Scientific Article

# Vase life of floral and vegetative stems of Costaceae[1]

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**ABSTRACT**

This study aimed to evaluate the vase life of floral and vegetative stems of Costaceae and describe their morphological characteristics. To evaluate the vase life of floral and vegetative stems, four and six species were used, respectively. Three cutting stages were established for floral stems. Stems were cut a few days before flower opening at stage 1, upon opening of the first flower(s) (anthesis) at stage 2, and when floral stems showed more than 15 opened flowers at stage 3. However, only two different stages were applied for each species. Floral stems were standardized with 50 cm in length, while vegetative stems were standardized with 70 cm in length. The morphological characteristics determined for floral stems included diameter of the floral stem, length of inflorescence, diameter of inflorescence and fresh mass of floral stem. For vegetative stems, we considered diameter and fresh mass. After the first evaluation, stems were maintained at 22 ºC and 53% of humidity. The total number of post-harvest days (global longevity) in which the quality of floral and vegetative stems was acceptable were evaluated. The highest vase life for floral stems at stage 1 was observed for *Costus woodsoni*, *Costus arabicus* x *Costus spiralis* (Costus Tropicales), and *Costus scaber*. *Hellenia speciosa* showed higher vase life at stage 3. *H. speciosa* showed the highest vase life and *C. woodsonii* the lowest values for morphological characteristics. The vase life of vegetative stems for the six species was satisfactory. *Costus scaber* (orange) showed the shortest longevity and *Costus arabicus* (yellow) longest longevity. *Dimerocostus strobilaceus* showed the highest values of morphological characteristics, and *Costus arabicus* (pink) showed lowest values. Based on the results, both floral and vegetative stems of Costaceae can be used for cutting.

**Keywords:** harvest stage, tropical plants, cut flowers, cut stems

**RESUMO**

**Longevidade pós-colheita de hastes florais e vegetativas de Costaceae**

Objetivou-se avaliar a longevidade pós-colheita de hastes florais e vegetativas de Costaceae e determinar as características morfológicas das mesmas. Para avaliação da longevidade pós-colheita de hastes florais foram utilizadas quatro espécies e a longevidade de hastes vegetativas foram utilizadas seis espécies. Para colheita das hastes florais, foi estabelecido três estádios de corte, estádio 1: hastes florais dias antes da abertura das flores, estádio 2: hastes florais no início da abertura da (s) primeira (s) flor (es) (antese) e estádio 3: hastes florais com mais de 15 flores abertas, entretanto só se aplicou 2 estádios diferentes para cada espécie. As hastes florais foram padronizadas quanto ao comprimento para 50 cm, e as hastes vegetativas para 70 cm. Das hastes florais foram determinadas as características morfológicas: diâmetro da haste floral, comprimento da inflorescência, diâmetro da inflorescência e massa fresca da haste floral, e das hastes vegetativas: o diâmetro e massa fresca. Após as primeiras avaliações, as hastes foram mantidas a temperatura média de 22 ºC e umidade de 53%. Foi avaliado o número total de dias (longevidade global) pós-colheita em que as hastes florais e vegetativas apresentavam aspectos aceitáveis para uso em vasos. A maior longevidade pós-colheita para hastes florais foi observada nas espécies *Costus woodsoni*, *Costus arabicus* x *Costus spiralis* (Costus Tropicais), e *Costus scaber* (laranja), quando suas hastes florais foram colhidas no estádio 1. Para *Hellenia speciosa* o estádio 3 de colheita apresentou maior longevidade. *H. speciosa* independente do estádio colhido apresentou os maiores valores e *C. woodsonii* os menores valores das características morfológicas. A longevidade pós-colheita das hastes vegetativas das seis espécies foi satisfatória, onde *Costus scaber* (laranja) apresentou menor longevidade e *Costus arabicus* (amarelo) a maior longevidade. *Dimerocostus strobilaceus* apresentou os maiores valores e *Costus arabicus* (rosa) os menores valores das características morfológicas. Tanto as hastes florais quanto as vegetativas de Costus podem ser empregadas para corte.

**Palavras-chave:** Estádio de colheita, plantas tropicais, flores de corte, hastes de corte.

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## 1. INTRODUCTION

The flowers and ornamental plants market is divided by sectors, such as cut flowers and foliage, potted plants, and plants for landscaping and gardening (JUNQUEIRA and PEETZ, 2010, 2014). Cut foliage, or foliated branches, comprise a set of several materials, such as leaves, foliage, pseudocaule, branches, stems or branches without flowers, that exhibit ornamental attributes (OSHIRO et al., 2001; CIOTTA and NUNES, 2012). Cut flowers are flowers, flower buds or inflorescences that may be accompanied by accessories, such as stem and leaves (DAIT, 2015).

The harvest stage is very important for cut flowers since it is directly related to the extension and conservation of their quality (DIAS-TAGLIACOZZO, 2004). The harvest stage of flowers also depends on the market and differs among species. For example, in the Marantaceae family, inflorescences have different harvest stages according to species (LAMAS, 2014). Beehive ginger (*Zingiber spectabile*) can be harvested with younger flowers and stems with yellow bracts showing excellent vase life, or older inflorescences of bracts with reddish color, even though this harvest of Beehive ginger will have lower vase life (ALMEIDA et al., 2014). Orchid cut flowers must be harvested with fully open flowers, preventing premature wilting and guaranteeing that the blooms will be open (PIVETTA et al., 2012).

Among the tropical ornamental plants used in floriculture, species of the family Cactaceae have been more frequently found in the marketplace. These plants can be used as cut flowers or foliage, potted plants, or as landscape and garden plants (CASTRO et al., 2011). The main characteristics of Costaceae are the presence of spiral branches, leaves with spiral phyllotaxy and rhizomatous stem. Stems and leaves may show distinctive green patterns. The species are flowering plants with spike-type inflorescences that initiate at the end of a branch with or without leaves and rarely on leaf axils (Monocostus). The bracts with flowers inside form the inflorescences. The color of the bracts and flowers are diverse and attractive (COSTA et al., 2011).

Few studies have reported on the harvest stage of Costaceae inflorescences and the species with potential for cut flower or cutting stem. Therefore, this study aimed to evaluate the vase life of Costaceae floral and vegetative stems at three different harvesting stages to determine distinct morphological characteristics in the context of vase life.

## 2. MATERIAL AND METHODS

The species examined were *Costus woodsoni*, *Costus pictus*, *Hellinia speciosa*, *Dimerocostus strobilaceus* sub. *strobilaceus*, the natural hybrid *Costus arabicus* x *Costus spiralis* (Costus Tropicales), *Costus spiralis* (red) and *Costus scaber* (orange). The color in parentheses is used to distinguish species in the Germplasm Active Bank (GAB). Plants were obtained from the GAB of the State University of Mato Grosso-UNEMAT, Campus of Cáceres, and were cultivated for a year and two months in full sunlight.

The floral and vegetative stems of Costaceae were harvested by pruning at the soil level, followed by transport to the laboratory in the morning. Three cutting stages were established for floral stems. Stems were cut a few days before flower opening at stage 1, upon opening of the first flower(s) (anthesis) at stage 2, and when floral stems showed more than 15 opened flowers at stage 3. However, only two different stages were applied for each species. *Costus woodsoni*, *Costus arabicus* x *Costus spiralis* (Costus Tropicales), and *Costus scaber* (orange) were harvested at stages 1 and 2 and *Hellinia speciosa* at stages 2 and 3. Floral stems harvested at stage 3 had the flowers and flower buds of the inflorescences removed, leaving only the bracts.

Morphological characteristics evaluated for floral stems included 1) diameter of floral stem (mm) of 50 cm measured from the basal part of the stems, 2) inflorescence length (mm) on longitudinal direction, 3) inflorescence diameter (mm) in the middle, and 4) fresh mass of floral stem (g) without leaves and standardized to 50 cm.

The standardized and leafless floral stems (Figure 1) were cleaned with water and neutral soap and immersed in water for 30 minutes to remove field heat. After this period, stems were transferred to a 500 ml glass container with tap water in a laboratory environment under 22.6 ± 0.83 °C and 53.8% ± 09.05% of humidity. The base of the stems was immersed in water (11 cm), and the water in the flasks was changed every two days.

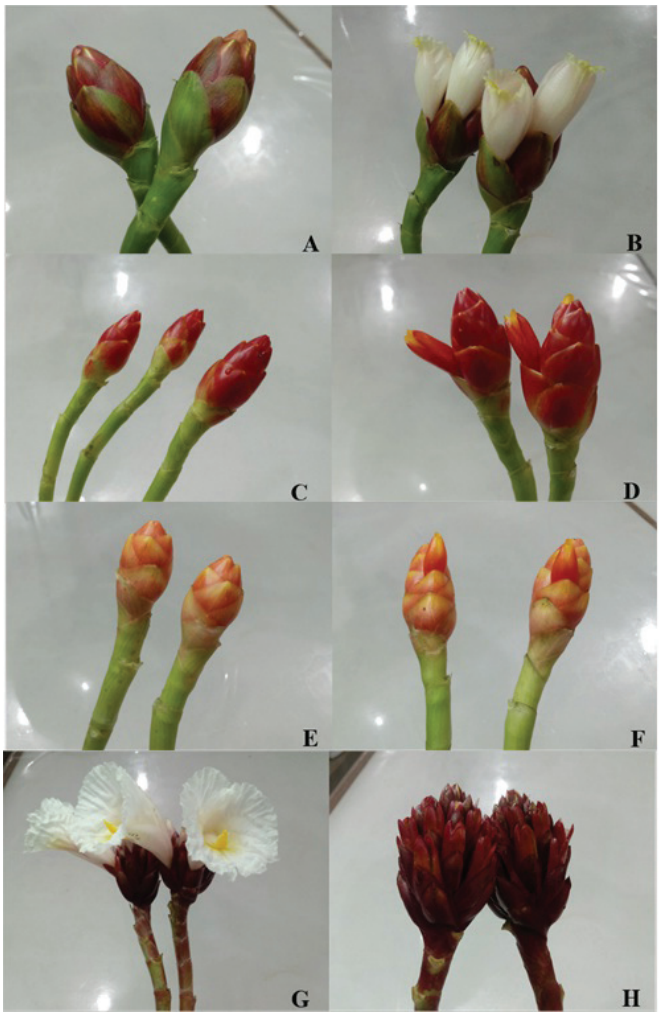


**Figure 1.** Two stages of inflorescence harvesting of four Costaceae species/accesses used in the experiment: *C. arabicus* x *C. spiralis* (Tropical Costus); stage 1 (A) and stage 2 (B), *C. woodsonii*; stage 1 (C) and stage 2 (D), *C. scaber* (orange); stage 1 (E) and stage 2 (F) and *H. speciosa*; stage 1 (G) and stage 2 (H).
1(C) e estágio 2 (D), *C. scaber* (laranja); estágio 1 (E) e estágio 2(F) e *H. speciosa;* estágio 1 (G) e estágio 2 (H).

Evaluation of vase life (days) was performed every two days, analyzing the senescence for the floral stems from cutting to disposal. The senescence parameters analyzed were wilt, loss of color and brightness, spots, yellowing, desiccation of bracts and necrosis. The species used for vase life evaluation of vegetative stem were *Costus pictus*, *Costus spiralis* (red), *Costus scaber* (orange), *Dimerocostus strobilaceus* and *Hellinia speciosa*. The species were selected based on ornamental characteristics stated by Castro et al. (2012), such as straightness and hardness of stem over 50 cm in length and color.

Vegetative stems with excellent form and no injuries were harvested in the field and evaluated for the following morphological characteristics: 1) diameter of stem (mm) measured at the base and 2) fresh mass of vegetative stem (standardized to 70 cm). Subsequently, the vegetative stems were subjected to standardization by the same treatments as those used for floral stems, only differing by the use of 1,000 mL glass containers. The senescence parameters analyzed for vegetative stems were striae, wilt, color loss, firmness, yellowing, desiccation and necrosis.

The experimental design used for post-harvest evaluation of cut flowers and cut stems was completely randomized with 3 replicates containing 5 floral or vegetative stems per replicate with means and standard deviation (±) of the values.

## 3. RESULTS AND DISCUSSION

### Floral cutting stems

The highest vase life was observed for *C. woodsoni*, *C. scaber* (orange) and *C. arabicus* x *C. spiralis* (Costus Tropicales) when their inflorescences were harvested at stage 1, the earliest stage a few days before flower opening, and the average vase life was 9, 9 and 8 days, respectively (Table 1).

**Table 1.** Post-harvest vase life of four species/accessions of Costaceae harvested in two stages.

| Species | Vase Life (days) | Diameter of flower stems standardized (mm) | Length of inflorescences (mm) | Inflorescence diameter (mm) | Fresh standardized mass of floral stems (g) |
|---|---|---|---|---|---|
| Estágio de colheita 1 | | | | | |
| *C. arabicus* x *C. spiralis* (Costus Tropicales) | 8.13 | 10.99 | 56.03 | 24.90 | 51.42 |
| *C. woodsonii* | 9.93 | 9.73 | 42.82 | 17.50 | 35.07 |
| *C. scaber* (orange) | 9 | 11.80 | 46.01 | 22.19 | 56.19 |
| *H. speciosa* | 4 | 12.43 | 62.43 | 44.74 | 69.20 |
| Estágio de colheita 2 | | | | | |
| *C. arabicus* x *C. spiralis* (Costus Tropicales) | 4 | 11.51 | 60.52 | 28.85 | 61.77 |
| *C. woodsonii* | 4 | 9.22 | 49.271 | 19.781 | 36.39 |
| *C. scaber* (orange) | 4 | 11.65 | 54.74 | 25.78 | 64.65 |
| *H. speciosa* | 9 | 12.43 | 73.59 | 48.28 | 68.77 |

The floral stems of *H. speciosa* harvested at stage 3 had a vase life of 9 days, while *C. woodsoni*, *C. scaber* (orange), *C. arabicus* x *C. spiralis* (Costus Tropicales) and *H. speciosa* harvested at stage 2 had a vase life of 4 days. Costaceae species are recommended as cut flowers if they have five days or more of vase life (Castro et al., 2012); consequently, all species studied can be used as cut flowers at one of three harvest stages. Studies with tropical flowers, such as that of Dias et al. (2013), evaluating strelitzia (*Strelitzia reginae*); Carneiro et al. (2014), evaluating torch ginger (*Etlingera elatior*); or Castro et al. (2014) and Sales et al. (2015), evaluating calla lily (*Zantedeschia aethiopica*), all reported the observation that flower stems harvested at earlier stages had greater vase life. However, Dias and Castro (2009) did not report vase life differences between harvest stages for torch ginger (*Zingiber spectabile*). Costaceae can be harvested at different flowering stages, either early or more developed, depending on the species. Species with juxtaposed and imbricated bracts should be harvested later on during full development, but all species must be harvested without damage, healthy and without signs of senescence (CASTRO et al., 2012).

*Tapeinochilos ananassae* is the only Costaceae with standardized cut flower stage cited in literature. *Tapeinochilos ananassae* inflorescences are classified as Type A with inflorescences having the same length and diameter, intense red color, pseudocaule above 40 cm, and diameter > 1 cm, or Type B with pseudocaule smaller than 40 cm and diameter < 1 cm (LOGES et al., 2005). Loges et al. (2005) reported that *Costus barbatus*, *Costus speciosus*, *Costus scaber*, *Costus stenophyllus* and *Costus spicatus* should be harvested with an 80 cm stem. Since information about the harvest stage of tropical flowers is scarce, producers are doing their own post-harvest tests in order to find the best stage(s) for commercialization and market acceptance.

The poor durability of *C. woodsoni*, *C. scaber* (orange), *C. arabicus* x *C. spiralis* (Costus Tropicales) and *H. speciosa* inflorescences harvested at stage 2 is probably related to the retention of flowers into the bracts. These flowers start to decompose, giving the inflorescences an unpleasant appearance, and as this process advances, the bracts become dark and have a burned appearance. Inflorescences of *C. woodsoni*, *C. scaber* (orange), *C. arabicus* x *C. spiralis* (Costus Tropicales) and *H. speciosa* on the day of harvest showed an optimal appearance. Two days later, the inflorescences still had acceptable quality with two to three flowers adhered to the inflorescence. At four days post-cutting, the second evaluation found deterioration of the flowers in inflorescences. Consequently, the floral stems were discarded, even if the stems still had an acceptable characteristic color on most of the bracts. However, due to the potential of the species as a cut flower, the requirement to remove the flowers of inflorescences is not an impediment to use these species as cut flower (CASTRO et al., 2011). It is also important to note that the characteristic of retaining flowers in the inflorescences does not occur in all Costaceae species. As shown by Castro et al. (2011), only two of 12 species studied exhibited flowers constrained to the bracts after senescence. This characteristic does not exclude the use of these species as cut flowers, especially if they have good productivity, high durability and market acceptance. Studies in breeding programs and new techniques should be directed towards these species in order to overcome this characteristic. Cut flowers harvested early in the opening of the flowers with flower retention characteristic may be

used for short-lived floral decoration. When Costaceae inflorescences are harvested with open flowers, additional care should be taken to prevent mechanical damage, which would depreciate their quality, essentially because these beautiful flowers are very delicate, especially the bigger ones like *H. speciosa*. After inflorescences are discarded 4 to 5 days after harvest, we observed that *C. arabicus* x *C. spiralis* (Costus Tropicales) and *H. speciosa* no longer opened their flower buds, while *C. woodsoni* and *C. scaber* (orange) continued to open their flowers 4 to 5 days after being discarded, but the flowers were smaller.

The main signs of senescence for *C. woodsoni*, *C. scaber* (orange), and *C. arabicus* x *C. spiralis* (tropical costus) harvested at stage 1 were yellowing of stems and spots on bracts. *H. speciosa* at stage 1 showed darkening of stem and bracts. These species showed characteristic flower retention on bracts. The stems of all species from harvest to disposal were straight, firm and resistant with no occurrence of tipping or distortion. According to Stumpf et al. (2008), firmness of stem is a key feature for handling and transporting where there is no requirement for artificial support.

Flowers harvested very early or later may have reduced vase life, producing losses to the producer and low quality. Thus, cut flowers should be harvested prior to full development to have greater longevity, while, at the same time, recognizing the characteristics of each species, the distance to market and consumer preference (DIAS, 2016).

*H. speciosa* showed the largest floral stem diameter, while the smallest stem diameter was observed for *C. woodsonii*. As expected, all species harvested at stage 1 displayed smaller length and diameter of inflorescences. *H. speciosa* harvested at stage 3 had the longest inflorescences, and *C. woodsonii* harvested at stage 1 had the smallest inflorescences. Inflorescence length for Costaceae cut flowers must be between 4 and 20 cm (CASTRO et al., 2012); consequently, all the studied species not considering the harvesting stage are within the recommended size for cut flower.

The variable standard fresh mass of the floral stem is very important, mainly for transportation. *H. speciosa* had stems with most fresh mass, while *C. woodsonii* had the least fresh mass. According to Castro et al. (2012), floral stems have to be light, i.e., between 30 and 250 grams, in consideration of transportation cost. Thus, all species in the present study meet this requirement.

**Vegetative cutting stems**

*C. arabicus* (yellow) showed the longest vase life with 30 days, while *C. scaber* (orange) had the shortest vase life with 10 days (Table 2). According to Castro et al. (2012), a vegetative stem must have a vase life longer than 10 days to be used as a cut stem. Even though *C. scaber* (orange) had the shortest vase life, it could be used as decoration for short to medium periods.

**Table 2.** Post-harvest vase life of vegetative stems of six species/accessions of Costaceae.

| Accessions | Vase Life (days) | Diameter of stem (mm) | Fresh mass standardized (g) |
|---|---|---|---|
| *C. arabicus* (pink) | 30 | 10.97 | 45.60 |
| *D. strobilaceus* | 21 | 21.71 | 159.72 |
| *C. pictus* | 21.70 | 13.85 | 68.35 |
| *C. spiralis* (red) | 12.26 | 15.38 | 95.66 |
| *C. scaber* (orange) | 10.52 | 16.20 | 90.16 |
| *H. speciosa* | 18.25 | 20.65 | 137.94 |

Evaluating the vase life of *Costus stenophyllus* stems at 21 °C, Souza et al. (2013) observed that the stems had a vase life of 60 days. Another important characteristic shown by the cut stems was the firmness from harvest to discard. According to Stumpf et al. (2008), this characteristic allows their use in different arrangements and floral compositions.

Stems of the six studied species showed different colors and adornments of green, gray, brown and purple. These cut stems are very distinct if compared to the traditional cutting stems and very attractive (Figure 2).

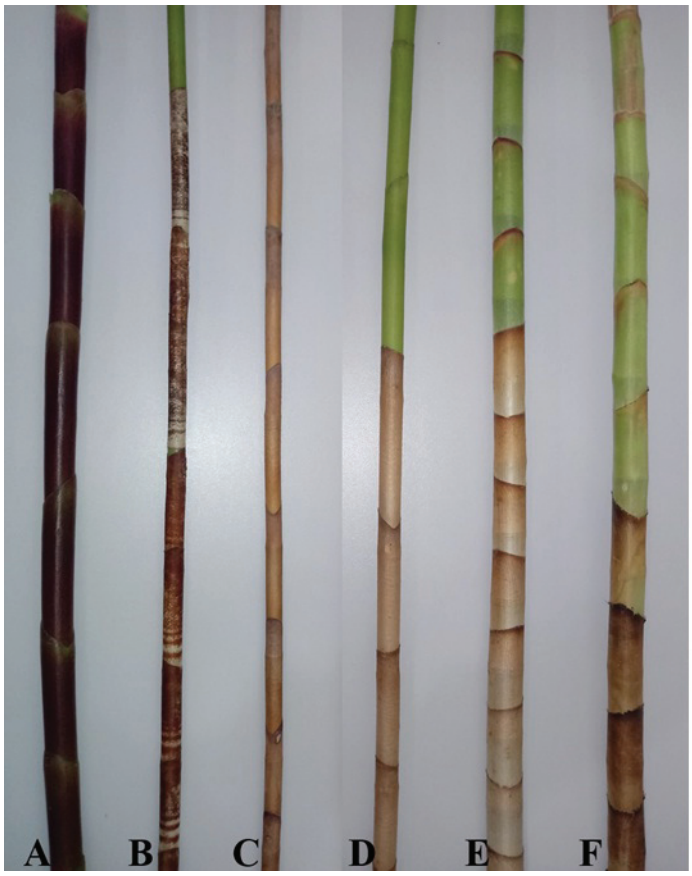


**Figure 2.** Vegetative stems of six Costaceae species/accessions used in the experiment. A - *C. spiralis* (red), B - *C. pictus*, C - *C. arabicus* (pink), D - *C. scaber* (orange), E- *D. strobilaceus* and F - *H. speciosa*.

The flower market is always looking for new products, such as new colors and shapes. *H. speciosa* and *D. strobilaceus* cut stems changed their colors during the experiment, turning parts of the stems from green to gray. The stems of *H. speciosa* had a pinkish-gray color, and *D. strobilaceus* stems had a gray color with brown spots. Since these stems had a good ornamental appearance, they were maintained after the color change. According to Stumpf et al. (2008), gray is a neutral color and very suitable for floral art in combination with several colors.

The senescence of the cut stems was characterized by desiccation of the apex. Other signs of senescence were specific to each species. The end of the *C. arabicus* stem where it was not covered by fiber changed from green to yellow and was excluded. *C. pictus* stems wilted at the end of the experiment, and some stems that reached 20 days of vase life had to be discarded owing to the emission of roots and shoots. The green part of the *C. scaber* (orange) stem turns to yellow, and the *C. spiralis* (red) stem changes color from red to pink and was discarded at this stage. *H. speciosa* and *D. strobilaceus* stems changed their colors and showed colored stripes. The stems were discarded when the end of stems faded, decreased in diameter, and the base of the stem became dark.

The production of cut stems started in the early 2000s, and since then, production has increased every year and is highly sought for arrangements (PADILHA et al., 2017). In the past, the production of cut foliage and stems was not relevant because this activity was an extractive practice. To use Costaceae for cut stems, Castro et al. (2012) recommend that stems be straight and firm and that stems be longer than 50 cm in length and at least 2 cm in diameter. All studied species here meet the first three requirements; however, only two species showed diameters > 2 cm.

*C. arabicus* (pink) had the smallest diameter with 10.97 mm, while *D. strobilaceus* had the largest diameter with 21.71 mm. *H. speciosa* and *D. strobilaceus* were the species with a diameter of 2 cm. However, this is not a limiting factor since other ornamental species have smaller diameters and are still very marketable. *C. arabicus* (pink) had the smallest diameter and greatest vase life; thus, a smaller diameter does not tend to delay vase life. Fresh mass analyses showed that *C. arabicus* (pink) had lighter stems at 45.06 g and that *D. strobilaceus* had heavier stems at 159.72 g.

## 4. CONCLUSIONS

Stage 1 provides a longer vase life for *C. woodsoni*, *C. scaber* (orange), and *C. arabicus* x *C. spiralis* (Costus Tropicales) floral stems, while stage 3 provides longer vase life for *H. speciosa*. *H. speciosa* having the highest values of morphological characteristics and *C. woodsonii* the lowest values. Vase life of the vegetative stems of all species/accessions is satisfactory. *C. scaber* (orange) has

the shortest vase life, and *C. arabicus* (yellow) has the longest. *D. strobilaceus* has the highest morphological characteristics, while *C. arabicus* (pink) has the lowest. *C. arabicus* (pink) has the lightest stems with 45.06 g, and *D. strobilaceus* has the heaviest at 159.72 g.

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**M.A.S.J.** 0000-0001-5956-8926: Conception or design of the work, data collection, data analysis and interpretation, drafting the article. **P.B.L.** 0000-0003-4067-0087: Conception of the work, data analysis and interpretation, drafting and critical revision of the article, final approval of the version to be published. **C.F.C.P.P.B.** 0000-0002-1779-4017: Data collection, data analysis and interpretation, drafting the article. **C.M.M.** 0000-0002-3065-4422: Data collection, data analysis and interpretation, drafting the article.

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