. Most florets that were not open at the time of treatment with AG did not fully open after treatment.

Stock. Flowers treated with FL had higher DAL than any other treatment and was followed by RW. All AG treatments had a detrimental effect on stock cut flowers.

Gerbera daisy. In ratings of gerbera daisy cut flowers, there were no differences among any of the treatments. RW, FL, AG5, and AG5+FL had the highest FW.

Sprengeri. Cut sprengeri treated with FL had the highest DAL, followed by RW, AG5+FL, and AG10+FL. AG alone had a negative effect on the aesthetic life of cut sprengeri.

Iris. Flowers treated with AG10+FL had higher DAL than any other treatment. There were no other differences.

Stargazer. FL standard and RW control showed the highest DAL, followed by AG5 and AG10. Flowers treated with AG10+FL had the lowest DAL. AG treated flowers had crinkled edges of the petals.

Overall, none of the Acacia gum treatments extended the vase life beyond those treated with reverse osmosis water in carnation, rose, aster, stock, gerbera daisy, and stargazer lily. The FL standard resulted in the highest DAL for carnation, aster, liatris, stock, sprengeri, and stargazer lily. Flowers treated with AG+FL were not different from FL alone in alstroemeria, daisy mum, gladiolus, and sprengeri. AG was equal to FL in rose and aster. Generally, FL resulted in the highest DAL for most cut flower species, while AG10+FL resulted in the lowest DAL for most cut flower species. Flowers treated with AG at 5% concentration generally showed more positive results than those treated with 10%. With some exceptions, AG+FL performed better than AG alone. Except for stargazer lily, AG seemed to have less negative effect on single flowers vs. double.

In this study, FL was clearly the standard against which all could be measured. In only one case, AG10+FL in iris, was any treatment better than FL alone. All other treatments were at best comparable but not better than FL. Therefore, AG shows no benefit over what is currently used.

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Table 1. Effects of Acacia gum and Floralife preservative on post-harvest keeping quality of 12 cut flowers.

Alstroemeria		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.88ab[z]	22.4ab
Floralife	0.71b	24.6ab
5% Acacia gum	0.84ab	21.0b
10% Acacia gum	0.88a	22.6ab
5% Acacia gum + Floralife	0.84ab	26.2a
10% Acacia gum + Floralife	0.81ab	23.0ab
Carnation		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.40b	27.4b
Floralife	0.61a	31.8a
5% Acacia gum	0.44b	21.4c
10% Acacia gum	0.44b	21.0c
5% Acacia gum + Floralife	0.46b	20.2c
10% Acacia gum + Floralife	0.50ab	15.0d
Daisy mum		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.66ab	27.0b
Floralife	0.77ab	33.2ab
5% Acacia gum	0.625b	27.2ab
10% Acacia gum	0.86a	27.0b
5% Acacia gum + Floralife	0.73ab	33.4a
10% Acacia gum + Floralife	0.69ab	29.8ab

Rose		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.55 [ns]	16.1a
Floralife	0.49	14.4a
5% Acacia gum	0.53	14.8a
10% Acacia gum	0.55	14.7a
5% Acacia gum + Floralife	0.47	4.5b
10% Acacia gum + Floralife	0.51	5.0b
Aster		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.27ab	13.0b
Floralife	0.31a	15.2a
5% Acacia gum	0.23bc	13.0b
10% Acacia gum	0.29ab	9.0cd
5% Acacia gum + Floralife	0.15d	10.4c
10% Acacia gum + Floralife	0.18cd	7.6d
Gladiolus		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	1.5 [ns]	6.6bc
Floralife	1.5	7.6ab
5% Acacia gum	1.3	6.8b
10% Acacia gum	1.3	7.0ab
5% Acacia gum + Floralife	1.3	8.0a
10% Acacia gum + Floralife	1.6	5.6c

Liatris		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.25a	9.2cd
Floralife	0.3a	21.0a
5% Acacia gum	0.26a	10.6b
10% Acacia gum	0.27a	9.8c
5% Acacia gum + Floralife	0.23ab	9.2cd
10% Acacia gum + Floralife	0.24a	9.0d
Stock		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.92 [ns]	8.8b
Floralife	0.87	11.8a
5% Acacia gum	0.76	2.9c
10% Acacia gum	0.84	4.1c
5% Acacia gum + Floralife	0.78	3.5c
10% Acacia gum + Floralife	0.85	3.0c
Gerbera daisy		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.42ab	11.0 [ns]
Floralife	0.51a	14.2
5% Acacia gum	0.39ab	13.6
10% Acacia gum	0.37b	12.4
5% Acacia gum + Floralife	0.48ab	14.4
10% Acacia gum + Floralife	0.37b	14.6

Sprengeri		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.14ab	12.2ab
Floralife	0.10ab	15.6a
5% Acacia gum	0.08b	9.2b
10% Acacia gum	0.11ab	8.0b
5% Acacia gum + Floralife	0.11ab	12.4ab
10% Acacia gum + Floralife	0.15a	11.4ab
Iris		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.79 [ns]	6.0b
Floralife	0.84	6.0b
5% Acacia gum	0.93	6.0b
10% Acacia gum	0.91	6.0b
5% Acacia gum + Floralife	1.01	6.0b
10% Acacia gum + Floralife	1.00	6.4a
Stargazer Lily		
Treatment	Fresh weight (oz)	Days to aesthetics loss
Reverse osmosis water	0.17ab	6.0a
Floralife	0.19a	6.6a
5% Acacia gum	0.14b	4.8b
10% Acacia gum	0.19a	4.8b
5% Acacia gum + Floralife	0.18a	3.4c
10% Acacia gum + Floralife	0.16ab	2.2d

[z] Means in columns followed by identical letters are not significant based on Waller-Duncan, $P = 0.05$. Not significant ([ns]).

CHAPTER IV

EFFECTS OF ACACIA GUM APPLIED BEFORE OR AFTER STORAGE IN A COOLER IN COMBINATION WITH FLORALIFE ON CUT FLOWER VASE LIFE OF DIANTHUS AND LISIANTHUS

Abstract

The purpose of this experiment was to test the effects of Acacia gum applied before or after storage in a cooler, in combination with Floralife, on vase life of two cut flower species. 'ABC 1-3 Purple' lisianthus (*Eustoma grandiflorum*) and 'Super Parfait Raspberry' dianthus (*Dianthus chinensis*) were grown in a greenhouse, harvested, and treated with Acacia gum (5% or 10%) before or after storage in a cooler. Storage times were zero, four, eight, or twelve days. Dianthus treated with Acacia gum had longer vase life if treatments were applied after cooler if storage time was shorter, but the reverse was true of those with longer storage times. Regardless of preservative treatment, the longer flowers were stored, the longer they kept their aesthetic value after removal from cooler. Acacia gum had no effect on the number of days to aesthetic loss of lisianthus.

Index words: floral preservative

Species used in this study: 'ABC 1-3 Purple' lisianthus [*Eustoma grandiflorum* (Raf.) Shinn.], 'Super Parfait Raspberry' dianthus (*Dianthus chinensis* L.)

Significance to the Nursery Industry

Post-harvest handling plays a major role in cut flower quality. Floral preservatives are an important part of post-harvest procedures. They are highly effective in prolonging quality and increasing longevity of cut flowers. In less developed countries where refrigeration may be far from the production area, more efficient methods are needed to preserve cut flowers while in transit. Even in developed countries where handling methods are more modern, losses in the marketing chain can be high. Acacia gum, a naturally occurring bio-polymer, has been successful in the reversible preservation of microorganisms and has shown promise as a floral preservative. The results of this study were variable. Vase life of dianthus treated with Acacia gum was comparable to Floralife in some treatments. Longer storage times were beneficial to the vase life of dianthus, regardless of Acacia gum treatment. Acacia gum did not lengthen the vase life of lisianthus.

Introduction

There are many factors that can interact to reduce fresh flower vase life. Growers must be aware of these obstacles and be prepared to manage them with correct post-harvest handling procedures. Cold storage maintained at the proper temperatures delays normal maturation/aging, bacterial and fungal infection, and bluing. Floral preservatives, meticulous handling, and proper sanitation practices prevent food depletion, poor water quality, bruising/ crushing, wilting, and incursion of microorganisms (1).

Cold storage is critical to bringing fresh cut flowers from the producer to the marketplace. Low temperatures, in the range of 33-40 F, help extend vase life by reducing respiration, decreasing water loss and wilting, diminishing the growth of disease organisms, decreasing ethylene production, and by providing time for proper handling, packaging and marketing (2). Higher temperatures are associated with faster utilization of carbohydrates stored in plant tissues (5). Low temperatures help cut flowers conserve carbohydrates by reducing respiration, therefore restricting the quality loss that results from the consumption of carbohydrate reserves. Not only must the temperature be optimal, but also the period of time between harvest and arrival at final destination should be as short as possible (6).

The transportation of cut flowers from the field to the consumer is a process that takes particular care and planning. There are many important decisions to be made, one of which is whether to ship the flowers in water or dry-packed. Dry-packing eliminates the weight of water in the buckets, but increases the risk of water stress. This method is used often by commercial growers that ship flowers all over the world (3).

In 2003, a method of reversible preservation of biological samples using Acacia gum was developed. The Acacia gum was used to isolate and preserve a biological specimen in a prolonged dormant condition without damage to the specimen. The specimen was later restored to its previous state (7). Because of its success in the preservation of microorganisms, it is possible that Acacia gum can be used to preserve larger specimens, such as cut flowers. The results in Chapter II demonstrated this possibility when cut snapdragon vase life was extended by using the Acacia gum.

However, results were variable with delphinium. The objective of this experiment was to test the effects of Acacia gum applied before or after storage in a cooler in combination with Floralife on vase life of two cut flower species.

Materials and methods

On August 24, 2005, plugs of 'ABC 1-3 Purple' lisianthus [*Eustoma grandiflorum* (Raf.) Shinn.] and 'Super Parfait Raspberry' dianthus (*Dianthus chinensis* L.), grown in 288 plug flats were obtained from Ball Seed Company (West Chicago, IL). Both species were transplanted into 606 jumbo market flats containing Fafard 3B (Fafard, Inc., Anderson, SC) potting media. Plants were grown in an unshaded polycarbonate-covered greenhouse with a night temperature of 18.3C (65F) and ventilation began at 23.9C (75F). Fertilization began when roots reached the side of the container with 150 mg/liter (ppm) N using a 20N-4.4P-16.6K (Pro Sol 20-10-20, Frit Industries, Inc., Ozark, AL) fertilizer applied three out of four times the plants required water. Plants were transplanted into 15-cm (6 in) plastic pots containing Fafard 3B potting mix when their canopies began to close.

Cut flower harvest stages varied for each species. Dianthus was harvested when petals were at least ½ open and lisianthus when petals were open just enough to see the center of the flower. Both species were cut at stem lengths of 7.6-12.7 cm (3-5 in) using hand pruners and all foliage was removed.

At harvest, flowers were weighed, then either treated with the Acacia gum (Instantgum AS, CNI, Normandy, France) before storage in a cooler or after storage. Controls and standards were placed directly in 22.9 cm (9 in) glass bud vases (Syndicate

Sales, Inc., Kokomo, IN) filled with 300 mL reverse osmosis water or Floralife solution, respectively (Floralife, Inc., Waterboro, SC) mixed at 40g/3.79L and put in simulated indoor environment rooms with temperature maintained at 20-21.1C (68-70F) and continuous fluorescent lighting. The flowers were treated with one of two different concentrations of the Acacia gum, 5% or 10%, which was prepared prior to the start of the experiment. The Acacia gum powder was mixed using stir plates (Fisher Scientific International, Inc., Hampton, NH) and left to dissolve overnight. Treatments were applied by dipping the flower in a 500mL beaker of Acacia gum, covering all parts with the exception of the bottom 22.9 cm (9 in) of the stem. Groups of treated and untreated flowers were dry-packed in cardboard cut flower boxes (Hall's Wholesale Floral Company Opelika, AL). Boxes were lined with wax paper to prevent sticking. The boxes of flowers were placed in a cooler set at 4.4C (40F) for 4, 8, or 12 days. Upon removal, untreated flowers were re-cut, re-hydrated for 2 hrs in reverse osmosis water, treated with the Acacia gum, and then placed in 22.9 cm (9 in) glass bud vases filled with water or Floralife solution. Flowers treated before storage were re-cut and placed directly in vases filled with 300 mL reverse osmosis water or Floralife. All flowers were then placed in simulated indoor environment rooms. Conditions in the controlled indoor environment rooms were as described previously. The vases containing reverse osmosis water were emptied and re-filled with fresh water every two days. Vases with Floralife were topped off as needed.

Data recorded for each species consisted of ratings every other day according to aesthetic value. Dianthus was rated on a scale of 1 to 5; 5 = flowers open, 4 = partially

closed, 3 = closed, 2 = wilted, or 1 = dead. Lisianthus was rated on a scale of 1 to 5; 5 = no damage, 4 = petals crinkled slightly, ¼ flower damaged, 3 = petals fused and crinkled, ½ flower damaged, 2 = petals wilted and crinkled, ¾ flower damaged, or 1= dead. Flowers were weighed at a rating of 1 (dead). Flowers were considered to have lost all aesthetic value when they reached a rating of 2. The number of days from the date of treatment to the date the flowers lost their aesthetic value was calculated to determine vase life of the flowers. Each individual flower was a replication and there were ten replications per treatment.

The experiment was a split plot design with cooler time as the main plot and preservative treatment as the sub-plot. Data were analyzed using PROC GLM in PC-SAS (SAS Institute, Cary, NC). Differences in Acacia gum/Floralife treatments were determined using the Waller/Duncan mean comparisons at $P = 0.05$. Linear and quadratic trends over cooler time were determined using orthogonal contrasts, $P = 0.05$.

Results and discussion

Dianthus. There was a cooler time by preservative treatment interaction for days to aesthetic loss (DAL)(Table 1). DAL increased linearly or quadratically with increasing cooler time for all preservative treatments. Regardless of preservative treatment, the longer the flowers were stored, the longer they kept their aesthetic value after removal from cooler. Percent increase in DAL with increasing cooler time ranged from 9.8% to 78.6% with the highest increases occurring with reverse osmosis water (64.4%), FL (67%), and 5% AG before cooler (78.6%) Average increases in DAL were 51.6% for preservative treatments applied before the cooler and 21.1% for preservative treatments

applied after the cooler. Average increases in DAL were 41.5% for preservative treatments without Floralife and 32.4% for preservative treatments with Floralife.

Preservative treatments receiving no cooler time showed the highest DAL with FL, AG10B, 5% AG before cooler (AG5B)+FL, and AG10B+FL while DAL was lowest with RW and AG5B.

At 4 days in the cooler, dianthus treated with 5% AG after cooler (AG5A) + FL, AG5B, FL, and 10% AG after cooler (AG10A) showed the highest DAL. The treatments with the lowest DAL were AG5B and AG10B.

At 8 days, flowers treated with AG5B+FL, AG5A+FL, and AG10B+FL had the highest DAL. The lowest DAL was with AG10A, AG10A+FL, and AG10B. Flowers treated before storage consistently showed higher DAL than those treated after storage.

In flowers stored for 12 days, those treated with AG5B+FL, RW, FL, AG5B, AG10B, AG10A, AG10B+FL, and AG10A+FL had the highest DAL. AG5A and AG5A+FL showed low DAL, but were only significantly lower than AG5B+FL. Dianthus treated with AG5B+FL and AG10B+FL had among the highest DAL in when stored for zero, eight, and twelve days. Flowers treated with FL had among the highest in DAL for flowers stored zero, four, and twelve days. AG5B resulted in one of the lowest DAL for flowers stored zero and four days in the cooler. Dianthus treated with AG10B had one of the lowest DAL when stored four and eight days in the cooler. Generally, AG seemed to perform better if applied after cooler if storage time was shorter, but the reverse was true of those with longer storage. Regardless of treatment, flowers that were stored for longer periods of time typically had longer vase life. Cold storage is widely

known to help extend vase life; however, long term storage has been known to reduce vase life (4). Therefore, this particular result warrants further investigation.

Lisianthus. There was an interaction between preservative treatment and cooler time for DAL of lisianthus cut flowers (Table 2). DAL increased linearly or quadratically with increasing cooler time for most preservative treatments, with the exception of AG5A, AG10A, and AG5B+FL. The percent increase ranged from 7% to 57%, with the highest increases occurring with RW and AG5B, which were 57% and 44%, respectively. Most treatments showed the highest DAL when stored for eight days, regardless of treatment. Flowers stored for eight and twelve days had the highest FW (Table 3).

At 0, 4, and 8 days of storage, flowers treated with FL alone had higher DAL than other treatments. At 12 days, FL and RW had highest DAL. AG5B, AG10B, AG5A+FL, AG10A+FL were among the lowest DAL for three out of four storage times. Acacia gum treatments had no significant effect on the number of days to aesthetic loss in lisianthus.

Whether treatment was better before or after storage depended on the species, storage time, and whether or not FL was involved. FL promoted high DAL for both species. Storage was usually beneficial to cut flower longevity, but length of storage time could depend on treatment or species.

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Table 1. Effects of Acacia gum concentration and Floralife applied before or after storage in a cooler on days to aesthetics loss of Dianthus cut flowers[z].

	Days in cooler				
Treatment	0	4	8	12	Signif.[y]
Reverse osmosis water	9.0bc[x]	10.2b	13.9cd	14.8ab	L***
Floralife	9.4abc	11.7ab	13.9cd	15.7ab	L***
5% Acacia gum before cooler	8.4c	7.6c	14.0bcd	15.0ab	L***
5% Acacia gum after cooler	–	12.2a	12.8cde	13.4b	L***
10% Acacia gum before cooler	9.4abc	7.2c	12.2def	14.2ab	Q**
10% Acacia gum after cooler	–	11.6ab	10.6f	14.6ab	L***
5% Acacia gum before cooler + Floralife	10.8ab	10.4b	16.4a	16.2a	L***
5% Acacia gum after cooler + Floralife	–	12.2a	14.8abc	13.8b	Q**
10% Acacia gum before cooler + Floralife	11.2a	10.6b	16.0ab	14.2ab	L***
10% Acacia gum after cooler + Floralife	–	10.6b	11.6ef	14.8ab	L***

[z] There was a significant cooler time × preservative treatment interaction, $P = 0.05$.
[y] Significant linear (L) or quadratic (Q) trend at $P = 0.01$ (**) or 0.001 (***). Reverse osmosis water or Floralife controls includes in trend analysis for after cooler treatments.
[x] Means in columns followed by identical letters were not significantly different based on Waller-Duncan, $P = 0.05$. Not significant ([ns]).

Table 2. Effects of Acacia gum concentration and Floralife applied before or after storage in a cooler on days to aesthetics loss of Lisianthus cut flowers[z].

	Days in cooler				
Treatment	0	4	8	12	Signif.[y]
Reverse osmosis water	15.2b[x]	17.5b	21.1b	23.8a	L***
Floralife	20.4a	20.3a	23.7a	23.6a	L***
5% Acacia gum before cooler	13.5bc	14.0def	19.4bc	16.2b	Q*
5% Acacia gum after cooler	–	15.6bcde	17.0de	16.8b	ns
10% Acacia gum before cooler	12.7c	12.8f	17.6cd	15.8b	L***
10% Acacia gum after cooler	–	16.6bc	16.4de	16.0b	ns
5% Acacia gum before cooler + Floralife	14.8b	16.2bcd	16.2de	15.0b	ns
5% Acacia gum after cooler + Floralife	–	14.5def	16.6de	15.4b	Q**
10% Acacia gum before cooler + Floralife	13.6bc	13.5ef	17.2d	15.2b	L*
10% Acacia gum after cooler + Floralife	–	12.1f	15.3e	15.0b	Q***

[z] There was a significant cooler time × preservative treatment interaction, $P = 0.05$.
[y] Non-significant (ns) or significant linear (L) or quadratic (Q) trend at P=0.05 (*), 0.01 (**), or 0.001 (***). Reverse osmosis water or Floralife controls includes in trend analysis for after cooler treatments.
[x] Means in columns followed by identical letters were not significantly different based on Waller-Duncan, $P = 0.05$. Not significant ([ns]).

Table 3. Effect of storage in a cooler on fresh weight at death of Lisianthus cut flowers[z].

	Days in cooler			
	0	4	8	12
Fresh weight (oz)	0.08c[y]	0.09bc	0.10ab	0.11a

[z] Only cooler time was significant, $P = 0.05$.

[y] Means in a row followed by identical letters are not significant based on Waller-Duncan, $P = 0.05$.

CHAPTER V

FINAL DISCUSSION

The significant increase in imports of cut flowers from less developed countries presents a rising need for better preservative methods of cut flowers. The sub-optimal production methods, lengthy transport and storage time, and fluctuating temperatures are just some of the adversities that must be overcome in order to increase cut flower consumption in the U.S. Our objective was to evaluate the post-harvest performance of fresh cut flowers treated with Acacia gum, which has the potential to prolong vase life.

In Chapter II, treatment by method of dipping flowers in AG showed the most positive results in 'Maryland True Pink' snapdragons. This may be explained by the thorough coverage of the Acacia gum on the flower. When sprayed on the flowers, the Acacia gum beaded up, making it difficult to insure that every flower part was covered. The success of this treatment may also be partially accredited to the sturdiness of the snapdragon flower itself. Unlike other flowers used in the Acacia gum studies, snapdragon petals are fused. When senescence begins, the florets collapse instead of shatter. Higher concentrations of the Acacia gum had a drying effect on the snapdragon florets, which in turn, did not collapse and stayed in place.

In delphinium ‘Guardian Mid Blue’, the dip method was comparable to Floralife and better than reverse osmosis water. The treatment in which only the flowers were sprayed at harvest had the highest number of days to all wilted florets.

In snapdragon ‘Maryland Dark Red’ and delphinium ‘Guardian White’, flowers placed in Floralife alone showed the most positive results overall.

In Chapter III, none of the Acacia gum treatments extended the vase life beyond those treated with reverse osmosis water in carnation, rose, aster, stock, gerbera daisy, and stargazer lily. Treatments of Acacia gum + Floralife were not different from Floralife alone in alstroemeria, daisy mum, gladiolus, and sprengeri. The Acacia gum alone showed similar results to Floralife in rose and aster. In most species, flowers treated with Floralife had the longest vase life and highest aesthetic value, while 10% Acacia gum plus Floralife resulted in the shortest vase life and aesthetic value for the most cut flower species. The Acacia gum did not significantly increase the vase life of the cut flowers used in this study.

The results of this experiment may be unlike the previous outcome because of difference in species or because of post harvest handling techniques. Flowers in this experiment were obtained from a wholesale florist. The exact harvest and handling procedures are unknown. In the first experiment, flowers were grown in a greenhouse, harvested, treated, and placed directly in simulated indoor environment rooms. The obscure handling conditions, amount of time before treatment, and variation among species may explain the differing outcomes.

Floralife was clearly the standard against which all could be measured. In only one case, was any treatment better than Floralife alone. All other treatments were at best comparable but not better than Floralife. Therefore, Acacia gum shows no benefit over what is currently used.

In Chapter IV, there were significant interactions between cooler time and preservative treatment for the number of days to aesthetic loss (DAL) of dianthus, and lisianthus cut flowers. In dianthus, there was an overall increase in DAL and DTD from 0 to 12 days in the cooler. Dianthus treated with 5% Acacia gum before cooler (AG5B)+ Floralife (FL) and 10% Acacia gum before cooler (AG10B)+FL had among the highest DAL in when stored for zero, eight, and twelve days. Flowers treated with FL had among the highest in DAL for flowers stored zero, four, and twelve days. AG5B resulted in one of the lowest DAL for flowers stored zero and four days in the cooler. Dianthus treated withAG10B had one of the lowest DAL when stored four and eight days in the cooler. Generally, AG seemed to perform better if applied after cooler if storage time was shorter, but the reverse was true with those with longer storage. Regardless of treatment, flowers that were stored for longer periods of time typically had longer vase life.

In lisianthus, DAL increased linearly or quadratically with increasing cooler time for most preservative treatments, with some exceptions. Most treatments showed the highest DAL when stored for eight days, regardless of treatment. At 0, 4, and 8 days of storage, flowers treated with FL alone had higher DAL than other treatments. At 12 days, FL and RW had highest DAL. AG5B, AG10B, 5% Acacia gum after cooler

(AG5A)+FL, 10% Acacia gum after cooler (AG10A)+FL were among the lowest DAL for three out of four storage times. Acacia gum treatments had no significant effect on the number of days to aesthetic loss in lisianthus.

Whether AG treatment is best before or after storage may depend on the species, length of storage time, and whether or not Floralife is part of the treatment. Storage seemed to be beneficial to cut flower longevity, but length of storage time could depend on treatment or species. Obstacles involved in the use of the Acacia gum include the weight of the solution that causes bending and breakage of the flowers, the messiness, the flakiness when it dries, and the damage it causes to the petals and foliage of some flower species.

The remarkable results from the first study provide motivation for further research with snapdragons and the Acacia gum. Combinations of the Acacia gum, storage time, temperature, different rates, other preservatives, and surfactants have yet to be analyzed. Other flower species, such as calla lilies, zinnias, tulips, statice, freesia, sunflowers, and others can also be evaluated. The Acacia gum could be applied to cut flowers during storage and then rinsed off when flowers are removed from storage. Acacia gum use on preservation of woody cut flowers could be another area of interest.

APPENDIX

Table 1. Effect of Acacia gum concentration and Floralife applied before or after storage in a cooler on days to death of Dianthus cut flowers[z].

	Days in cooler				
Treatment	0	4	8	12	Signif.[y]
De-ionized water	11.0	12.8bc[x]	16.1cd	17.8	L***
Floralife	12.4	14.8a	17.2abc	18.7	L***
5% Acacia gum before cooler	11.0	9.6d	16.4bcd	16.4	L***
5% Acacia gum after cooler	–	13.8ab	15.2d	17.4	L***
10% Acacia gum before cooler	11.4	9.0d	15.0d	17.8	Q***
10% Acacia gum after cooler	–	13.2bc	15.4d	17.8	L***
5% Acacia gum before cooler + Floralife	12.4	12.0c	18.2a	17.8	L***
5% Acacia gum after cooler + Floralife	–	14.0ab	17.8ab	18.2	L***
10% Acacia gum before cooler + Floralife	13.0	12.6bc	18.6a	18.4	L***
10% Acacia gum after cooler + Floralife		13.0bc	16.2bcd	17.6	L***

[z] There was a significant cooler time × preservative treatment interaction, $P = 0.05$.
[y] Significant linear (L) or quadratic (Q) trend at P=0.001 (***). De-ionized water or Floralife controls includes in trend analysis for after cooler treatments.
[x] Means in columns followed by identical letters were not significantly different based on Waller-Duncan, $P = 0.05$.

Table 2. Effect of Acacia gum concentration and Floralife applied before or after storage in a cooler on days to death of Lisianthus cut flowers[z].

	Days in cooler				
Treatments	0	4	8	12	Signif.[y]
De-ionized water	17.8bc	20.2c	23.2[ns]	25.8abc	L***
Floralife	22.0a	22.9abc	25.6	26.8ab	L***
5% Acacia gum before cooler	17.5c	20.9c	25.2	22.6d	Q**
5% Acacia gum after cooler	–	21.2c	24.6	25.0abcd	L***
10% Acacia gum before cooler	18.3bc	21.5bc	24.2	23.8bcd	L***
10% Acacia gum after cooler	–	25.0a	21.6	25.0abcd	L***
5% Acacia gum before cooler + Floralife	20.2ab	21.7bc	22.8	23.2cd	ns
5% Acacia gum after cooler + Floralife		20.3c	25.2	27.8a	L***
10% Acacia gum before cooler + Floralife	19.8abc	24.4ab	24.6	23.4cd	Q*
10% Acacia gum after cooler + Floralife	–	22.4abc	22.6	23.8bcd	ns

[z] There was a significant cooler time × preservative treatment interaction, $P = 0.05$.
[y] Non-significant (ns) or significant linear (L) or quadratic (Q) trend at P=0.05 (*), 0.01 (**), or 0.001 (***). De-ionized water or Floralife controls includes in trend analysis for after cooler treatments.
[x] Means in columns followed by identical letters were not significantly different based on Waller-Duncan, $P = 0.05$. Not significant ([ns]).