Study on the fresh-keeping effect of domestic vase solution on *Gladiolus* cut flowers

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Abstract. According to the basic principle and method of cut flowers preservation, orthogonal experimental design was carried out to study the preservation effect of domestic vase solution made of sugar, aspirin and lemon juice on *Gladiolus* cut flowers. The results showed that J7 containing 20 g L⁻¹ white granulated sugar and 28 ml L⁻¹ lemon juice could significantly prolong the vase life of *Gladiolus* cut flowers, promote the opening of florets, improve the daily ornamental value, increase the fresh weight of spray, maintain the water balance and water content of petals, delay the decomposition of protein and the production of malondialdehyde, which was the best domestic vase solution.

1. Introduction

*Gladiolus (Gladiolus hybridus)* is a bulb flower of the Iridaceae [1]. It has many varieties and various colors. It is loved by people because of its long pedicel and gorgeous colors. It is one of the “four cut flowers” in the world [2]. The *Gladiolus* cut flowers is known as the “all-purpose champion” [3] in the field of flower arrangement because of its rich, elegant, warm and human, and the beautiful meaning of happiness, celebration and harmony [4] also makes the *Gladiolus* cut flowers a popular choice for domestic vase cut flowers.

At present, chemical drugs are widely used in the vase solution used to prolong the ornamental life of *Gladiolus* cut flowers, such as silver nitrate, Silver Thiosulfate, 8-hydroxyquinoline, etc., which will pollute the environment, even harm people's health [5], and is not conducive to the use of ordinary families. With the gradual enhancement of national awareness of ecological and environmental protection, the fresh-keeping direction of fresh cut flowers is toward the direction of environmental protection, non-toxic, effective and convenient domestic fresh-keeping, but at present, there is no research report on the preparation of *Gladiolus* cut flowers vase solution with all commonly used household products. In the current situation of fresh-keeping of *Gladiolus* cut flowers of in the family, sugar was used as the energy supply material of *Gladiolus* cut flowers, and Akafen powder (It’s main ingredient is aspirin) and lemon juice beverage were used as fungicides. The purpose of this study was to maintain the normal physiological metabolism of *Gladiolus* cut flowers, prolong the vase life and improve the ornamental quality.
2. Materials and methods

2.1. Plant material and treatments
Cut flowers used in the experiment were *Gladiolus hybridus* cv. “Amer kana” come from Qicai flower shop of Zhaotong City. Choose the robust flower branches with the same size, freshness and floret opening. The Xiaoxiao brand bagged white granulated sugar (360 g per bag), Akafen powder (It’s main ingredient is aspirin, with a content of 230 g per bag.) and the water-soluble C100 lemon juice (445 mL per bottle, 7 mL per cap) were used as the three components of the domestic vase solution for *Gladiolus* cut flowers (see Table 1).

| Levels | A: White granulated sugar (g L\(^{-1}\)) | B: Aspirin (mg L\(^{-1}\)) | C: Lemon juice (mL L\(^{-1}\)) |
|--------|----------------------------------------|-----------------------------|--------------------------------|
| 1      | 0                                      | 0                           | 0                              |
| 2      | 10                                     | 115                         | 14                             |
| 3      | 20                                     | 230                         | 28                             |

The purchased *Gladiolus* cut flowers are cut at a slant mouth in water, the branches are left for 70 cm and a pair of leaves at the top are retained, and inserted into a wide mouth bottle containing a bottle of liquid insertion, the formula of the bottle liquid insertion is shown in Table 2, and the cold boiled water of J1(CK) is the control. Three repetitions were set for each treatment and three cut flowers were inserted for each repetition. The room temperature is 16°C-19°C, and the relative humidity is 32%-52%. The morphological and physiological indexes of cut flowers were measured regularly.

| Treatments | White granulated sugar (g L\(^{-1}\)) | Aspirin (mg L\(^{-1}\)) | Lemon juice (mL L\(^{-1}\)) |
|------------|---------------------------------------|--------------------------|------------------------------|
| J1 (CK)    | 0                                     | 0                        | 0                            |
| J2         | 0                                     | 115                      | 14                           |
| J3         | 0                                     | 230                      | 28                           |
| J4         | 10                                    | 0                        | 14                           |
| J5         | 10                                    | 115                      | 28                           |
| J6         | 10                                    | 230                      | 0                            |
| J7         | 20                                    | 0                        | 28                           |
| J8         | 20                                    | 115                      | 0                            |
| J9         | 20                                    | 230                      | 14                           |

2.2. Indexes and methods of test determination

2.2.1. Daily ornamental value of Gladiolus cut flowers. According to Huang Jiao’s scoring method, when the length of petals of *Gladiolus* cut flowers is equal to the length of outer bracts of small flowers, the ornamental value is recorded as 1 point. When the petals are open but not rolled, it is recorded as 2 points. When the petals are in full swing, the score is 3. When the edge of the petal begins to wilt after the floret is in full bloom, the ornamental value is 1 point, while the withered petal value is 0 point. During the vase insertion, the ornamental value of each inflorescence was recorded
from bottom to top one by one, and then the ornamental value of each inflorescence was accumulated respectively. The sum of them was the daily ornamental value of *Gladiolus* cut flowers [6].

2.2.2. *Vase life evaluation*. The broken flower stem or the ornamental value of cut flower less than 5 points per day were taken as the sign of the end of the vase life of *Gladiolus* cut flowers [6].

2.2.3. *Fresh weight measurements*. The fresh weight of *Gladiolus* cut flowers on the first day (That is, the data before the treatment of vase insertion, the same below) of vase insertion was 100, and the change rate of fresh weight was measured and calculated every day [7].

2.2.4. *Water balance value*. The weight of flower branch, solution and vase was measured by weighing method every day, and the water loss during the period of two successive weight difference was measured. In the same way, the water absorption can be calculated by weighing the solution and vase. The difference between water absorption and water loss is the water balance value [8].

2.2.5. *Percentage of floret opening*. The percentage of the number of small flowers whose daily ornamental value reaches 2 point or more in *Gladiolus* cut flowers inflorescence to all the floets in the inflorescence is the Percentage of floret opening [3].

2.2.6. *Soluble protein content in petals*. Coomassie brilliant blue G-250 staining method [2] was used for the determination every other day.

2.2.7. *Relative water content in petal*. Refer to the determination method of relative water content in leaf [9] every other day.

2.2.8. *Malondialdehyde*(MDA) content in petals. Thiobarbituric acid method [9] was used for the determination every other day.

2.3. *Test data analysis*

The software Excel 2010 and SPSS23.0 were used to analyze the test data.

3. Results

3.1. *The effect of different domestic vase solution treatment on the vase life of Gladiolus cut flowers*

One of the important indexes for keeping cut flowers fresh is vase life [10]. It can be seen from Figure 1 that the vase life of *Gladiolus* cut flowers by J7 treatment is the longest, up to 10.7 days, 2 days longer than that of J1, followed by J4 and J8 treatment, 1.3 days longer than that of J1; the remaining 5 groups of treatment are all 1 day longer than that of J1. According to Duncan’s Multiple Range Test (DMRT), there were significant differences in vase life of *Gladiolus* cut flowers. There was significant difference between J7 treatment and J1, J2, J3, J5, J6, J9 treatment, but there was no significant difference between J4 and J8 treatment and other 6 groups. It can be concluded that each treatment can prolong the vase life of *Gladiolus* cut flowers to a certain extent, and J7 treatment is the most effective.
Figure 1. The effect of different domestic vase solution treatment on the vase life of Gladiolus cut flowers. Note: The small letters a, b and c in the figure indicate the significant difference of data at the level of $P < 0.05$.

It can be seen from table 3 that the most influential factor on the vase life of Gladiolus cut flowers is A($R=0.75$), followed by C($R=0.56$) and B($R=0.11$). The optimal level of each factor is $A_3$, $B_1$ (or $B_2$), $C_3$, that is, 20 g L$^{-1}$ of white granulated sugar, 0 mg L$^{-1}$ (or 115 mg L$^{-1}$) of aspirin, 28 ml L$^{-1}$ of lemon juice.

Table 3. Range analysis of orthogonal test results on vase life (days) of Gladiolus cut flowers.

| Factors          | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|------------------|---------------------------|------------|----------------|
| $k_1$            | 9.37                      | 9.79       | 9.46           |
| $k_2$            | 9.78                      | 9.79       | 9.79           |
| $k_3$            | 10.11                     | 9.68       | 10.01          |
| R                | 0.75                      | 0.11       | 0.56           |

3.2. The effect of different domestic vase solution treatment on the daily ornamental value of Gladiolus cut flowers

The higher the ornamental value of cut flowers is, the longer the growing days of maintaining the ornamental value are, the higher the ornamental quality is [6]. It can be seen from Figure 2 that the daily ornamental value of Gladiolus Cut flowers in each treatment increased first and then decreased with the opening of flowers. The treatment of J2, J4, J6, J7 and J8 reached the maximum value on the 6th day of bottle insertion, which was 3 days later than that of J1 and 2 days later than that of J3, J5 and J9. Compared with the maximum value of daily appreciation of cut flowers, J7 treatment had the highest score of 14.67 points, followed by J6 treatment, 14.33 points, J5 and J8 treatment, 14.00 points, J2 and J9 treatment, 13.67 points; J3 and J4 treatment, 13.33 points, the lowest was J1 treatment, only 10.33 points. In conclusion, the longer the growing days of daily ornamental value of Gladiolus Cut flowers maintained by J7 treatment, the higher the maximum value of daily ornamental value, which significantly improved the ornamental quality of Gladiolus cut flowers.
Figure 2. The effect of different domestic vase solution treatment on the daily ornamental value of Gladiolus cut flowers.

It can be seen from Table 4 that the most influential factor on the maximum value of daily ornamental value of Gladiolus cut flowers is A (R=1.56), the least is B and C (R=0.89). The optimal level of each factor is A$_3$, B$_2$ (or B$_3$), C$_3$, that is, 20 g L$^{-1}$ of white granulated sugar, 115 mg L$^{-1}$ (or 230 mg L$^{-1}$) of aspirin, 28 ml L$^{-1}$ of lemon juice.

Table 4. Range analysis of orthogonal test results on the maximum value of daily ornamental value (points) of Gladiolus cut flowers.

| Factors          | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|------------------|---------------------------|------------|---------------|
| k$_1$            | 12.67                     | 13.00      | 13.11         |
| k$_2$            | 13.89                     | 13.89      | 13.67         |
| k$_3$            | 14.22                     | 13.89      | 14.00         |
| R                | 1.56                      | 0.89       | 0.89          |

3.3. The effect of different domestic vase solution treatment on the change of fresh weight of Gladiolus cut flowers

Fresh weight change rate is an important morphological index of cut flowers, which reflects the water absorption and loss of cut flowers, and then reflects the aging process of cut flowers [11]. The change of fresh weight of Gladiolus cut flowers during Vase planting is shown in Figure 3. The fresh weight of Gladiolus cut flowers in each treatment shows a trend of first rising and then declining, and the change rate of fresh weight of the other 8 groups of treatment is always higher than that of the J1. Among them, J7 and J8 had the best effect in maintaining the fresh weight growth of flowers and shoots for 6 days, which was 2 days longer than that of J1, followed by J2, J3, J5 and J9, which were 1 day longer than that of J1. In terms of the increment of fresh weight of flower branches, the effect of J7 treatment was the best, reaching 24.65%, 14.33% higher than that of J1 treatment; the others were J9, J8, J5, J6, J2, J3, J4 and J1 treatment, the increment of fresh weight of flower branches was
20.00%, 19.27%, 18.13%, 16.52%, 16.36%, 16.02%, 15.62% and 10.32% respectively. In conclusion, J7 treatment was the most effective to promote the fresh weight of *Gladiolus* cut flowers.

**Figure 3.** The effect of different domestic vase solution treatment on the change of fresh weight of *Gladiolus* cut flowers.

It can be seen from Table 5 that the primary and secondary order of influence of each factor on fresh weight increase of *Gladiolus* cut flowers is the influence of A(R=6.84), C(R=3.67) and B(R=0.64), and the optimal level is A₃, B₃ and C₃, that is, 20 g L⁻¹ white granulated sugar, 230 mg L⁻¹ aspirin and 28 ml L⁻¹ lemon juice.

**Table 5.** Range analysis of orthogonal test results on fresh weight increase (%) of *Gladiolus* cut flowers.

| Factors         | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|-----------------|---------------------------|------------|----------------|
| k₁              | 14.23                     | 16.90      | 15.13          |
| k₂              | 15.98                     | 16.88      | 17.36          |
| k₃              | 21.07                     | 17.51      | 18.80          |
| R               | 6.84                      | 0.64       | 3.67           |

3.4. The effect of different domestic vase solution treatment on the change of water balance value of *Gladiolus* cut flowers

The water balance value of cut vase is determined by water loss and water absorption. When the water loss exceeds the water absorption, the cut flower will wilt, leading to the senescence of cut flower and the decline of ornamental quality [8]. It can be seen from Figure 4 that the water balance value of *Gladiolus* cut flowers treated by vase insertion gradually decreases from positive value to negative value after vase insertion. When the water balance value is positive, it indicates that the water absorption of cut flowers is greater than the water loss, and when it is negative, the water absorption is less than the water loss. J7 and J8 had the best effect on maintaining the water balance of *Gladiolus* cut flowers.
cut flowers. The water balance value increased significantly and maintained for 6 days in the early stage of vase insertion, while J2, J3, J5 and J9 were maintained for 5 days, and J1, J4 and J6 were maintained for 4 days. It can be seen that J7 and J8 can obviously improve the water condition of *Gladiolus* cut flowers and delay the withering process of petals caused by water loss.

![Figure 4](image)

**Figure 4.** The effect of different domestic vase solution treatment on the change of water balance value of *Gladiolus* cut flowers.

It can be seen from table 6 that the most influential factors on the time of maintaining positive water balance value of *Gladiolus* cut flowers is A (R=1.33), the least is B and C (R=0.67). The optimal level of each factor is A$_3$, B$_2$, C$_3$, that is, 20 g L$^{-1}$ of white granulated sugar, 115 mg L$^{-1}$ of aspirin, 28 ml L$^{-1}$ of lemon juice.

**Table 6.** Range analysis of orthogonal test results on the time of maintaining positive water balance value (days) of *Gladiolus* cut flowers.

| Factors  | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|----------|---------------------------|------------|----------------|
| k$_1$    | 4.67                      | 4.67       | 4.67           |
| k$_2$    | 4.33                      | 5.33       | 4.67           |
| k$_3$    | 5.67                      | 4.67       | 5.33           |
| R        | 1.33                      | 0.67       | 0.67           |

3.5. The effect of different domestic vase solution treatment on the change of water balance value of *Gladiolus* cut flowers

Percentage of floret opening is an important index to reflect the opening degree of *Gladiolus* cut flowers [12]. Table 7 shows the initial percentage of floret opening (the first day's percentage of floret opening), the maximum percentage of floret opening and the increase of percentage of floret opening of *Gladiolus* cut flowers treated with each domestic vase solution. All the domestic vase solution treatments promote the opening of floret of *Gladiolus* cut flowers more or less. Among them, the percentage of floret opening of *Gladiolus* cut flowers treated with J7 increased by 74.17%, which was
28.04 percentage points higher than that of J1 treatment. According to Duncan’s Multiple Range Test (DMRT), there were significant differences in percentage of floret opening of *Gladiolus* cut flowers among all treatments, among which, there was a significant difference between J7 treatment and J1, J2, J3 treatment, and there was no significant difference between J4, J5, J6, J8, J9 treatment and the other four groups. In conclusion, J7 is the most significant solution to promote the opening of floret and improve the ornamental value of *Gladiolus* cut flowers.

**Table 7.** The effect of different domestic vase solution treatment on the change of percentage of floret opening of *Gladiolus* cut flowers.

| Treatments | The first day's percentage of floret opening (%) | The maximum percentage of floret opening (%) | The increase of percentage of floret opening (%) |
|------------|-----------------------------------------------|---------------------------------------------|-----------------------------------------------|
| J1(CK)     | 14.14±7.07                                     | 60.27±21.44                                 | 46.13±16.33<sup>b</sup>                        |
| J2         | 15.45±4.72                                     | 65.76±9.80                                  | 50.30±12.38<sup>b</sup>                        |
| J3         | 25.76±5.17                                     | 74.55±13.76                                 | 48.79±11.87<sup>b</sup>                        |
| J4         | 9.70±0.53                                      | 68.18±16.39                                 | 58.48±16.52<sup>ab</sup>                       |
| J5         | 19.53±9.38                                     | 77.21±10.21                                 | 57.68±13.03<sup>ab</sup>                       |
| J6         | 20.45±9.91                                     | 79.55±9.91                                  | 59.09±7.88<sup>ab</sup>                        |
| J7         | 10.83±1.44                                     | 85.00±1.00                                  | 74.17±0.76<sup>a</sup>                         |
| J8         | 17.04±11.24                                    | 82.96±11.24                                 | 65.93±10.27<sup>ab</sup>                       |
| J9         | 12.47±6.53                                     | 69.80±3.03                                  | 57.32±6.88<sup>ab</sup>                        |

Note: The values in the table are mean value ± standard deviation, and<sup>a, b, c</sup> in the same column indicate significant difference at the level of P < 0.05, the same below.

It can be seen from table 8 that the primary and secondary order of influence of each factor on the increase of percentage of floret opening of *Gladiolus* cut flowers is the influence of A(R=17.40), C(R=4.85) and B(R=4.53), and the optimal level is A<sub>3</sub>, B<sub>1</sub> and C<sub>3</sub>, that is, 20 g L<sup>-1</sup> white granulated sugar, 0 mg L<sup>-1</sup> aspirin and 28 ml L<sup>-1</sup> lemon juice.

**Table 8.** Range analysis of orthogonal test results on the increase of percentage of floret opening (%) of *Gladiolus* cut flowers.

| Factors | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|---------|----------------------------|------------|----------------|
| k<sub>1</sub> | 48.41                      | 59.59      | 57.05          |
| k<sub>2</sub> | 58.42                      | 57.97      | 55.37          |
| k<sub>3</sub> | 65.81                      | 55.07      | 60.21          |
| R       | 17.40                      | 4.53       | 4.85           |

3.6. *The effect of different domestic vase solution treatment on the change of soluble protein content in petals of Gladiolus cut flowers*

The decrease of soluble protein content in petals is considered as an important index of senescence of cut flowers [13]. It can be seen from table 9 that the content of soluble protein in petals of *Gladiolus*...
cut flowers of each treatment increased in the early stage of vase insertion due to the increase of synthesis; decreased with the senescence of cut flowers, the decrease of synthesis weakened or even stopped, and the acceleration of degradation; the content increased briefly in the later stage, possibly due to the relative content increase caused by the withering and water loss of petals [14]. Among them, the soluble protein content of petals treated with J2, J3, J5, J6, J7 and J8 reached the maximum value on the fifth day of vase insertion, which was 2 days later than that of the treatments of J1, J4 and J9; the increase of the soluble protein content of petals treated with J7 was the largest, which was 149.05%. According to Duncan’s Multiple Range Test (DMRT), the increase of the soluble protein content in petals of Gladiolus cut flowers treated with J7 was significantly higher than that of the other treatments. It can be seen that J7 is the most significant solution to promote the synthesis of soluble protein in Gladiolus cut flowers, slow down the degradation rate and delay the senescence of cut flowers.

Table 9. The effect of different domestic vase solution treatment on the increase rate of soluble protein content in petals of Gladiolus cut flowers.

| Treatments | Soluble protein content in petals (mg L⁻¹) | Increase rate(%) |
|------------|------------------------------------------|-----------------|
|            | 1d | 3d | 5d | 7d | 9d | 11d |                  |
| J1(CK)     | 9.46 | 10.94 | 10.49 | 8.83 | — | — | 15.71±2.64ᵇ       |
| J2         | 7.37 | 9.32 | 10.7 | 10.66 | 8.51 | — | 45.21±7.78ᵇ       |
| J3         | 7.15 | 8.95 | 10.48 | 9.68 | 8.27 | — | 46.64±19.02ᵇ      |
| J4         | 8.44 | 10.42 | 10.24 | 8.78 | 8.78 | — | 23.49±9.58ᵇ       |
| J5         | 9.13 | 10.42 | 10.55 | 8.98 | 5.9 | — | 15.63±2.27ᵇ       |
| J6         | 6.74 | 8.62 | 10.6 | 8.68 | 9.94 | — | 57.24±2.87ᵇ       |
| J7         | 5.48 | 8.74 | 13.65 | 8.86 | 8.84 | 11.56 | 149.05±33.9ᵃ     |
| J8         | 8.56 | 10.4 | 10.55 | 6.62 | 7.94 | — | 23.33±7.18ᵇ       |
| J9         | 9.25 | 12.04 | 9.11 | 8.18 | 8.83 | — | 30.20±20.03ᵇ      |

Note: “—” means that the life of bottle insertion has ended, and its data cannot be measured, the same below.

It can be seen from tab.10 that the most influential factor on the increase rate of soluble protein content in petals of Gladiolus cut flowers is C(R=38.34), A(R=35.41) followed by and B(R=34.69). The optimal level of each factor is A₃, B₁, C₃, that is, 20 g L⁻¹ of white granulated sugar, 0 mg L⁻¹ of aspirin, 28 ml L⁻¹ of lemon juice.

Table 10. Range analysis of orthogonal test results on the increase rate (%) of soluble protein content in petals of Gladiolus cut flowers.

| Factors | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|---------|---------------------------|------------|---------------|
| k₁      | 35.86                     | 62.75      | 32.10         |
| k₂      | 32.12                     | 28.06      | 32.97         |
| k₃      | 67.52                     | 44.69      | 70.44         |
| R       | 35.41                     | 34.69      | 38.34         |
3.7. The effect of different domestic vase solution treatment on the change of relative water content in petal of Gladiolus cut flowers

Enough water content is needed to maintain the normal physiological metabolism of cut flowers. Water deficit will lead to wilting of petals and dim color of flowers, which makes cut flowers lose their ornamental value [9]. As shown in Table 11, the relative water content in petals of Gladiolus cut flowers increased first and then decreased, but the overall fluctuation was not significant; if compared with the daily average value, the order of effect of each treatments was J7 > J2 > J3 > J5 > J8 > J6 > J1 > J9 > J4. The daily average value of relative water content in petals of Gladiolus cut flowers treated with J7 was the highest, reaching 93.72 %, which was the most effective way to maintain the physiological metabolism of cut flowers.

Table 11. The effect of different domestic vase solution treatment on the daily average value of relative water content in petals of Gladiolus cut flowers.

| treatments | Relative water content in petals(%) | Daily average value |
|------------|------------------------------------|---------------------|
|            | 1d       | 3d       | 5d       | 7d       | 9d       | 11d      |
| J1(CK)     | 92.89    | 93.30    | 93.84    | 93.51    | —        | —        | 93.38    |
| J2         | 92.43    | 93.69    | 94.41    | 94.15    | 93.88    | —        | 93.71    |
| J3         | 93.05    | 93.96    | 94.34    | 93.48    | 93.16    | —        | 93.60    |
| J4         | 92.46    | 93.43    | 92.92    | 92.96    | 92.28    | —        | 92.81    |
| J5         | 92.62    | 93.68    | 94.09    | 93.73    | 93.65    | —        | 93.55    |
| J6         | 92.05    | 93.69    | 94.02    | 94.34    | 93.18    | —        | 93.46    |
| J7         | 92.97    | 94.60    | 95.11    | 94.39    | 92.95    | 92.31    | 93.72    |
| J8         | 92.62    | 93.75    | 94.20    | 93.30    | 93.68    | —        | 93.51    |
| J9         | 92.12    | 93.53    | 93.36    | 93.53    | 92.79    | —        | 93.06    |

It can be seen from Table 12 that the most influential factor on the maximum value of daily ornamental value of Gladiolus cut flowers is C(R=0.43), the least is A and C (R=0.29). The optimal level of each factor is A₁, B₂, C₃, that is, 20 g L⁻¹ of white granulated sugar, 115 mg L⁻¹ of aspirin, 28 ml L⁻¹ of lemon juice.

Table 12. Range analysis of orthogonal test results on the daily average value of relative water content (%) in petals of Gladiolus cut flowers.

| Factors | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|---------|---------------------------|------------|----------------|
| k₁      | 93.56                     | 93.30      | 93.45          |
| k₂      | 93.27                     | 93.59      | 93.20          |
| k₃      | 93.43                     | 93.37      | 93.62          |
| R       | 0.29                      | 0.29       | 0.43           |
3.8. The effect of different domestic vase solution treatment on the change of MDA content in petal of *Gladiolus* cut flowers

MDA content reflects the degree of lipid peroxidation of cell membrane, which is positively related to the degree of cell aging [3]. As shown in table 13, the change of MDA content in petal of *Gladiolus* cut flowers of each treatment after vase insertion showed a trend of first decreasing and then rising, which indicated that vase insertion solution of each family could alleviate the adversity stress of cut flowers to a certain extent and delay senescence. On the third day of vase insertion, the MDA content in petals of each treatment decreased to the lowest value, and the largest decline was in J7 treatment, reaching 56%; the others were in turn in J9, J8, J6, J2, J3, J4, J5 and J1 treatment, with a decrease of 53.74%, 52.96%, 45.42%, 36.95%, 34.99%, 33.92%, 30.56% and 27.39%, respectively. According to the daily mean value of MDA content in petals, the treatment effect of each family vase is the best from J7, J5, J2, J4, J9, J3, J8, J6, J1, which is only 0.3691 μmol / g, 0.0175 μmol / g lower than that of J1 treatment. It can be seen that J7 treatment significantly alleviated the degree of membrane lipid peroxidation and delayed the senescence of *Gladiolus* Cut flowers.

| Treatments | 1d | 3d | 5d | 7d | 9d | 11d | Daily average value |
|------------|----|----|----|----|----|-----|------------------|
| J1(CK)     | 0.4155 | 0.3017 | 0.3852 | 0.4438 | —  | —   | 0.3866          |
| J2         | 0.4293 | 0.2707 | 0.3815 | 0.3881 | 0.3953 | —  | 0.3730          |
| J3         | 0.4314 | 0.2805 | 0.3063 | 0.4217 | 0.4374 | —  | 0.3755          |
| J4         | 0.4278 | 0.2827 | 0.3182 | 0.4119 | 0.4285 | —  | 0.3738          |
| J5         | 0.3888 | 0.2699 | 0.3005 | 0.4416 | 0.4564 | —  | 0.3714          |
| J6         | 0.4786 | 0.2612 | 0.3676 | 0.3752 | 0.4128 | —  | 0.3791          |
| J7         | 0.4255 | 0.1872 | 0.2732 | 0.4121 | 0.4487 | 0.4681 | 0.3691          |
| J8         | 0.4578 | 0.2153 | 0.3165 | 0.4220 | 0.4765 | —  | 0.3776          |
| J9         | 0.4894 | 0.2264 | 0.2538 | 0.4146 | 0.4874 | —  | 0.3743          |

It can be seen from Table 14 that the most influential factor on the daily average value of MDA content in petals of *Gladiolus* cut flowers is C(R=0.0091), followed by A(R=0.0046) and B(R=0.0025). The optimal level of each factor is A3, B2, C3, that is, 20 g L\(^{-1}\) of white granulated sugar, 115 mg L\(^{-1}\) of aspirin, 28 ml L\(^{-1}\) of lemon juice.

Table 1. The effect of different domestic vase solution treatment on the change of MDA content in petal of *Gladiolus* cut flowers.

| Factors | A: White granulated sugar | B: Aspirin | C: Lemon juice |
|---------|---------------------------|-------------|----------------|
| k₁      | 93.56                     | 93.30       | 93.45          |
| k₂      | 93.27                     | 93.59       | 93.20          |
| k₃      | 93.43                     | 93.37       | 93.62          |
| R       | 0.29                      | 0.29        | 0.43           |
4. Discussion
The results showed that the fresh-keeping effect of the *Gladiolus* cut flowers was different in different degree. Among them, the vase life of *Gladiolus* cut by J7 treatment is the longest, up to 10.7 days. The maximum growth time of ornamental value was 6 days, and the maximum score was 14.67 points. The maximum growth time of fresh weight was 6 days, the maximum growth was 24.65%. The time of maintaining positive water balance value of *Gladiolus* cut flowers was 6 days, and the flowering rate increased 54.17%. The time of keeping the content of soluble protein in petals continuously increasing was up to 5 days, the biggest increase was 149.05%. The daily mean water content of petals was the highest, 93.72%. The content of MDA decreased the most, 56.00%, and the daily mean value was the lowest, 0.3691 μmol g⁻¹.

The results of orthogonal test showed that the most important factors affecting the vase life, the maximum daily ornamental value of cut flowers, the increase of fresh weight of flowers and branches, the positive time of water balance value maintenance and the increase of flowering rate were the white granulated sugar, and the optimal water average was 20 g L⁻¹, the high concentration of sugar supply is conducive to maintaining the appearance quality and improving the ornamental value of *Gladiolus* cut flowers; while the biggest factor affecting the physiological indexes such as the increase of soluble protein content, water content and daily mean of MDA content in petals of *Gladiolus* cut flowers is lemon juice, the optimal water level is 28 mL L⁻¹, which is conducive to maintaining the normal physiological metabolism of *Gladiolus* cut flowers. Aspirin has the least influence on the results of the indexes, and there is no difference between the levels. Considering the economic applicability, the optimal level is 0 mg L⁻¹. The optimal level of the three factors was 20 g L⁻¹ white granulated sugar, 28 mL L⁻¹ lemon juice and 0 mg L⁻¹ aspirin.

Conclusion
To sum up, J7 is the best treatment for prolonging the vase life, improving the ornamental quality and delaying the aging of *Gladiolus hybridus* cv. “Amer kana” in terms of the morphological and physiological indexes measured in this experiment. Because there are many varieties of *Gladiolus* cut flowers, whether J7 is also suitable for other varieties should be make a profound study in the future.

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