How Important Are Bacteria for the Vase Life of Cut Gerbera Flowers?

U. van Meeteren and R. Schouten
Wageningen University
Horticultural Supply Chains Group
PO Box 630, 6700 AP Wageningen
The Netherlands

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Abstract

The vase life of cut flowers is mainly determined by the rate of development (including senescence), water relations (water uptake and transpiration) and *Botrytis* infection. Here we present the effect of temperature on the growth rate of bacteria and the fresh weight development of cut gerbera flowers. This is accomplished by controlling the vase water temperature independently from the air temperature. Air and water temperature combinations used were 15/15, 15/22, 15/28, 22/4, 22/22, 22/28, and 28/28°C (air/water). In order to have the same transpiration rate, the water vapour deficit was kept at 0.92 kPa at all air temperatures. Other factors studied were the effect of cultivar and of a bactericide in the vase water. Bacteria numbers in the vase water were measured during vase life as well as fresh weight of the flowers. Water temperature and cultivar greatly affected the growth rate of bacteria. The effect of cultivar was correlated to the amount of sugars that were leaking out of gerbera flower stems into the vase water. Although the various treatments (water temperature, cultivar, and bactericide) affected the growth rate of bacteria, there was not always a clear correlation with fresh weight loss of the flowers. Vase life was mainly affected by air temperature.

INTRODUCTION

About 55 years ago, Aarts (1957) demonstrated a relation between hydraulic conductance of cut flower stems and growth of microorganisms in their vase water. Thereafter, others confirmed a negative relation between bacteria numbers in vase water and length of vase life of cut flowers (Put and Jansen, 1989; van Doorn et al., 1986; van Meeteren, 1978; Zagory and Reid, 1986). The important role of bacteria in water uptake of cut flowers is now generally accepted. Because the importance of bacteria for vase life, bactericides are used to improve the quality of cut flowers.

Van Meeteren (1978) was the first to demonstrate the relation between bacteria number in vase water and the occurrence of 'stem break' in gerbera flowers. 'Stem break' was always preceded by fresh weight loss, due to a decrease in hydraulic conductance of the stem. This was confirmed by van Doorn and de Witte (1994). Often, differences in the susceptibility to bacteria in vase water are observed between gerbera cultivars, especially in more applied vase life research (by flower auctions and research stations). Understanding the mechanism(s) responsible for this difference in susceptibility will facilitate breeding for longer vase life. Bacterial growth in vase water could be different due to differences in available nutrients or growth-inhibiting substances leaking from the flower stems. Woltering (1987) showed already the importance of substances leaking from cut rose stems for bacterial growth. Anatomical differences in stem structure could possibly be another cause for differences in susceptibility to bacteria between cultivars.

Models that simulate the effect of temperature on quality loss, will be more reliable when the temperature effect on senescence rate of the flowers could be separated from the effect on growth rate of bacteria. The aim of the research presented in this paper was to determine the effect of temperature on bacteria growth and fresh weight loss, and their interaction with cultivar of gerbera flowers. This is accomplished by controlling the vase water temperature independently from the air temperature.

MATERIALS AND METHODS

Plant Material and Vase Life Determination

Three cultivars of cut gerbera flowers were obtained from the 'GreenQ Improvement Centre' (Bleiswijk, The Netherlands). All cultivars were grown in the same greenhouse compartment and harvested at the commercial harvesting stage, with a stem length of about 50 cm. They were transported to the lab at room temperature in buckets with a low level of tap water containing sodium hypochlorite (0.1%) and stored over night at room temperature. The next morning, they were re-cut to 45 cm while in water to prevent air emboli and the flowers were placed in Erlenmeyer flasks with tap water or tap water + 8-HQS (0.3 g/L), 4 flowers per flask. Flasks were covered with Parafilm® to diminish water evaporation from the flasks and to prevent bacteria entrance from the air. For the air/water temperature treatments 3 flasks per treatment were used, for the relation between cultivar, sugar leakage into the vase water, and bacteria number (including treatments with 8-HQS) 2 flasks per treatment were used.

Experimental Set Up Temperature Treatments

For the temperature treatments flasks with flowers were placed in Styrofoam boxes with a layer of water that could be heated or cooled. The boxes were placed in temperature controlled cabinets, all with the same VPD of 0.92 kPa with 200 µmol m^{-2} s^{-1} PAR supplied in a 12-h photoperiod, and air temperatures of 15, 22, and 28°C. Temperature combinations used were 15/15, 15/22, 15/28, 22/4, 22/22, 22/28 and 28/28°C (air/water). Bacteria number and sugar content in the vase water, and fresh weight of the flowers were measured at regular intervals.

Fresh Weight of the Flowers

The fresh weight of the cut flowers is expressed as percentage of the fresh weight at the start of the vase experiment.

Enumeration Bacteria Number in the Vase Water

Samples of 2 ml were taken at regular intervals of the vase water to measure bacteria number. Samples were inoculated on R2A agar using a spiral plater (Eddy jet, IUL Systems). Colonies were counted after incubation of 48 hours at 28°C.

Carbohydrates

Sugars in vase water samples were measured using an HPAEC Dionex anion exchange chromatography system (CarboPac1 column, eluent: 100 mM NaOH in water).

RESULTS AND DISCUSSION

Cultivar Effects on Bacterial Growth

After 3 days of vase life, the number of bacteria in the vase water of cultivar (cv) A was about 10 times the number of bacteria in the vase water of the 2 other cultivars (Fig. 1). In the vase water of cv A, bacteria grow exponentially to 10^9 CFU·ml^{-1} after 13 days of vase life. For both other cultivars the number of bacteria was around 5.10^7 CFU·ml^{-1} at day 13. These results demonstrate that the growth rate of bacteria in vase water can be affected by the cultivar of a cut flower species.

In the first hours of vase life, there was a fast increase in sugar concentrations in the vase water, especially with cultivars A and B (Fig. 2). The main sugar in the vase water of all 3 cultivars was glucose (Fig. 2). Sugar concentrations decreased after the first day, likely because the sugars are consumed by the bacteria. During the first 6 days of vase life, the concentration glucose in the vase water of cultivars A and B was much higher as compared with the vase water of cv C. After 6 days, the concentration of sugars was very low for all cultivars. When 8-HQS was added to the vase water, the concentration of sugars increased during the whole vase life period for all three cultivars

(Fig. 3) and reached levels much higher in comparison with the vases without 8-HQS (Fig. 2). Adding 8-HQS inhibited totally the growth of bacteria in the vase water for all 3 cultivars (data not shown). These results confirm that sugars leaking out of the gerbera flower stems are used as nutrient by bacteria in the vase water and agrees with the results of Woltering (1987) for roses. It is likely that the amount of sugars leaking out of the stems of different cultivars affects bacterial growth rates of bacteria in the vase water, resulting in different bacteria number for different cultivars.

Temperature Effect on Fresh Weight

The fresh weight (FW) of cv A increased the first three days of vase life, FW of B and C decreased (Fig. 4). From day 3, FW of cv A decreased rapidly, while FW of cultivars B and C decreased from the start of vase life, when flowers were placed in water. As the number of bacteria after 3 days of vase life was highest with cv A (Fig. 1), differences in FW changes between cultivars conflicted with bactericidal growth during this vase period. After 3 days of vase life, FW loss related well to the differences in bacteria number in the vase water. The cause of the large increase in FW of cv A during the first days in water is unclear. It could have been related to further flower development (opening of disc florets). Why this was not inhibited by the high number of bacteria is unclear. When bacteria growth was inhibited by HQS, all cultivars showed an increase in FW during the first days of vase life, followed by a gradual decrease after 3-5 days. After 10 days, FW was 70-75% for flowers in water, and 79-85% for flowers in HQS. These results seem to confirm the negative role of bacteria in water uptake. The large increase in FW of cv A during the first days was absent when HQS was present; this could indicate that HQS affect the development (growth) of the flower.

Temperature of the vase water affected the growth rate of bacteria during the first days of vase life (Fig. 5). For cultivars A and B, bacterial growth rate was lowest at 4°C and highest at 28°C. The number of bacteria reached a steady state level after 12 days of vase life for both cultivars. Likely, the amount of sugars available was the limiting factor for growth. Only a small effect of 4°C water temperature on FW changes was observed during vase life as compared with 22 and 28°C for cv A. No differences between the 3 water temperatures on FW changes for cv B (Fig. 6). Comparable results were found at an air temperature of 15°C, combined with water temperatures of 15, 22, and 28°C: for cv A there was a small delay in bacteria growth as compared with water temperatures of 22, and 28°C, but no differences in the dynamics of FW (data not shown). These results question the role of bacteria in FW changes of cut gerbera flowers.

For cv B, FW decreased slower at an air temperature of 15 as compared with 22 and 28°C (water temperature 28°C) (Fig. 7); the rate of decrease at 22°C was between the rate at 15 and 28°C air temperature. Also at a water temperature of 22°C, the FW decrease at 15°C air temperature was slower compared to a 22°C air temperature (data not shown). For cv A there was no significant difference in FW changes between air temperatures of 15 and 22°C at a water temperature of 28°C (Fig. 7). FW decreased faster at an air temperature of 28°C (Fig. 7). It seems that mostly air temperature affects FW changes and that the effect of air temperature differs per cv. This could be related to the differences in bacteria number in the vase water between the cultivars. With high bacteria numbers (cv A), only high air temperatures hasten FW loss, while with lower bacteria numbers (cv B) also in the range of 15 to 22°C air temperature had an effect on FW loss.

Overall, part of the results confirmed the important role of bacteria in FW loss of cut gerbera flowers (with/without 8-HQS), while other results (low water temperature) conflicted with the importance of bacteria. Bacterial growth in vase water can be different for different cultivars, related to the different amount of sugars leaking out of the flower stems. The different number of bacteria between ccultivars did not correlate with FW changes during the first days of vase life, but correlated with the rate of FW loss during the second part of vase life.

CONCLUSIONS

Low water temperature inhibited the growth of bacteria in vase water of gerbera cut flowers. This did not result in delay of FW loss. High air temperatures hastened the loss of FW; the effect of intermediate air temperatures on FW was cultivar dependent. Different cultivars differed in the amount of sugar that leaks out of the stem into the vase water; these differences correlated with the growth rate of bacteria. However, there was no straightforward relation with different dynamics of FW's of the cultivars during vase life.

8-HQS inhibited the growth of bacteria; however, it also inhibited the increase in FW of one of the cultivars used. After 3-5 days of vase life, 8-HQS delayed FW loss. Overall, the role of bacteria in FW changes of cut gerbera flowers is still not fully understood. Bactericidal compounds could have effects on flower physiology and other processes, like wounding responses, besides the inhibition of bacterial growth. Separating air and water temperature seems to be an elegant tool to investigate the role of bacteria and the interaction between flower genotypes and bacteria in water relations of cut flowers.

ACKNOWLEDGEMENTS

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Literature Cited

Aarts, J.F.T. 1957. Over de houdbaarheid van snijbloemen (On the keepability of cut flowers; in Dutch, with English summary). Meded. Landbouwhogesch. Wageningen. 57(9):1-62.

Put, H.M.C. and Jansen, L. 1989. The effects on the vase life of cut Rosa cultivar 'Sonia' of bacteria added to the vase water. Sci. Hort. 39:167-179.

van Doorn, W.G. and de Witte, Y. 1994. Effect of bacteria on scape bending in cut *Gerbera jamesonii* flowers. J. Amer. Soc. Hort. Sci. 119:568-571.

van Doorn, W.G., Buis, H.C.E.M. and de Witte, Y. 1986. Effect of exogenous bacterial concentrations on water relations of cut rose flowers. Bacteria in the vase solution. Acta Hort. 181:463-465.

van Meeteren, U. 1978. Water relations and keeping-quality of cut gerbera flowers 1. The cause of stem break. Sci. Hort. 8:65-74.

Woltering, E.J. 1987. The effects of leakage of substances from mechanically wounded rose stems on bacterial growth and flower quality. Sci. Hort. 33:129-136.

Zagory, D. and Reid, M.S. 1986. Role of vase-solution microorganisms in the live of cut flowers. J. Amer. Soc. Hort. Sci. 111:154-158.

Figures

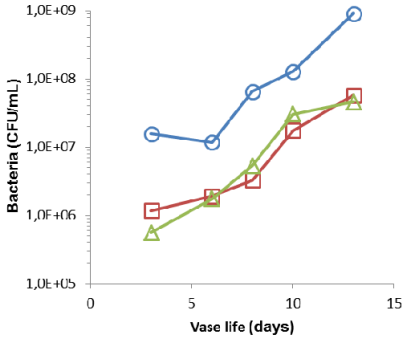

Fig. 1. Bacteria numbers in vase water during vase life of 3 gerbera cultivars (○=cv. A, □=cv. B, △=cv. C).

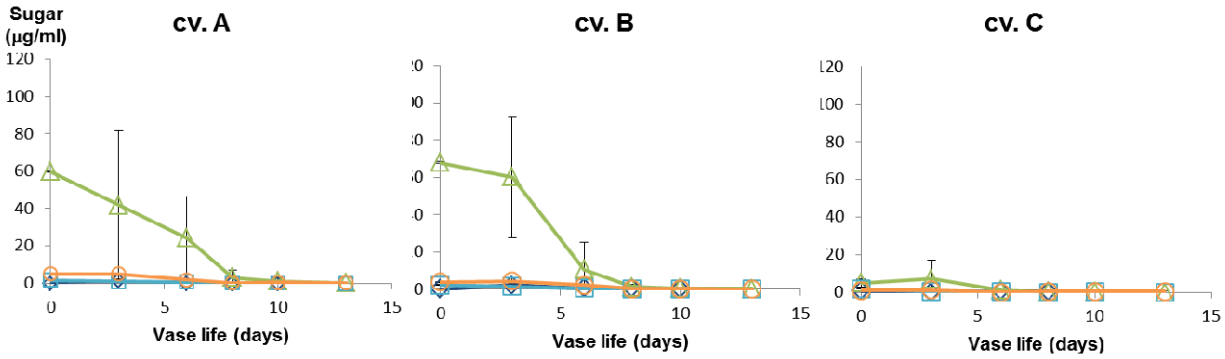

Fig. 2. Sugar concentrations in vase water during vase life of cultivars A, B, and C (○=sucrose, △=glucose, □=fructose, ◇=myo-inositol). At day 0, samples were taken about 2 h after placing the flowers in the vase water. Mean values of 2 vases/treatment; vertical bars indicate standard deviations.

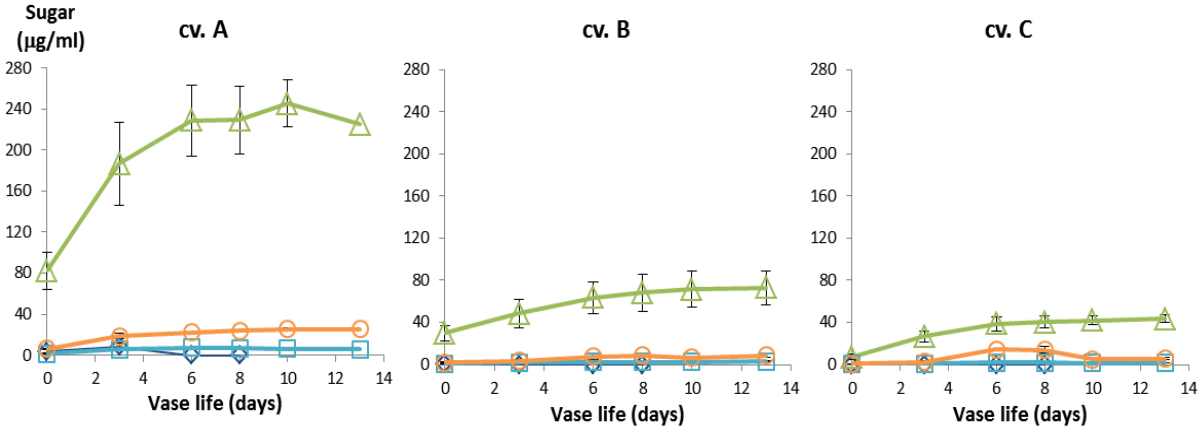

Fig. 3. Sugar concentrations in vase water containing 8-HQS during vase life of cultivars A, B, and C (○=sucrose, △=glucose, □=fructose, ◇=myo-inositol). Mean values of 2 vases/treatment; vertical bars indicate standard deviations.

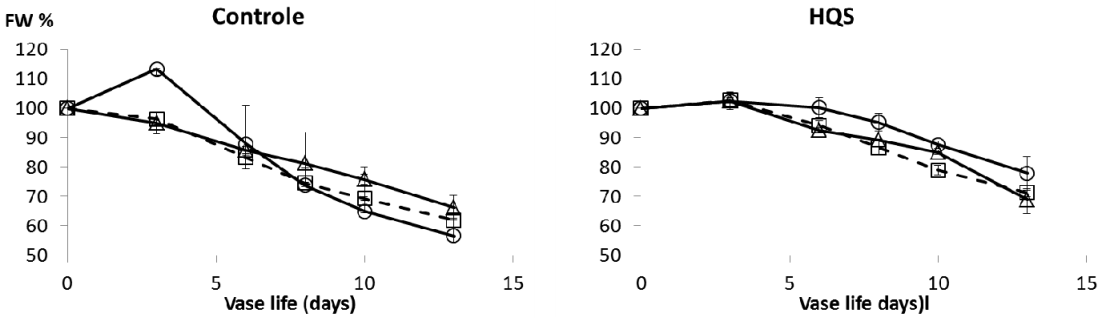

Fig. 4. Fresh weight (FW) of 3 gerbera cultivars (○=cv. A, □=cv. B, △=cv. C) during vase life of flowers placed in water (Control) or in water + 8-HQS (HQS).

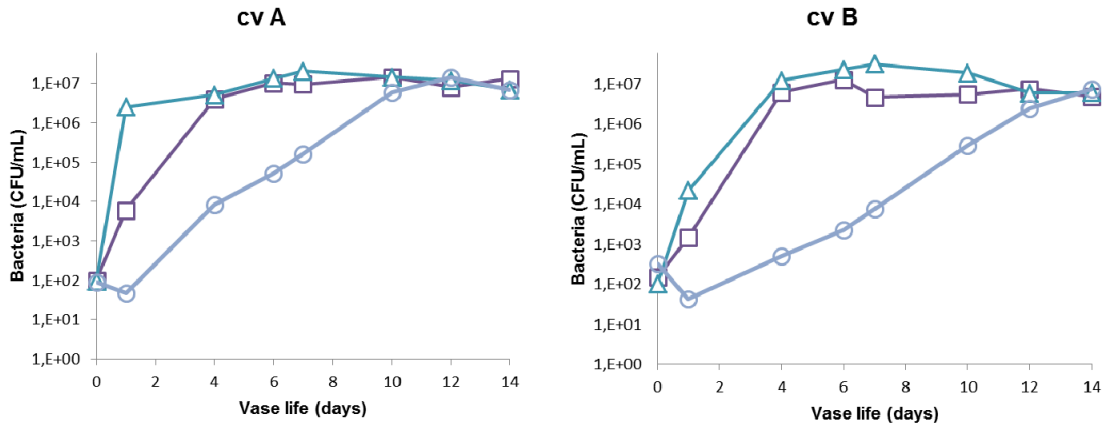

Fig. 5. Bacteria number in vase water of cultivars A and B with different temperatures of the vase water (△=28°C, □=22°C, ○=4°C). The air temperature was in all treatments 22°C.

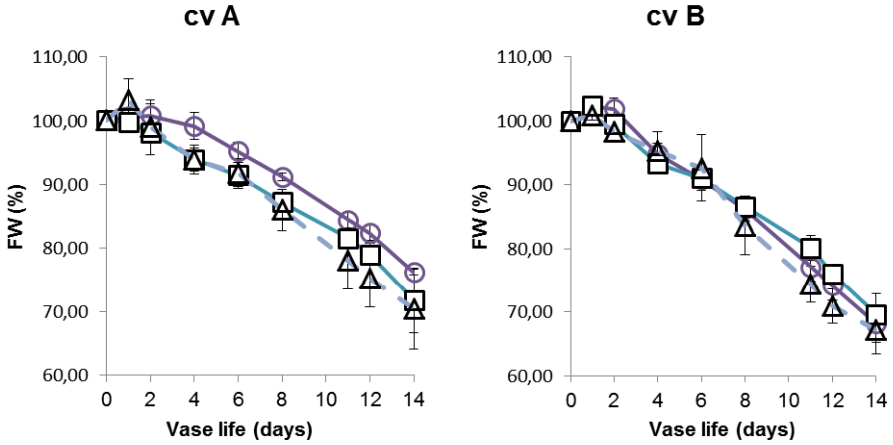

Fig. 6. Fresh weight (FW) of flowers of cultivars A and B in water with different temperatures (△=28°C, □=22°C, ○=4°C). The air temperature was in all treatments 22°C.

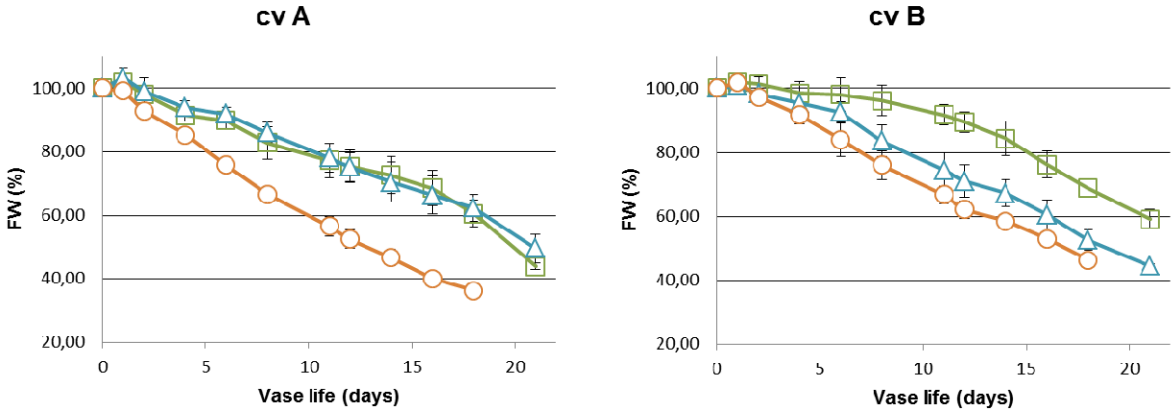

Fig. 7. Effect of air temperature (□=15°C, △=22°C, ○=28°C) on fresh weight (FW) changes of cultivars A and B. Water temperature was in all treatments 28°C.