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Effect of Glucose and Biocides on Vase-life and Quality of Cut Gladiolus Spikes

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Abstract. Post-harvest quality and vase life of cut gladiolus (*Gladiolus gandavensis*) “Rose Supreme” and “Nova Lux” cultivars were significantly improved by placing the inflorescence in vase solutions containing antibiotics (200 ppm penicillin + 250 ppm streptomycin) and glucose (5, 10 or 20%). The addition of the biocide to the preservative solution reduced the bacterial counts in the solution, inhibited the microbial growth, improved flower-opening rates, and reduced flower deterioration rate. Although there were positive proportional relationships among sugar concentration (up to 10%) and total bacterial counts in the solution, the addition of the biocide reduced the bacterial counts, resulting in the improvement of post-harvest quality of both tested cultivars. The highest and lowest number of opened and deteriorated flowers, respectively, were achieved when the preservative solution contained a mixture of biocide and 20% glucose. Sugar concentrations in the vase solution resulted in high leaf content of both chlorophyll and total carbohydrates, whereas, presence of biocide in the vase solution reduced both total carbohydrates and chlorophyll contents in the leaves of the cut gladiolus spikes.

Keywords: Gladiolus, *Gladiolus gandavensis*, vase life, biocides, glucose, preservative solution, postharvest quality

Introduction

Cut gladiolus spikes suffer from relatively short vase-life. Among the most common reasons for early senescence of fresh cut spikes are both the inability of stems to absorb water due to their blockage and the short supply of carbohydrates to support respiration [1-3]. The inability of stems to absorb water is a very common reason for premature wilting. Many studies indicated that high bacterial counts in water reduced the longevity of the cut flowers [4-6]. The water conducting tubes in the stem (xylem vessels) become plugged by bacteria, yeast, and/or fungi, which are living in the water or on the flower, and proliferate in the containers holding the flowers [7]. These microorganisms and their chemical products plug the stem ends and restrict water absorption. They continue to multiply inside and eventually block the stem tubes [8, 9]. Adding antimicrobial agents to the cut flower preservative solution could inhibit the microbial growth and prevent the obstruction of the vascular system in the stem [10-12], and subsequently, prolong the vase life of the flowers [13,14].

Low carbohydrate is another reason for flowers deterioration. Supplying cut flowers with carbohydrate sources could prolong flower vase life and improve flower quality. Several studies indicated that the floral preservatives should perform two functions: provide carbohydrate, and supply a bactericide to prevent microbial growth and to block water-conductive system in the stem [1, 15]. Although the role of external carbohydrate supply on photosynthetic pigments may be less clear [16], however, some research stated that photosynthetic pigments are positively correlated with the supply of carbohydrates[17].

Some studies indicated that bromopropanediol, Dantogard (1,3-dimethyl-5,5-dimethylhydantion) and thiabendazole with concentration of 0.05 g/liter in a solution containing 0.2 g citric acid/liter and 10 g glucose/liter, achieved a longer flower life of cut roses (Classy cultivar), *Alsroemeria pelegrinathan* (Sunset hybrids) and carnations (unknown white cultivar) the control [11]. Information regarding the response of cut gladiolus spikes to antibiotic treatments is meager.

The objective of this study was to determine the effect of biocide (a mixture of penicillin and streptomycin) and various concentrations of glucose on the solution microbial counts and the vase life of cut gladiolus “Rose Supreme” and “Nova Lux” cultivars.

Materials and Methods

Gladioli (*gladiolus gandavensis*) corms of “Rose supreme” and “Nova lux” cultivars, 10-12 cm in circumference, were introduced from Orman Botanical Garden in Cairo, Egypt. Plants were grown in the open field of the Experimental Research Station, College of Agriculture, King Saud University, Buraidah, Al-Qassim, The Kingdom of Saudi Arabia. The corms were planted 20 x 50 cm apart inter and intra row spacing in plots of 2 x 2 m. Plants received the common cultural practices according to the research station program. The spikes were harvested when the colored perianth of the base flower started to show. All spikes used in this experiment were as uniform as possible. The post-harvest studies were conducted in a 24°C room illuminated for 12 h per day. Artificial light (15 µmole.m^{-2}.s^{-1} *PPF*) from cool-white fluorescent lamps. The spikes were placed in vase solution containing different treatments: 5 % glucose, 10 % glucose, 20 % glucose, 5% glucose + biocide, 10 % glucose + biocide, 20% glucose + biocide, biocide, and control (distilled water). The biocide used in this experiment was a mixture of 200 mg penicillin and 250 mg streptomycin per liter.

Microbial counts

A 10 ml sample of the preservative solution was collected from each replicate of the various treatments, at each sampling date, for the determination of the total microbial counts. Each sample was used for plating on nutrient agar medium using a 10-fold dilution series. After 3 days of incubation at 25° C, the most probable count method was used to estimate the total number of bacteria in each sample [18].

Determination of vase life

The flowers were examined at two-day intervals. The total numbers of both opened and deteriorated flowers were recorded. Vase life of each spike was considered terminated when the number of senesced flowers exceeded the number of the unsenesced ones [15].

Determination of chlorophyll and carbohydrates

At the end of the experiment, leaf total chlorophyll, chlorophyll a and b, and were extracted in 80% acetone solution, and determined by using a PerkinElmer EZ301 spectrophotometer [19]. Spike carbohydrate contents were determined using a PerkinElmer EZ301 spectrophotometer [20].

Statistical analysis

The data were statistically analyzed using a randomized block design with 5 replicates per treatment. Analysis of variance was performed (general linear model, PROC GLM) to test the effects of the various treatments [21]. LSD was used to compare means at the 5% level. The experiment was repeated twice.

Results and Discussion

Total bacterial counts

A positive proportional relationship between glucose concentration (up to 10%) in the preservation solution and total bacterial counts (cfu/ml) in the vase solution was recorded (Table 1). Sugar concentration of 10% glucose in the vase solution gave higher bacterial count than 5% glucose. However, as the glucose concentration reached 20% in the vase preservative solution, the bacterial counts decreased significantly. This influence could be due to the preservative effect of the high concentration of glucose (20%) in the vase preservative solution [13]. The addition of the antibiotic compounds (penicillin + streptomycin) reduced the bacterial counts to almost half despite the presence of glucose in the solution. Although high concentration of glucose (20%) showed an inhibitory effect on the bacterial growth, yet, the total counts of bacteria remained high enough to have some adverse effects on cut flowers. On the other hand, at the end of the experiment, the glucose free solution, that contained biocide, remained free of any bacterial growth.

Table 1. Effect of glucose and biocide (penicillin +streptomycin) treatments on total bacterial counts[1] in the vase preservative solution

Treatment	Sampling date				
	1 day	3 days	5 days	7 days	9 days
Control	0	0 b[2]	0 c	0 d	0 d
5%Glucose	0	1×10^3 a	1×10^3 a	1×10^3 b	1×10^4 a
10%Glucose	0	1×10^3 a	1×10^3 a	1×10^4 a	1×10^4 a
20%Glucose	0	1×10 b	1×10^2 b	1×10^3 b	1×10^3 b
5% Glucose + biocide	0	0 b	1×10^2 b	1×10^2 c	1×10^2 c
10% Glucose + biocide	0	0 b	1×10^2 b	1×10^2 c	1×10^2 c
20% Glucose + biocide	0	0 b	1×10 c	1×10^2 c	1×10^2 c
Biocide	0	0 b	0 c	0 d	0 d

[1] Total bacterial counts as cfu/ml in the preservative solution.
[2]Means in the same column with different letters are significantly different ($P \leq 0.05$). Each value in the table is the mean of three replicates.

Number of open flowers

The number of opened flowers of both "Rose supreme" and "Nova lux" cultivars was significantly promoted due to glucose concentrations (Fig. 1). After 11 days of the application, the number of opened flowers of both cultivars was directly proportional to glucose concentration in the vase solution (up to 10 % glucose). The sugar concentration of 10% gave higher number of the open flowers than the other sugar concentrations. This observation occurred whether glucose was used alone or combined with the biocide (Figs. 1 and 2). The influence of the sugar treatments on “Nova lux” cultivar fluctuated during the first 5 days of the experiment compared to the control (Fig. 1). On day 5 there was a very slight difference between 5%, 20% glucose and the control. However, at the end of the experiment, it was obvious that the lower glucose concentrations (i.e., 5 and 10%) showed significantly higher number of opened flowers than both the 20% glucose and the control. Treating cut carnation with sugar-rich solutions promoted full opening of flower buds and enabled opening of standard cut carnation when buds were still tightly closed [2].

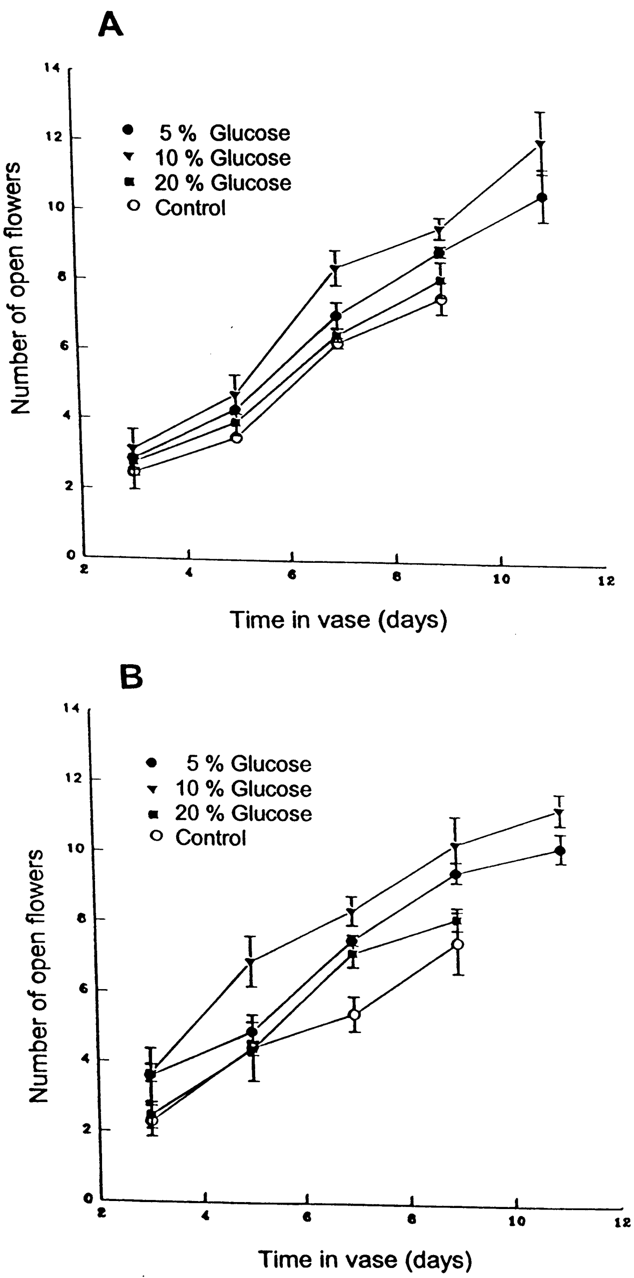


Fig. 1. Effect of glucose concentrations on average number of open flowers of (A) 'Rose supreme' and (B) 'Nova lux' glasdiolus cultivars. Vertical bars show standard deviation of five replicates.

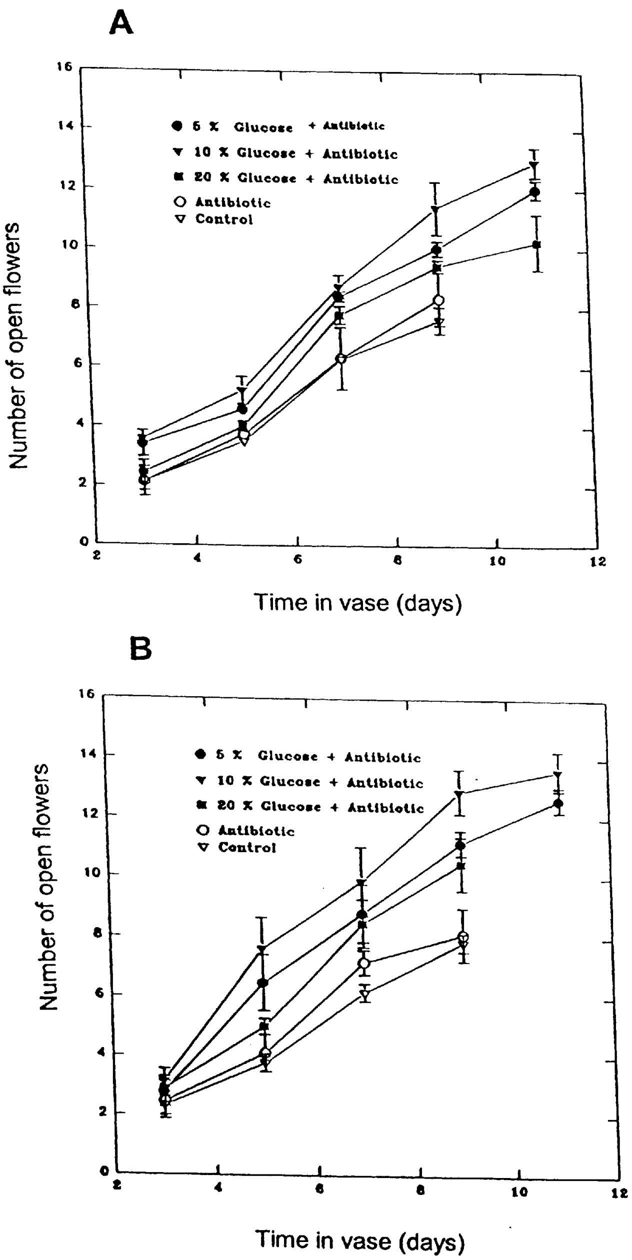


Fig. 2. Effect of glucose and biocide treatments on average number of open flowers of (A) 'Rose supreme' and (B) 'Nova lux' glasdiolus cultivars. Vertical bars show standard deviation of five replicates.

It could be concluded that biocide, whether added alone to the vase preservative solution or combined with glucose, improved total number of opened flowers as compared with the control (Fig 2). It is quite clear that adding biocide to the vase solution increased the number of the opened flowers and also magnified the influence of glucose treatments as regarding the number of the opened flowers.

Both investigated cultivars (i.e., “Rose supreme” and “Nova lux”) showed, similar trend regarding the influence of combined biocide and glucose in the preservative solution.

Number of deteriorated flowers

A significant reduction occurred in number of deteriorated flowers when glucose was added to the vase solution of both cultivars compared with the control (Fig. 3). There was an adversely proportional relationship between glucose concentration in the preservative solution and the number of deteriorated flowers in both tested cultivars. At the end of the experiment, the lowest number of deteriorated flowers was observed in treatment containing 10% glucose plus biocide. Whereas, the largest number of deteriorated flowers was observed in the control, which suggests that there was a continuous development of the flowers [1] since the vase life was significantly improved when placed in glucose solutions (Fig. 3). However, higher concentrations of glucose (20%) resulted in flower collapse. The percentage of collapsed flowers which received 20% glucose was significantly higher than those received either 5% or 10% glucose in both cultivars. Negative effects of high concentration of sugar on post-harvest quality of cut flowers have been reported for several species [2].

Use of biocide (penicillin + streptomycin) in the preservative solution significantly reduced the number of deteriorated flowers in both cultivars (Fig. 4). Biocide application improved cut gladiolus flower vase life through inhibiting the deterioration process in the treated flowers. in both cultivars, the lowest number of deteriorated flowers occurred when cut flowers received biocide + 10% glucose, whereas the highest deterioration rate occurred in the control. Although the biocide used in this experiment did not totally prevent the buildup of bacteria in the floral solution, it showed clear effects as a bactericide and it retarded the deterioration of the flowers when accompanied with 10% glucose. The ability of biocide to prolong vase life of gladiolus spikes could be due to its fatal influence on wide range of microorganisms, since high bacterial counts in the vase water can shorten flower longevity [11]. Many studies indicated that high bacterial counts in water reduced the longevity of the cut flowers [4-6]. The harmful influence of high bacterial counts in the vase water occurs due to an increase in the bacterial population in the stem of the cut flowers. Subsequently, it leads to vascular occlusion [4]. The vascular occlusion causes water stress and perianth wilting which results in shorter vase life [5].

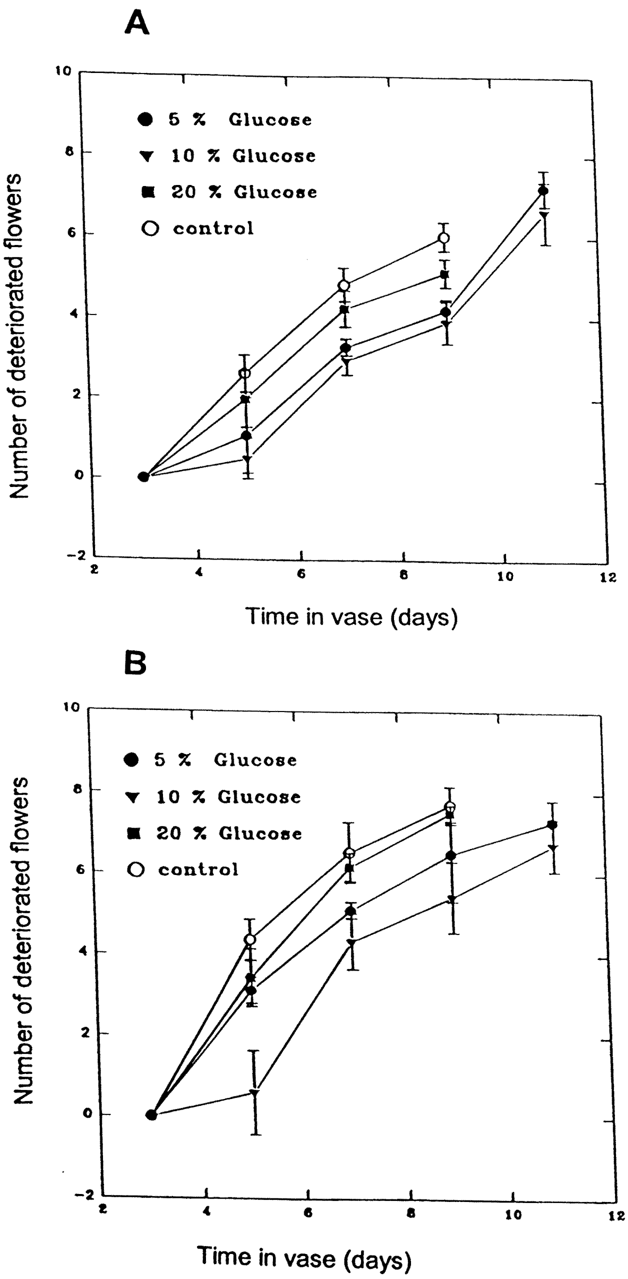
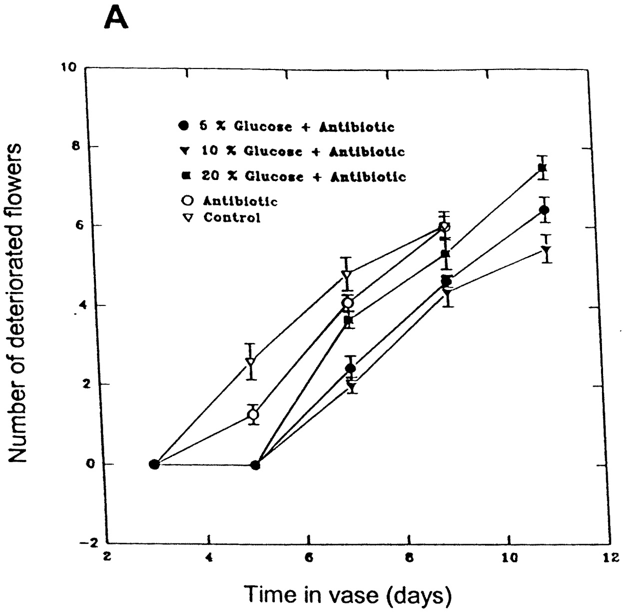


Fig. 3. Effect of glucose concentrations on average number of deteriorated flowers of (A) 'Rose supreme' and (B) 'Nova lux' glasdiolus cultivars. Vertical bars show standard deviation of five replicates.



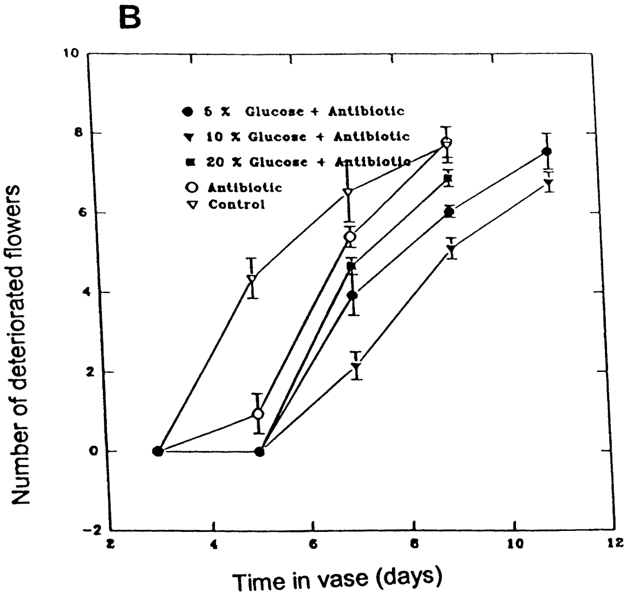


Fig. 4. Effect of glucose and biocide treatments on the average number of deteriorated flowers of (A) 'Rose supreme' and (B) 'Nova lux' glasdilus cultivars. Vertical bars show standard deviation of five replicates.

Leaf chlorophyll content

Glucose treatments improved the leaf content of chlorophyll a, b, and total chlorophyll (Table 2). This observation occurred in both cultivars. On the other hand, biocide treatment, when applied separately or combined, resulted in a great reduction in leaf chlorophyll content. The influence of biocide in promoting chlorophyll degradation was highest when the biocide was applied alone.

Table 2. Effect of glucose and biocide (penicillin +streptomycin) treatments on leaf chlorophyll contents ($mg.g^{-1}$. fresh weight) of gladiolus cut spikes

Treatment	cv. Supreme rose			cv. Nova lux		
	Chloro-phyll a	Chloro-phyll b	Total Chloro-phyll	Chloro-phyll a	Chloro-phyll b	Total Chlorophyll[x]
Control	16.05 a[1]	8.96 b	25.01 bc	12.17 ab	6.24 b	18.41 a
5%Glucose	16.62 a	12.94 a	29.56 a	13.16 ab	6.17 a	19.33 a
10%Glucose	16.98 a	9.33 b	26.31 b	13. 41 ab	6.04 a	19.45 a
20%Glucose	16.79 a	9.18 b	25.97 b	15.31 a	7.01 a	22.32 a
5% Glucose + biocide	15.61 a	8.12 bc	23.73 c	14.11 ab	5.01 a	19.32 a
10% Glucose + biocide	15.53 a	5.92 d	21.45 d	12.73 b	2.99 b	15.72 b
20% Glucose + biocide	11.92 b	6.62 cd	18.54 e	11.82 b	1.02 c	12.84 c
Biocide	9.92 c	4.90 d	14.82 f	9.53 c	1.781 bc	11.24 c

[1]Means in the same column with different letters are significantly different ($P \leq 0.05$). Each value in the table is the mean of three replicates.

Biocide treatment significantly decreased the total microbial count in the vase solution that would improve solution uptake which resulted in a slight phytotoxicity and subsequently chlorophyll degradation. Although the addition of glucose to the vase solution greatly reduced the strong effect of the biocide on chlorophyll degradation, leaf chlorophyll content of gladiolus cut spikes which received a combined application of sugar and biocide (in vase solution) was still much lower than the leaf chlorophyll content of the control.

The role of external carbohydrate supply on photosynthetic pigments may be less clear [16]. The author suggested that external carbohydrate supply may enhance the synthesis of photosynthetic pigments. Nowak and Rudnicki [17] stated that photosynthetic pigments are positively correlated with the supply of carbohydrates.

Leaf carbohydrate content

Carbohydrate content in gladiolus leaves was affected by both glucose and biocide treatments (Table 3). Addition of penicillin and streptomycin to vase water reduced total carbohydrate content in the leaves, compared with the control.

Biocide treatment alone improved the post-harvest quality of the spikes by stimulating the flower opening rate that would otherwise lead to carbohydrate depletion in the spikes due to consumption of carbohydrate by newly opened flowers. Moreover, improving the flower opening rate probably requires an external supply of carbohydrates to recover the consumption of carbohydrate by newly opened flowers.

It was observed that the addition of biocide to the vase water apparently enhanced chlorophyll degradation (Table 2) and subsequently caused a reduction in photosynthesis process and carbohydrate content in the leaves (Table 3).

Table 3. Effect of glucose and biocide (penicillin +streptomycin) treatments on leaf total carbohydrate contents of gladiolus cut spike

Treatments	cv. Rose supreme mg.g^{-1}. fw	cv. Nova lux mg.g^{-1}. fw
Control	0.095 ef	0.076 b
5% Glucose	0.129 cd	0.870 a
10% Glucose	0.172 b	0.103 b
20% Glucose	0.205 a	0.132 b
5% Glucose + biocide	0.112 de	0.079 b
10% Glucose + biocide	0.131 cd	0.096 b
20% Glucose + biocide	0.142 c	0.108 b
Biocide	0.082 f	0.055 b

Means in the same column with different letters are significantly different ($P \leq 0.05$). Each value in the table is the mean of three replicates.

However, addition of glucose caused a sound increase in leaf carbohydrate content. The high concentration of glucose (20%) caused the highest leaf content of carbohydrate (Table 3). In general, there was a positive proportional relationship between glucose concentration in the vase solution and leaf carbohydrate content.

Conclusion

Significant improvement of post-harvest quality and vase life of cut gladiolus spikes (Rose Supreme and Nova Lux cultivars) occurred when glucose and a mixture of penicillin and streptomycin, as antimicrobial agents, were added to the vase water. The addition of the biocide to the preservative solution reduced the total bacterial counts, inhibited and/or delayed the microbial growth in the solution, improved flower opening, and reduced flower deterioration. Glucose improved the leaf content of chlorophyll a, b, and total chlorophyll and total carbohydrates. in general, there was a positive proportional relationship between glucose concentration in the vase solution and leaf carbohydrate content. The interactive effects of the combined application of glucose and antimicrobial agents increased vase life by up to 22%, and improved spikes quality of the two gladiolus cultivars.

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تأثير استخدام الجلوكوز والمضادات الحيوية على مدة بقاء وجودة أزهار الجلاديولس بعد القطف

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(قدم للنشر في ١٤٢٣/١٢/١٧هـ ؛ قبل للنشر في ١٤٢٤/١٠/٢٢هـ)

ملخص البحث. أجريت هذه الدراسة على أزهار الجلاديولس صنفي روز سوبريم ونوفالوكس وذلك بهدف اختبار تأثير إضافة كل من سكر الجلوكوز (كمصدر للكربوهيدرات) والبنسلين والإستربتوميسين (كمضادات حيوية) في المحاليل الحافظة المستخدمة في أوعية الأزهار وذلك على مدة بقاء الأزهار وجودتها بعد القطف.

أخذت عينات الأزهار من الحقل مباشرة بعد القطف حيث تم وضعها في محاليل تحتوي على كل من سكر الجلوكوز (بتركيزات ٥٪، ١٠٪ ،٢٠٪) والمضاد الحيوي المكون من خليط من البنسلين (٢٠٠جزء في المليون) ، والأستربتوميسين (٢٥٠جزء في المليون) وقد تم دراسة تأثير هذه المركبات على العدد البكتيري في محاليل الحفظ ومعدل تفتح وذبول الأزهار ومدة بقائها حية ، ومحتوى الأوراق من الكربوهيدرات والكلوروفيل. دلت النتائج على أن إضافة كل من الجلوكوز والمضادات الحيوية للمحاليل الحافظة قد قلل العدد البكتيري في المحاليل ، وزاد من معدل تفتح الأزهار ، وقلل من معدل ذبولها . وبالرغم من أنه كانت هناك علاقة طردية بين تركيز الجلوكوز في المحاليل والعدد البكتيري بها ، إلا أن إضافة المضادات الحيوية لهذه المحاليل قد قلل إحصائيا من الأعداد البكتيرية بهذه المحاليل مما أدى إلى زيادة جودة الأزهار المحفوظة فيها.

ولقد أظهرت المعاملة المحتوية على ٢٠٪ جلوكوز بالإضافة إلى المضادات الحيوية، أعلى معدل تفتح للأزهار وأقل معدل لتدهورها. كما أدت المعاملة بالجلوكوز إلى زيادة محتوى الأوراق من الكربوهيدرات والكلوروفيل ، في حين أدت إضافة المضادات الحيوية إلى تقليل تركيزهما بالأوراق . و بصفة عامة فإنه في كلا الصنفين المختبرين أدت المعاملة بالجلوكوز والمضادات الحيوية إلى زيادة جودة الأزهار ومده بقائها.