Current Trends in Natural Sciences
Vol. 11, Issue 22, pp. 247-254, 2022
https://doi.org/10.47068/ctns.2022.v11i22.029
Current Trends in Natural Sciences (on-line)
ISSN: 2284-953X
ISSN-L: 2284-9521
Current Trends in Natural Sciences (CD-Rom)
ISSN: 2284-9521
ISSN-L: 2284-9521

MAINTAINING THE QUALITY OF CARNATION CUT FLOWERS DEPENDING ON TEMPERATURE

Tincuța-Marta Gocan[1], Ileana Andreica[1], Daniela-Sabina Poșta[2], Melinda Rozsa[1], Vasile Lazăr[1], Sándor Rózsa[1,*]

[1] University of Agricultural Sciences and Veterinary Medicine Cluj-Napoca, Faculty of Horticulture, Cluj Napoca, Romania
[2] Banat University of Agricultural Sciences and Veterinary Medicine „King Michael I of Romania" from Timisoara, Faculty of Horticulture and Forestry, Romania

Abstract
In the assortment of cut flowers, carnations (Dianthus caryophyllus L.) fall in the first places, with a large number of varieties, of various colors, being appreciated on the cut flowers market. Carnations flowers that cannot be sold immediately after harvest, being a time of year when the market offers an abundance of cut flower species, they are prone to rapid depreciation under normal environmental conditions. Carnation is an important ornamental plant, which is used as a potted plant as well as a cut flower. One factor that influences the shelf life is temperature. From the flowering stage to the total depreciation of the inflorescence, it plays an important role. In this experiment, the flowers were harvested on two different dates for about a month. The temperatures at which the varieties were kept had 6 graduations (from 10 to 22 °C). The parameters followed were: bud height, corolla height above the calyx, bud diameter and flower stem length. Storing flowers in water at 4 °C for 6 to 15 days, did not increase the diameter of the flower bud. In flowers kept at 22 °C for 6 days, the values of several parameters of cell senescence fell below the values of fresh flowers. However, in flowers kept at 4 °C there was no expected slow decrease in these parameters, but rather an increase above the levels found in fresh flowers. We conclude that storage at low temperatures has effects on carnation cut flowers, other than slowing down the aging process.

Keywords: carnations, flower diameter, storage, temperatures,

1. INTRODUCTION

Carnations are part of the assortment of flowers that are appreciated throughout the year, there are periods when they cannot be used as there is a lower demand, they depreciate easily in the usual environmental conditions and they need to be kept in cooled spaces. To meet consumer demand for fresh flowers and grower profitability, it is necessary to find the best storage solution that can prolong and improve the quality of carnation flowers. The genus *Dianthus* includes about 300 species that grow in Europe, Asia, South Africa (Jürgens et al., 2003, Gocan et al., 2021). The most important difficulties facing carnation production is the climate factor; thermal stress, which affects plant growth and development. Thermal stress negatively affects flower quality in general and stem length in particular (Al-Ma'athidi et al., 2013, Gocan et al., 2021). Preharvest conditions have a considerable effect not only on the quality and longevity of carnations cut immediately after harvest, but also on their response to postharvest treatments (Celikel and Karaçalý, 1995).

*Corresponding author, E-mail address: rozsa.sandor@usamvcluj.ro

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Inadequate temperature during the storage period also has a negative influence and can lead to depreciation and shortening of the storage period in the vase (Çelikel, Reid, 2002, Rózsa, 2021). The effects of temperature on cut flower life in carnations were studied by Maxie et al., (1973). Time-temperature monitoring in the handling of cut flowers from harvest to storage was pursued and demonstrated by Staby and Reid (2005). Higher preharvest temperatures reduce the level of pigmentation (Salunkhe et al., 1990). Another study shows the retardation and development of flower buds during storage (Eason et al. 2002). Low temperature influences the metabolism, limits respiration limits the development of pathogens (Teixeira da Silva, 2003). The effect of cold dry storage on the keeping qualities of the peony was tested and from the 12th week of storage (0–10 C°) it reduced the longevity of the flower by 20% (Skutnik et al., 2020).

2. MATERIALS AND METHODS

The material used in the experiment was purchased from Cluj-Napoca. The experiments were set up in two stages. The first stage of harvesting was carried out on March 15, 2020, where the white and red varieties were used. For the second stage, the white, red and yellow varieties were studied, the harvesting was carried out on April 20, 2020. The varieties are described in Table 1.

Table 1. The biological material used in the experiment

					
American carnations from the red William Sim variety, then mutated with flowers colored in white, pink, yellow, orange, purple, plain or striped, are grown all over the world. → the plant is tall (80-100 cm), vigorous, with stiff shoots, long leaves (8-10 cm), covered with a layer of bluish wax; → the flowers have a long, cylindrical calyx, less exposed to cracking; - the flower stalks are led with a single flower at the top.					

The flowers were harvested between 9 and 10 in the morning, the flower being in the closed bud phase, when the corolla protruded above the calyx approximately 1.80-2.00 cm for the white and yellow variety 1.82-2.20 cm for the red variety. Storage was done in buckets kept at different temperatures. Before placing in the water, that was changed daily, the flower stem was refreshed by cutting from the base about 1.5 cm.

In the organization of the experience, the first factor A-the storage temperature with 5 graduations (1°C, 4°C, 8°C, 10°C and 20°C. The second factor B-being the storage period with 5 graduations (3 days, 5 days, 10 days, 12 days, and 18 days). The experimental variants resulting from the combination of the two factors. After storage at different temperatures the plants were kept at ambient temperature in the laboratory at 21°C for 18 days.

The main characteristics of the material used in the experiment were measured in terms of:

→ the height of the bud is between 3.73 cm and 4.42 cm;
→ the height of the corolla above the calyx is 1.84-2.10 cm;
→ the diameter of the bud having values between 2.15 and 2.48 cm;
→ rod length 52.14 cm and 52.77 cm.

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During the experiment, observations and determinations were made: the daily growth dynamics of the floral diameter; daily appreciation of flower opening according to a rating scale (5-bud closed, 4-bud ¼ open; 3-flower ½ open 2-flower ¾ open; 1-flower fully open); the life span of the flowers in the vase after the storage period at different temperatures.

3. RESULTS AND DISCUSSIONS

The first stage of experimentation, harvested on March 15, 2020. The temperatures achieved in the climatic chambers for the storage of carnations remained very close to the proposed values (Figure 1). The relative humidity of the air remained between 87-92%.

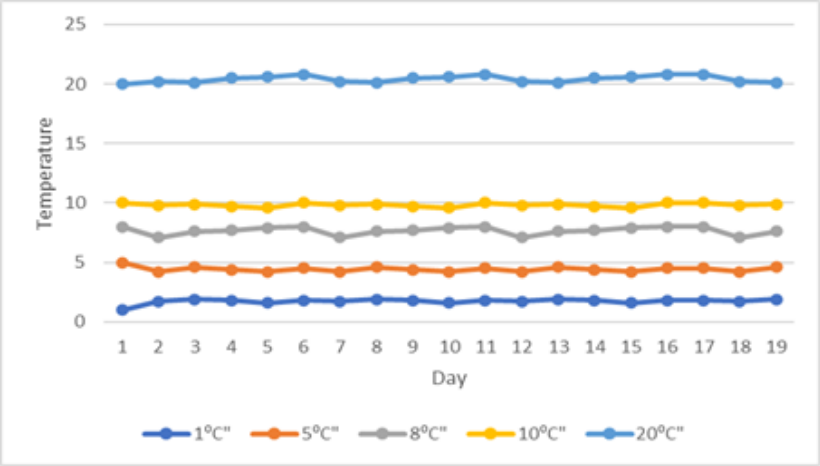

Figure 1. Temperature evolution during storage of the varieties on March 15, 2020

The evolution of the diameter of the flowers during storage at different temperatures (Figure 2) at the temperature of 1°C the buds and kept close to the initial dimensions, and after 8 days the diameter increased from 2.30 cm to 2.72 cm.

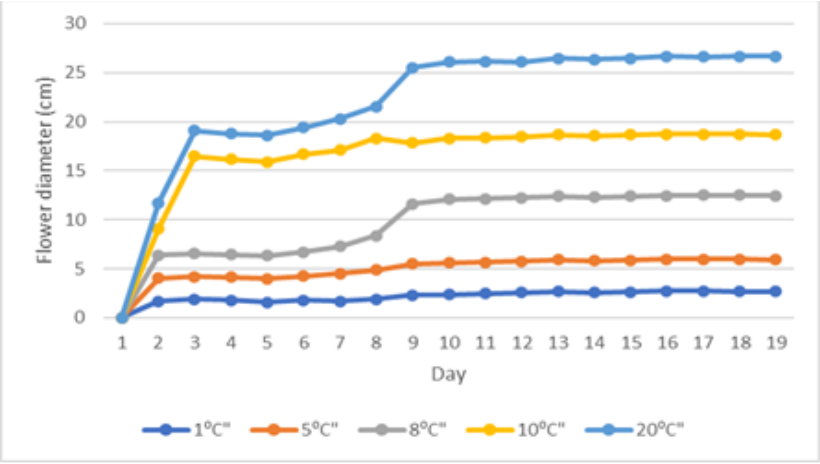

Figure 2.

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At the temperature of 5°C there were increases from 2.36 cm to 3.25 cm, and at the temperature of 8°C there were obvious increases in diameter from day three, doubling the initial values from day 8. At 10°C the diameter reached 6.20 cm on the 8th day of storage compared to 2.69 cm on the first day. As for the room temperature (20°C), in the first three days the diameter increases a little (from 2.60 cm to 3.24 cm), then a sudden increase followed and on the 8th day it reaches 7.80 cm.
The flowers at the time of harvesting were graded 5, being all in the dark bud phase with tight petals. The degree of opening of the flowers is influenced by the storage temperature and the duration of keeping at different temperatures.
The data from Table 1, show that the temperature of 1°C maintains the flowers in the closed bud phase in a proportion of 80 (%) even after 8 days of storage. At the temperature of 5°C, after 8 days half-open flowers predominated (58 .4%), and at 8°C 65% of flowers were 3/4 open. At 10°C, after 8 days, 60% of flowers were fully open, and at room temperature all flowers were fully open.
Following the opening of flowers kept at different temperatures for 4 and 8 days, at room temperature 11 days after harvesting, it is found that the lower the temperature and the more days the flowers are kept at low temperatures, the more reduces the rate of flower opening.

Table 1. Degree of flower opening during storage (%)

Temperature (°C)	Shelf life (days)	Note					Room temperature days	Note				
		5	4	3	2	1		5	4	3	2	1
1	4	88.9	10.8	-	-	-	3	-	-			100
	8	81.6	17.9	1.5	-	-	6	10	20	30	35	5
5	4	20.6	40.21	30.1	10.1	-	3	-	-	-	-	100
	8	15.9	10.5	58.4	15.4	-	6	-	11.2	16.8	64.2	28.0
8	4	15.0	25.3	46.7	20.0	3.3	3	-	-	-	-	100
	8	-	5.4	20.0	65.2	10.1	6	-	-	-	13.3	86.7
10	4	-	8.9	40.2	44.2	8.0	3	-	-	-		100
	8	-	-	-	40.3	60	6	-	-	-	5.5	95.5
20-21° C (Room temperature)	-	-	-	-	20.3	80	-	-	-	-	-	-
	-	-	-	-	-	100	-	-	-	-	-	-

Note 5 — bud closed; Note 4 — bud 1/4 open; Note 3 — flower ½; open Note 2 — flower ¾; open Note 1 — flower fully open.

Flower life at room temperature after storage. Flower life at room temperature was considered from the day the flowers were removed from storage temperatures, until they received a grade of 2 (petals begin to lose turgor and tend to shrink, showing signs of drowsiness).
The life span of flowers at room temperature varies depending on the temperature and the number of days of storage, being inversely related to the temperature level and storage time (Table 2).
The quality of the flowers. After storage in a controlled environment, the quality of the carnations did not change, they maintained their freshness even if the petals opened in the carnations kept at higher temperatures (Table 3). At a temperature of 10°C, after 8 days of storage, the quality was scored on average with 4.7, and at room temperature it reached 2.3, the carnations starting to lose their decorative value. After removal to room temperature, quality began to deteriorate at a faster rate in cloves stored at higher temperatures.

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Table 2. The life span of carnations stored at different temperatures, harvested on March 15, 2020

Temperature (°C)	Storage time at different temperatures (days)	Flower life at room temperature (days)
1	4	8
5	8	7
8	4	7
10	8	6
20-21 (Room temperature)	4	7

Table 3. Quality of carnations stored at different temperatures, harvested on March 15, 2020

Temperature (°C)	Storage days at different temperatures	Quality grade	Storage days at room temperature (note)								
			1	2	3	4	5	6	7	8	9
1	4	5	5	5	5	5	4.4	3.7	3.2	2.6	2.1
	8	5	5	5	4.5	4.2	3.7	3.0	2.5	-	-
5	4	5	5	5	5	5	4.3	3.8	3.2	2.3	-
	8	5	5	5	4.5	3.9	3.1	2.9	-	-	-
8	4	5	5	5	4.5	4.3	3.9	3.7	2.8	2.4	-
	8	5	5	5	4.9	3.9	2.6	-	-	-	-
10	4	5	5	5	4.8	4.4	3.9	3.5	2.1	-	-
	8	4.7	3.8	3.5	3.1	2.2	-	-	-	-	-
20-21 (Room temperature)	8	2.3	-	-	-	-	-	-	-	-	-

Second stage of experimentation (April 20, 2020).
In the case of keeping for 5 days at different temperatures and then at room temperature (Figure 3), it is found that the diameter of the flowers increased approximately at the same rate.

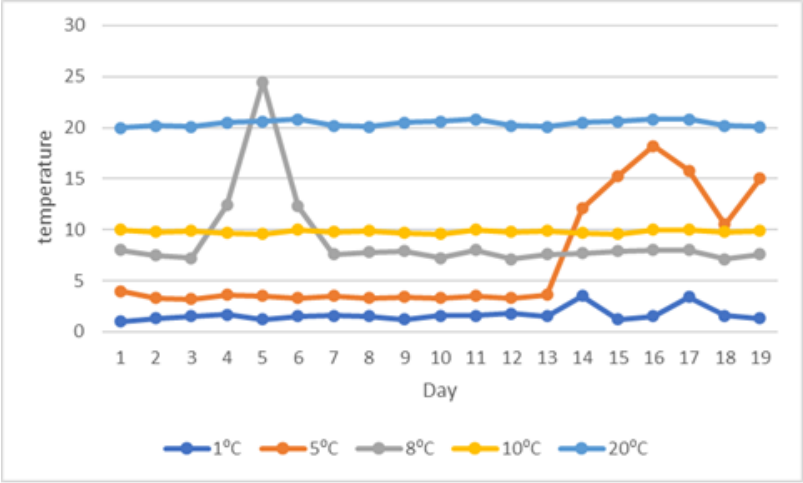

Figure 3. Temperature evolution during storage for varieties harvested on April 20, 2020

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Thus, carnations kept at a temperature of 1°C for four days grew slightly and after 7-8 days at room temperature they reached 8 cm. Carnations stored at 5 and 8°C increased in diameter from 3.20 cm to 7.47 cm and from 4.23 cm to 8.36 cm, respectively.
The diameter of the flowers of the studied varieties, after certain periods of storage at different temperatures and then at room temperature, is presented in Table 4. The diameter of the buds kept at the temperature of 1°C increased very little, regardless of the storage time. At the other temperatures, the diameter increased with the temperature level and with the storage time. After removal from low temperatures, the diameter of the flowers varied with the variety, the temperature at which they were kept and the duration of storage.

Table 4. Flower diameter according to duration and storage temperature, harvested on April 20, 2020

Temperature (°C)	Storage time at different temperatures (days)	Average flower diameter (cm)		The largest diameter after keeping the flowers at room temperature (cm)	Flower life at room temperature (days)
		Initial	Final		
1	12	2.30	2.70	6.95	7
	16	2.30	2.78	7.50	6
	19	2.30	2.87	5.52	5
5	12	2.33	3.58	6.92	6
	16	2.33	4.35	7.60	5
	19	2.33	4.68	7.17	4
8	12	2.38	4.90	7.50	5
	16	2.38	5.73	7.35	3
	19	2.38	5.80	7.20	2
10	12	2.25	4.96	7.18	3
	16	2.25	5.83	6.76	2
	18	2.25	6.11	6.51	1
20-21 (Room temperature)	8	2,35	6,90	6,90	8

Flower life at room temperature after storage varied with storage temperature, with storage life (Table 5) being shorter for flowers stored at higher temperatures (7 and 10°C) compared to those stored at 5° and 1°C. It is found that, at all temperatures, the life span of the flowers at room temperature is shortened with the maintenance period at low temperatures. Thus, after storage at a temperature of 1°C, which best maintained the quality of the flowers, the life span at room temperature varied between 7-5 days for the variety, depending on the duration of cold storage (12-19 days). The reduction of life with the duration of storage is due to the fact that, during storage, the flower consumes its own nutritional reserves, not being fed with energy substrate.
The quality of the flowers. After storing the three varieties of carnations, it was found that the quality appreciation scores were higher at the temperatures of 1 and 4°C compared to the temperatures of 7° and 10°C. The storage time influenced the quality especially at the temperatures of 7° and 10°C.

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Table 5. Quality of carnations stored at different temperatures, harvested on April 20, 2020

Temperature (˚C)	Shelf life (days)	Quality grade	Storage days at room temperature (average notes)							
			1	2	3	4	5	6	7	8
1	12	12	5.00	5.00	5.00	5.00	5.00	4.25	3.15	2.35
	16	16	5.00	5.00	5.00	5.00	4.15	3.65	2.15	
	19	19	5.00	5.00	4.50	3.70	2.85	2.00	-	-
5	12	12	5.00	4.75	4.15	3.75	3.05	2.55	2.11	-
	16	16	4.75	4.35	4.05	3.00	2.15	2.05	-	-
	19	19	4.50	4.00	3.50	2.75	2.13	-	-	-
8	12	12	4.75	4.00	3.75	3.15	2.80	2.15	1.95	-
	16	16	4.25	3.90	3.15	2.85	2.50	-	-	-
	19	19	3.70	2.65	1.95	-	-	-	-	-
10	12	12	4.25	3.05	2.75	l..95	-	-	-	-
	16	16	3.15	2.35	1.50	-	-	-	-	-
	19	18	3.00	2.80	-	-	-	-	-	-
20	20	8	2.15	-	-	-	-	-	-	-

After removing to room temperature, it is found that, in the case of keeping for more than 16 days at temperatures of 7° and 10°C, the flowers suddenly depreciate due to the more intense metabolic activity, with higher consumption of substances.

4. CONCLUSIONS

Based on the results obtained, it was found that:

→ The best storage temperature for carnations was 1°C, followed by 4°C.

→ The life span of flowers after being removed to room temperature varies inversely with the level of storage temperature within the same temperature.

→ Temperatures of 7° and 10°C can be used to store carnations for a maximum of 8-12 days so that the flowers have a life of 3-5 days at room temperature.

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