

Quality Characteristics of Cut Carnations Held in Various Water-based Solution

Tajana KRIČKA¹
Ana MATIN¹(✉)
Sanja KALAMBURA²
Darinka BOBINAC¹
Vanja JURIŠIĆ¹
Mateja GRUBOR¹

Summary

This research investigates the quality of cut carnation flowers that were kept for 10 days in various solutions (daily replaced tap water; tap water that was not replaced at all; 2% sugar solution; and 2% salt solution). The flower mass was investigated in relation to maintenance, water and solution volume, carbon content, hydrogen content, nitrogen content, sulphur content, protein content, bacteriological analysis of water and solutions as well as the damage of carnation flower. All the trials were conducted in accordance with the standard protocols. It was found that carnation mass in the first three days increases because of rehydration and then starts to wilt afterwards. Due to the fact that aerobic mesophilic bacteria grow fastest, the earliest changes occur as soon as the fourth day on the flowers that are kept in 2% sugar solution, while the flowers were best preserved in the daily fresh tap water. The protein content on the first day was lower in relation to the day 10.

Key words

carnation; water; solutions; quality; changes

¹ University of Zagreb, Faculty of Agriculture, Svetošimunska cesta 25, 10000 Zagreb, Croatia
✉ e-mail: amatin@agr.hr

² University of Applied Sciences Velika Gorica, Zagrebačka, Velika Gorica, 10410, Croatia

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Introduction

Carnations (*Dianthus* type cultivar) are perennial flowers meant for cutting. Carnations are grown in gardens for decoration of flower beds, edgings and rock gardens; as industrial plants carnations are raw material for the fragrance industry. Carnation flowers are decorative, sweet-smelling and come in a wide range of colours (Shella, 2008).

The optimal harvesting time depends on variety and bud opening after cutting. The plants mature enough to be cut must be healthy and of good quality, and carnation flowers should be cut at the time when the bud is half opened. It is important that the flower is cut, not broken (to avoid damaging the plant), and put into the water immediately. For a maximum vase life, carnations should be harvested in a proper stage of inflorescence (Jawaharlal et al., 2010). The flowers begin to age as soon as they are removed from the stem and for this reason it is advisable to cut the closed flower buds of carnation (Reid, 2001).

Storage of flowers is an important part of the process, following the harvest, designed to meet the market requirements. The vase life spans of various flower species differ by their capacity for storage, genetic, physiological and anatomic characteristics (Bala et al., 2008). The flowers are stored in cooled rooms, at low temperatures that reduce the consumption of nutrients during respiration, lower water loss, prevent unwanted flower opening (Singh et al., 2001) and reduce the number of bacteria (Van Doorn et al., 1991). The storage temperatures depend on inflorescence type and are usually in the range of 0-10°C; while relative air humidity is between 70 and 80% (Cevallos and Reid, 2001; Kofranek and Halevy, 1976).

In order to extend the storage time and to improve the quality and extend life of flowers, the carnations should be harvested at the budding stage (Goszczyńska and Rudnicki, 1982). The advantage of buds to fully open flowers is attributed to reduced respiration, ethylene sensitivity and smaller surfaces of petals that diminish moisture losses (Bhattacharjee, 1999). The carnation flowers show very high levels of respiration when stored in humid conditions (Hardenburg et al., 1986). Storing flowers at wet conditions, due to increase water uptake and slow bud development, increases fresh flower mass by about 20% (Goszczyńska and Rudnicki, 1982).

The vase life markedly depends on the quality of water. Many factors influence water absorption in the vase. Among them are temperature, transpiration level, microbiological population, pH, saccharose level and electrical conductivity. If distilled or deionized water is used for cut flowers, the preservative substances dissolve better because such water, unlike tap water, does not contain ions. Namely, due to its varying quality, tap water may react with chemicals from the preservative substances which causes their sedimentation (Nowak and Rudnicki, 1990).

Nevertheless, cut flowers are commonly kept in tap water. Lower pH slows down the growth of bacteria and improves water uptake through the stem. Tap water is mostly alkaline, thus, if acidity is added, flowers will more easily absorb water from the vase (Nowak and Rudnicki, 1990).

The growth of bacteria in the vase water has a major influence on cut flowers' longevity. Sugar ensures the nutrition of

the flower, but at the same it is a media for bacteria growth. Bacteria start to grow at the stem base as soon as flowers are put into the water, where their excessive number obstructs the water movement in the stem and leads to flower wilting (Reid and Dodge, 1997).

Electrical conductivity (EC) estimates the amount of soluble salts in water. Salinity affects the vase life of flowers depending on its concentration and type of flowers. Low concentrations of salt in the water may be useful for less sensitive varieties of flowers because salt increases the osmotic potential and improves water balance (Zhu, 2001). Lower EC reduces the interaction of water absorption and damages of foliage and petal edges, while high EC lowers pH of the water. In this way, the vase life of gladiolus flower (sword lily) starts to diminish when EC is between 1-2 dsm^{-1} , while roses and carnations suffer damage at 0.25-0.75 dsm^{-1} (Gast, 2000).

Proteins are constituents that make up living cells of any organism and are the carriers of physiological functions. By their chemical composition, they are complex organic compounds mostly made of carbon, hydrogen, oxygen and nitrogen, and many of them contain sulphur (Stryer, 1991). Senescence of cut flowers is generally related to the protein loss (Eason and Webster, 1995).

In the commercial use of cut flowers, it is the life duration of petals that most often determines the vase life of flowers (Nowak and Rudnicki, 1990). Water is a critical element that determines the rate of decay of cut flowers (Singh and Tiwari, 2002). When put into the water, stems show significant changes in their mass, which firstly increases due to development of the buds, and then decreases because of drooping of buds and foliage (Singh et al., 2001; Whitehead et al., 1984).

Based on the above, the objective of this study was to investigate the influence of different methods of post-harvest care of carnation flowers. In order to observe the longevity of cut carnation flowers, it was examined how two different solutions (a-2% sugar solution and a-2% salt solution) and two types of tap water (one replaced with fresh water on a daily basis during the trial period, and the other without replacing the water) influence the mass and quality of carnation flowers and microbiological quality of water during 10 days in vase.

Materials and methods

Materials

The carnation flowers (*Dianthus caryophyllus* L.) used in this investigation were grown under controlled conditions in a polythene greenhouse in the Split area. Thirty six flowers with closed buds were cut in the morning hours and divided into 12 vases. The experiment lasted for 10 days, with two solutions (additives were sugar and salt) and with tap water replaced daily and tap water not replaced at all. The trial was carried out in three replications. The flowers were previously marked, cut in equal length and the mass of every single flower was weighed by use of a precise scale. After that, the flowers were put into vases - three flowers per vase containing 500 mL water or solution.

Treatment

Tap water was used in all samples, while sample A water was without any additives but replaced with fresh tap water every

day. In sample B, sugar was added into water (2%); in sample C, water was not replaced at all during the whole trial period, and in sample D salt was added (2%). For samples B and D, water was not replaced during the whole trial period. Volumes of water and solutions in all samples were observed on a daily basis by use of measuring cylinder and decayed flowers were counted per each sample.

Analytical methods

In the flowers the analysis of protein in dry matter was carried out by the Kjeldahl method (HRN ISO 1871:1999). Total nitrogen, carbon and hydrogen were determined according to the protocol HRN EN 15104:2011, and total sulphur according to HRN EN 15289:2011. During the experiment the environmental temperature and relative moisture were also monitored.

Investigated samples of water and solutions were analysed for microbiological status according to the protocol SOP Z-II-2-20.

Statistical analysis

The data were analysed by use of version 9.3 of the programme package SAS (USA) using GLM procedures and Tukey test of multiple comparison with the level of significance $P \geq 0.05$.

Results and discussion

During the 10-day investigation, the mean values of temperature and relative air moisture of the environment where the carnations were held were as follows: $t=22^{\circ}\text{C}$ with relative humidity $\varphi=73\%$.

The investigation aiming at determining the post-harvest quality of carnation flowers held in two different solutions: a-2% sugar solution and a-2% salt solution, and water (tap water replaced daily, and tap water not replaced), was conducted in laboratory conditions. Colour changes were determined visually.

After weighing, the carnation flower mass was observed during 10 days. The obtained results are given in Figure 1.

During the investigation the water and solution volumes from the vases were measured by use of measuring cylinder for all four samples. The results are given in Figure 2.

In addition, the investigations included the number of closed (wilted) flowers on individual stems of cut carnations, in order to determine which medium is the best one for the longest vase life of carnations. The results are given in Figure 3.

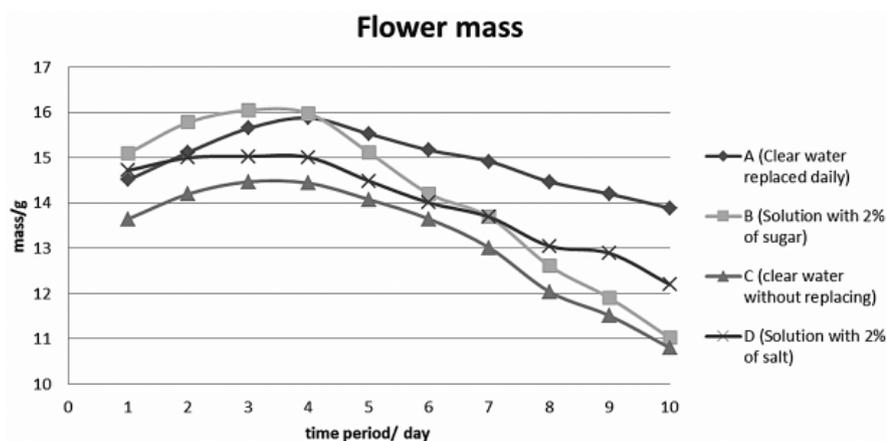


Figure 1. Mean values of flower mass held in different solutions and water in the 10 day period

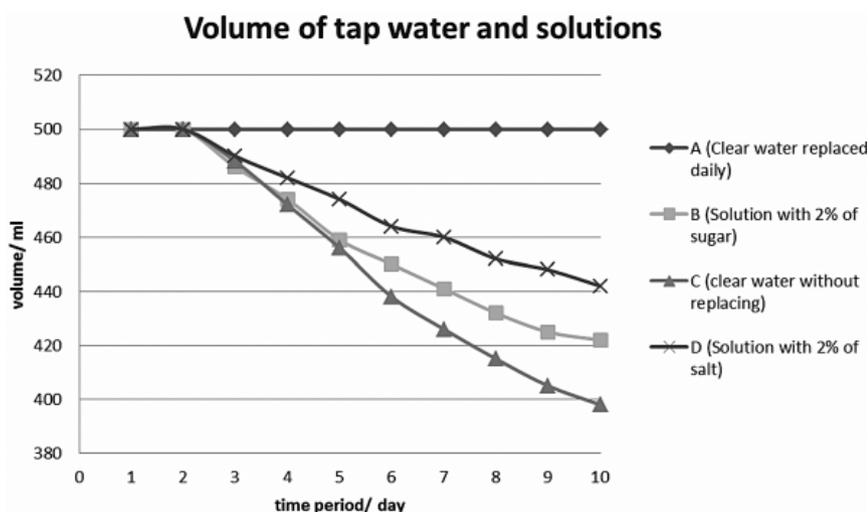


Figure 2. Mean values of volume of tap water and solutions observed in the 10 day period

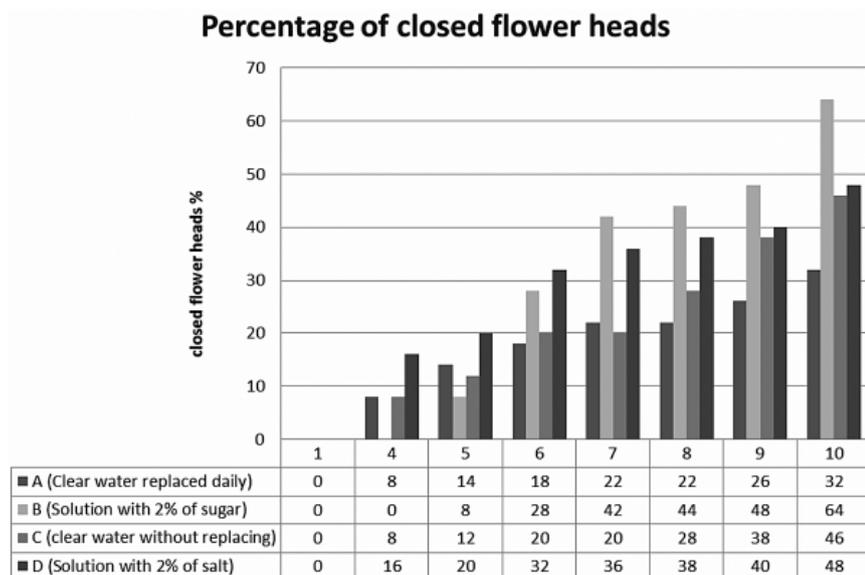


Figure 3. Percentage of closed flower buds for the samples A, B, C and D in the 10 day period

Table 1. Total quantity of C, H, N, S and proteins in flowers

Sample	Day	C %	H %	N %	S %	Proteins %
A, B, C, D	1	46.923a ± 0.006	11.470c ± 0.001	1.759a ± 0.001	0.049a ± 0.001	10.994a ± 0.001
A, B, C, D	5	46.783b ± 0.006	11.723b ± 0.012	1.748b ± 0.001	0.045b ± 0.001	10.92 b ± 0.001
A, B, C, D	10	46.543c ± 0.006	12.290a ± 0.001	1.601c ± 0.001	0.042c ± 0.001	10.006c ± 0.001

Sample A: clear water replaced every day; sample B: water with added sugar (2%); sample C: water not replaced at all; sample D: water with added salt (2%)

Due to too small total mass of carnation petals for a relevant analysis of C, H, N, S and total proteins, total mass of all the samples was analysed. Table 1 presents the obtained results.

At the end of the 10-day investigation, samples A, B, C, and D, water and solutions were analysed for total number of aerobic mesophilic bacteria in a-1 mL sample. The results are presented in Table 2.

Table 2. Analysis of water for total number of aerobic mesophilic bacteria at the end of investigation (day 10)

Sample	No. of bacteria in 1 ml
A	2x10 ³
B	14x10 ⁵
C	1,1x10 ⁴
D	9x10 ⁵

Sample A: clear water replaced every day; sample B: water with added sugar (2%); sample C: water not replaced at all; sample D: water with added salt (2%)

In addition to the described investigations, the damage of nodes, leaves and stems were visually observed. The first damages in form of edge browning were noticed on day 4 on the most of the nodes in the sample B, whilst lesser damages were observed in the samples C and D as well. In the sample A such damages were observed not sooner than day 9. Also, in the sample C on

day 8 the bending of the stems occurred in most of the flowers. Such changes did not appear in other samples.

Decay of the flowers was manifested by discolouration of petals of the visually observed samples. Initially the changes were insignificant, but afterwards the browning of petal edges appeared. The colour of carnations changed from dark pink to dark purple and brown.

The trial started by cutting flowers at identical length, weighing them and putting them into vases with water and water-based solutions; flowers were divided in four samples. The first visible changes were observed on day 2 at weighing of the samples, when the flower mass increased, which can be attributed to rehydration. The mass measured on this day remained approximately unchanged during the three following days in all the samples, with only slight variations. The flower mass visibly decreased after the fifth day when closing of large number of flowers was visually observed. Until the end of the trial the values of measured flower mass continuously decreased. In the sample A the average mass went from initial 14.57 g to 15.72 g on day 5 after which it started to shrink and finally reached 13.55 g. The flower mass of the sample B went from 15.13 g initially up to 15.93 g on day 4 and decreased to average 11.03 g on the last day. The sample C initially had the mass of 13.57 g, on the fourth day it was 14.58 g and decreased to 10.73 g on the last day. The initial mass of the sample D was 14.77 g, on day 4 it was 15.06 g and only 12.23 on day 10. As Singh et al. (2001) report, after flower stems are put in to water the changes appear on the flower mass

i.e., the mass increases which is connected with rehydration and development of buds, followed by mass decreasing because of buds decay.

After weighing, the flowers were put in to vases containing water and water-based solutions whose volume initially was 500 mL for each sample, respectively. Volume reduction was observed on day 3 and ranged from 490 mL for the sample B, 493 mL for the sample C, 495 mL for sample the D, while in the sample A the volume stayed constant through the whole trial period and was 500 mL. The largest volume loss was observed in the sample C (non-replaced water), from 500 mL initially down to 399 mL on the last day. The lowest volume loss was recorded in the sample D (2% salt solution) and on the last day the volume was 444 mL. The volume in the sample B (2% sugar solution) on the final day was 423 mL. Water loss was mainly caused by transpiration through the plant itself and only a smaller part by evaporation from the vase.

On day 4, it was observed that flower buds in the samples A, C and D started to close and petals started to wilt; also brown discoloration appeared on petal edges of some flower buds. Stewart et al. (1975) report that discoloration of decayed petal is largely caused by changes in pH values of vacuoles. In the same period the flowers of the sample B did not show signs of decay which is attributed to presence of sugar as a nutrient which prolongs the vase life of flowers. This can be explained by preservation of protein levels. Eason et al. (1997) also found in their investigations that the samples with added sugar had a prolonged pre-decay time. Sugar is often added to water in order to improve respiration and to maintain cells' osmotic pressure for water uptake. Also, Eason and Webster (1995) reported that senescence of cut flowers is connected to protein loss, which is corroborated by this investigation.

In addition, the obtained results show that the sample A contained the lowest number of closed flowers; thus, daily fresh vase water best contributes to longevity of cut flowers. The sample B had the highest number of closed flowers, or 64.4% (almost double than in the sample A with 32.42%). This is explained by growth of bacteria which obstruct water uptake. An equal percentage of closed flowers was recorded in the sample C (46.16%) with unchanged water, and in the sample D (48.01%) with 2% salt. Both samples had approximately 50% more closed flowers than the sample A.

Also, on days 1, 5 and 10 flower petals were collected from each sample for analysis of protein in flowers' dry matter. During the ten days of keeping carnations in vases we can report that carbon, nitrogen and sulphur contents were slightly decreasing, while hydrogen content was slightly rising depending on the age of flowers. The protein content was about 10% and decreasing with flower aging. Such protein content was also reported by Ceron et al. (1996).

In this investigation, the flowers were kept at room temperature that in the end leads to lowering the quality of flowers and shortens the vase life compared to storage of flowers in cooled spaces. According to Zencirkiran and Menguc (2003), maintaining temperatures low is essential for preserving the quality of cut flowers and satisfactory vase life. Also, Van Doorn et al. (1991) state that low storage temperatures reduce the development of microbes.

Initially, the addition of sugar contributes to extending the vase life of flowers, but it also enables rapid bacteria development, so in this investigation as early as day 4 the water became cloudy due to increasing amount of bacteria. The result was a visible damage of nodes in form of black spots; and the highest number of wilted flowers was found in the sample where sugar was added. Reid and Dodge (1997) report that the excessive number of bacteria in the water obstructs the movement of water through stem, which results in flower decay eventually.

Such result is the effect of not replacing the water through the whole trial period, and it is assumed that the result would be better if the water with sugar solution had been replaced with fresh solution daily. That would enable to keep the protein level, which would prevent excessive bacteria growth, and the resulting bacteriological findings showed that the largest number of bacteria was, of all the samples, in the sample B ($14 \times 10^5/\text{mL}$) where sugar was added in to vase water. It is thus presumed that the sugared water is the best suitable medium for bacteria development. In addition, in the sample C the bending of stems appeared on day 8. Probable causes are that the vase water was not replaced during the whole trial period, the storage temperature or low content of some chemical elements. Halevy and Mayak (1981) reported that low potassium increases the frequency of stem bending in rose flower, which was evident in this investigation as well.

Conclusions

Based on the investigation of the quality of cut carnations kept in different solutions (A- daily fresh tap water; B- water based 2% sugar solution; C- tap water not replaced; D- water based 2% salt solution) it can be concluded that:

- Regardless of whether the flowers were held in the solutions or tap water, the flower mass increased in the first three days due to rehydration. After the third day the mass begun to decrease because some flower buds started to close.
- Tap water that was replaced with fresh one on a daily basis had the most favourable influence on vase life length. Initially the 2% sugar solution had good performance, but the vase life of the flowers was shorter because of bacteria development. The 2% salt solution did not perform significantly better compared to tap water that was not replaced.
- Carbon, nitrogen and sulphur contents in petals of carnation flowers were dropping parallel to flower senescence, while the hydrogen content was rising. Because of the fact that nitrogen has a direct impact on protein content, with lowering the nitrogen content the protein content decreased as well.
- After day 10 the bacteriologic analysis of the water and solutions of all four samples showed that the lowest number of aerobic mesophilic bacteria was in the daily fresh tap water. The highest number of bacteria was found in a-2% sugar solution followed by a-2% salt solution, while it was significantly lower in the tap water that was not replaced.
- Damages of foliage and stem nodes and browning of the edges appeared on day 4, mostly on the sample with a-2% sugar solution. Somewhat lesser damages were observed on the samples with a-2% salt solution and tap water that was not replaced, while in the sample with daily fresh tap water

such changes were observed not before the day 9. In addition, on the sample with the tap water not replaced, stems and most of flowers were bent. In other samples such changes did not appear.

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