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Technical Article

# Heliconias with pendent inflorescences as cut flowers

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**Abstract**

The *Heliconia* species with pendent inflorescences and colorful bracts are a good option as a cut flower for floriculture market, but only a few species of this type of Heliconia eg. *H. rostrata, H. rauliniana* and *H. chartacea* are commercially produced in Brazil. This study was carried out to characterize 36 *Heliconia* accessions, with pendent inflorescences, to be used as cut flower, intending to increase knowledge and use of these exceptional plants among tropical flower enthusiasts and consumers. The evaluations were performed on plants of the Germplasm Collection of the Instituto Agronômico (IAC) growing in shade, partial shade or full sun conditions. Qualitative and quantitative characteristics, related to clump growth and flower stem aspects were analyzed. A point scoring system was used to determine the species most suitable for cut flower utilization. All evaluated genotypes reached enough points to be considered suitable for use as cut flowers, even those with large inflorescences and bracts arranged in different planes, facts that affect and limit handling, packaging and transportation. *H. mariae, H. fernandezii, H. platystachys, H. rauliniana, H. rostrata, H. standley, H. necrobracteata* and *H. laxa* were considered outstanding. This characterization and scoring system were important to facilitate the selection of heliconia genotypes for use as cut flowers.
**Keywords**: heliconias, scoring system, selection, tropical flowers, tropical plants.

**Resumo**

**Helicônias com inflorescências pendentes como flores de corte**

As espécies de *Heliconia* com inflorescências pendentes e brácteas coloridas são uma boa opção para o mercado de flores de corte, mas apenas algumas espécies de *Heliconia,* por exemplo. *H. rostrata*, *H. rauliniana* e *H. chartacea*, são comercialmente produzidas no Brasil. Este estudo foi realizado para caracterizar 36 acessos de diferentes espécies, com inflorescências pendentes para serem utilizadas como flor de corte, visando a aumentar o conhecimento e a utilização destas plantas excepcionais pelos consumidores e entusiastas das flores tropicais. As avaliações foram realizadas em plantas da Coleção de Germoplasma do Instituto Agronômico (IAC) Ubatuba, São Paulo, Brasil, crescendo em condição de sombra, sombra parcial ou pleno sol. Foram analisadas características qualitativas e quantitativas relacionadas ao crescimento da touceira e características da haste floral. Um sistema de pontuação foi usado para determinar as espécies mais adequadas para a utilização de flores de corte. Todos os genótipos avaliados foram adequados para serem usados como flores de corte, mesmo as de inflorescências grandes e brácteas dispostas em vários planos, fatos que afetam ou dificultam o manuseio, embalamento e transporte. *H. mariae*, *H. fernandezii*, *H. platystachys*, *H. rauliniana*, *H. rostrata*, *H. standley*, *H. necrobracteata* e *H. laxa* foram considerados excelentes. Esta caracterização e sistema de pontuação foram importantes para facilitar a seleção de genótipos de helicônias como flores de corte.
**Palavras-chave:** helicônias**,** sistema de pontuação, seleção, flores tropicais, plantas tropicais.

## Introduction

The number of accepted species in Heliconia genus, valid in the Index Kewensis is 203 (Govaerts et al., 2016). Intragenic classifications, compiled by Andersson (1981; 1985) and Kress et al. (1999) subdivide *Heliconia* into the subgenera *Taeniostrobus* (4 species), *Heliconia* (43 species in 6 Sections), *Stenochlamys* (56 species in 6 Sections, *Heliconiopsis* (6 species) and *Griggsia* (94 species in 11 Sections). The first four subgenus comprise species

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with upright inflorescences, *Heliconiopsis* comprises species with upright inflorescences and also with pendent inflorescences and *Griggsia* with pendent inflorescences species only.

Heliconia is an ornamental plant with exotic style (Linares-Gabrie et al., 2019), known as lobsters' claw, parrots flower, parrot's plantain, or false plantains (Buzard, 2019). Its ornamental appeal as cut flowers can be attributed to the attractive bracts that frame and protect the flowers, with several shapes and intense colors, often with contrasting colors that increase their acceptance by the consumer. However, although several species have great potential for use as cut flowers, just a few species have been cultivated for this purpose (Castro, 1995; Loges et al., 2014).

*Heliconia* species for cut flowers use should have small, light and, upright inflorescences, with a long post-harvest durability and with reduced diameter stems. Species with pendent inflorescences have an extra high market value, but could presents packaging difficulties (Watson and Smith, 1979), due its forms and dimensions. Long and wide flowers are directly related to packaging and transportation processes, once they may be damage by scrap among bracts and impacts from the package (Araújo et al., 2018). These characteristics, in part, explain the predominant trade of heliconias with upright inflorescences compared to the species with pendent inflorescences. In addition, the minor commercialization is also due to packaging complexities, once pendent inflorescences are large and heavy, and due to the lack of knowledge of the diversity of *Heliconia* species with inflorescences of this kind, which are similar in number to species with upright inflorescences.

Scheme of evaluation of some heliconia species as suitable for cut flower, using a scoring point system (Castro, 1993). This system considers that the use of heliconias as a cut flower results from the consumers' demand and the observation of characteristics, such as stem size and floral inflorescence, shape, size, vigor, distribution, presence of wax and/ or hairiness in the bracts, abscess of bract flowers, number of inflorescences per plant in the crop cycle and durability of inflorescences. These characteristics affect the inflorescence harvest, handling and packaging, transport and storage. The stems of inflorescences, of most species of heliconias, are kept only in clean water with or without phenolic foam, composing all kinds of decorative arrangements, of short or long durability (Castro, 1995; Castro et al., 2007; Castro et al., 2011; Loges et al., 2014; Loges et al., 2016).

The expansion of the tropical floriculture market is based on the beauty, exoticism, and post-harvest longevity of cut flowers (Dias, 2016). This market niche, of economic importance in tropical countries, has a constant demand for new products, so the objective of this work was to evaluate 36 species of heliconias with pendent inflorescences and to test indicators for the characterization and selection of cut inflorescences, not yet introduced in commercial crops.

## Material and methods

Accessions clumps, with five years of cultivation, of 36 heliconias species with pendent inflorescences were evaluated (Table 1).

**Table 1**. Heliconia species evaluated in the experiment with pending inflorescences.

| | | | |
|---|---|---|---|
| 1 | *H. chartacea* Lane *ex* Barreiros | 19 | *H. obscura* Dodson & Gentry |
| 2 | *H. colgantea* R.R. Smith *ex* Daniels & Stiles | 20 | *H. pendula* Wawra |
| 3 | *H. collinsiana* Griggs | 21 | *H. penduloides* Loes. |
| 4 | *H. combinata* Abalo & Morales | 22 | *H. platystachys* Baker |
| 5 | *H. dielsiana* Loes. | 23 | *H. pogonantha* Cufod. |
| 6 | *H. fernandezii* Abalo & Morales | 24 | *H. ramonensis* Daniels & Stiles |
| 7 | *H. flabellata* Abalo & Morales | 25 | *H. rauliniana* Barreiros |
| 8 | *H. griggsiana* L.B. Smith | 26 | *H. regalis* L. Anderss. |
| 9 | *H. huilensis* Abalo & Morales | 27 | *H. reptans* Abalo & Morales |
| 10 | *H. juruana* Loes | 28 | *H. revoluta* (Griggs) Standley |
| 11 | *H. laxa* Abalo & Morales | 29 | *H. rostrata* R.P. |
| 12 | *H. longissima* Abalo & Morales | 30 | *H. standleyi* Macbr. |
| 13 | *H. magnífica* Kress | 31 | *H. stella-maris* Abalo & Morales |
| 14 | *H. marginata* (Griggs) Pittier | 32 | *H. stilesii* Kress |
| 15 | *H. mariae* Hook. F. | 33 | *H. trichocarpa* Daniels & Stiles |
| 16 | *H. mutisiana* Cuatrec. | 34 | *H. vellerigera* Poepp. |
| 17 | *H. necrobracteata* Kress | 35 | *H. villosa* Kl. |
| 18 | *H. nutans* Woodson | 36 | *H. xanthovillosa* Kress |

The accessions used on the study are part of the Germplasm Bank of Ornamentals Zingiberales of IAC/APTA in the Research and Development Unity of Ubatuba (23°26´02´´S-45°04´16´´W) with annual rainfall of 2,700 mm and 6 meters above sea, located in the municipality of Ubatuba, São Paulo State, Brazil. Soil moisture was assessed as extremely high (swampy or waterlogged), high (edge of streams) or medium.

The plants were cultivated under full sun, half or intense shade, medium humidity soils, humid sites near streams or extremely humid sites with a tendency to soil soak in certain seasons. Other subsequent evaluations or measurements as plant height, formation of clumps with area, flowering season, and number of flowers, and inflorescences/cycle, provided the data of the general characteristics of the plants, cultivation environment and production of inflorescences.

The plant height comprised the distance between the base of the stems and the apex of the highest leaf. Clump formation considered the area occupied by the plant and was classified as small (less than 1 $m^2$), medium (between 1 and 2 $m^2$) or large (greater than 2 $m^2$). The preferential exposure was identified as being full sun, half shade or shade. The

flowering season comprised the time between the emission of the first inflorescence/clump and the appearance of the first signs of senescence of the last inflorescence emitted in the clump/cycle. The number of inflorescences/cycle was the total number of inflorescences developed in the clump during the flowering period.

Data were collected for three years, regarding the characteristics of the inflorescences described in Table 2. The data were compared with information available in the literature concerning the original description of the species to identify anomalies during the development process.

**Table 2**. Classification of the characteristics of heliconias inflorescences.

| **Inflorescences** | **Classification** | | | |
|---|---|---|---|---|
| Inflorescence length | small (up to 0.80 m), | | medium (0.81 and 1.50 m) | large (above 1.51m) |
| Number of bracts | | | | |
| Plan of insertion of bracts | same plan | | different plan | |
| Overlapping of bracts | free | | overlapping bracts | |
| Type and color of the rachis | straight and predominant color | | sinuous and predominant color | |
| Length of intermediate bracts (cm) | small (up to 10.0) | medium (between 10.1 and 20.0) | large (between 20.1 and 30.0 cm) | very large (over 30.1 cm) |
| Number of flowers per bract | | | | |
| Hairiness of bracts | very hairy | | little hairy | without hair |
| Waxiness of bracts | very waxy | | little waxy | without wax |
| Color of the bracts | | | | |
| Diameter of the floral stem (cm) taken 70 cm below the insertion of the inflorescence | thin (up to 1.0) | | medium (between 1.1 and 3.0) | large (above 3.1) |
| Stem firmness | firm | | intermediate | flaccid |
| Height of the floral stem and | light (up to 200.0 g) | | medium (between 200.1 and 500.0 g) | heavy (above 500.0 g) |

The selection of a species suitable for commercialization as a cut flower was made by points attribution to the characteristics stem firmness, flowering period, inflorescence production in each cycle, average post-harvest durability of the inflorescence, visual impact, suitability for handling and harvesting, packaging and transport, and resistance to transport.

The stem firmness stiffness characteristic considered were firm (4 points), floral stems with medium resistance to tipping (2 points) and fragile floral stems with tipping (0 point). The flowering period considered 3 scoring ranges long period (over 4 months - 4 points); medium (between 2 and 4 months - 2 points) and short (up to 2 months - 1 point). The production of inflorescences per clump was classified as high (more than 30 inflorescences/clump - 3 points), medium (between 15 and 30 inflorescences/clump - 2 points) and low (less than 15 inflorescences/clump - 1 point). The post-harvest durability of the inflorescences was evaluated by compiling the number of days in which inflorescences harvested and kept in water, remained in perfect condition and were classified as high (over 12 days - 6 points), medium (between 7 and 12 days - 4 points) and low (below 7 days - 2 points). The inflorescence was considered to be in a perfect state of conservation when the general appearance of recently harvested was maintained, with turgor, brightness, without signs of browning on the bracts, no stem tipping and with axis and pointer maintaining its original position. Signs of senescence were noted daily. The purchase impulse to acquire fresh inflorescences, estimated by 50 evaluators, were defined by a buying tendency measurement scale as high (above 80% - 3 points), medium (between 79 and 50% - 2 points), low (between 49 and 20% - 1 point) or nonexistent (between 19 and 0% - 0 points). The attributes and requirements of inflorescence manipulation were defined to identify the ease of handling and harvesting, transportation, packaging, and resistance to transportation. The ideal inflorescences for handling were those that meet the characteristics (1 point for each) inflorescences in a single plane, inflorescences with little or without hairiness, inflorescences with little or without wax, inflorescences of medium or small size, inflorescences with medium or small sized intermediate bracts; light or intermediate inflorescences; less than 10 flowers in bracts; thin or intermediate floral stems and firm stems and bracts with a firm or imbricate texture (10 points). The packaging characteristics considered the characteristics (1 point for each item) inflorescences in a single plane, inflorescences with medium or small size, inflorescences with intermediate bracts of medium or small size, light or intermediate

inflorescences, less than 10 flowers/bracts, thin or intermediate floral stems, firm stems, bracts with firm texture or imbricated, possibility of commercialization in boxes, which included the combined evaluation of the size, height and plan of insertion of the bracts (9 points). The transportation characteristics considered were (1 point for each item) inflorescences in a single plane, inflorescences with little or without wax; medium or small size inflorescences, inflorescences with intermediate bracts of medium or small size, light or intermediate inflorescences; less than 10 flowers/bracts; thin or intermediate floral stems; bracts with a firm or imbricated texture, firm stems, possibility of commercialization in boxes that included the combined evaluation of the size, height and insertion plan of the bracts (10 points). Extra points (3 points) was given to species with bracts with a firm or imbricated texture for simplifying harvesting and marketing processes, species with dark color bracts such as purple or red for delaying signs of senescence, and with a high post-harvest longevity for increasing marketing period. The maximum score obtained for a species was 52 points. The application of the scale of points allowed the definition of the species as little suitable (below 13), moderately suitable (between 13 and 39) and very suitable (above 39) for use as cut flowers.

## Results and Discussion

The species (Figure 1), classified in 10, of the 11 Sections of the subgenus *Griggsia*, namely, *Griggsia*, *Barbatae*, *Longae*, *Obscurae*, *Dromedarius*, *Sigmoideae*, *Rostratae*, *Pendulae*, *Contortex* and *Retiformes* showed a musoid habit, and *H. juruana*, presented a canoid growth habit, according to Watson and Smith (1979).

*H. magnifica*, *H. revoluta*, *H. villosa*, *H. mutisiana*, *H. obscura* and *H. stella-maris* growth better on sites with intense shade. *H. ramonensis*, *H. chartacea*, *H. flabellata*, *H. marginata* and *H. rostrata* growth better on sites under full sun (Table 3).

Half shade conditions were favorable to the other species. Heliconia cultivation under not ideal conditions affects the vigor of plants with unsatisfactory growth or etiolation, delay of flowering time and fewer inflorescences produced. The quality of the inflorescences is also affected, mainly in the size and color of the bracts and, post-harvest longevity. Lower levels of incident solar radiation on *H. bihai* stimulate flower stems production and greater vegetative growth (Lima et al., 2016). Heliconia ideal habitat vary a lot, depends on the species, *H. stricta* 'Iris' performs well at lower light intensity (30% to 35%), with improved light use, carbon gain efficiency, and improved reactive oxygen species (ROS) scavenging mechanism, resulting in high quality inflorescences (Nihad et al., 2019). The full sun environment can reduce yield and quality of *H. psittacorum* 'Golden Torch' inflorescences (Souza et al., 2016).

Regarding soil moisture, only *H. marginata* showed better development in conditions of extreme humidity, in seasonally soaked sites. Most of the species growth better in conditions of high soil moisture (edge of streams). The association of half shade and soils with high humidity proved to be the most suitable condition for plant growth to most of the species.

The area occupied by the clump of plants was small for *H. platystachys*, *H. marginata* and *H. penduloides*. As result of a smaller clump area, fewer inflorescence production per cycle was observed. The plant height, considering the most suitable growing environment conditions, varied from 1 to 1.2 m as observed for *H. stella-maris*, up to 4 to 7.5 m for *H. pogonantha* and *H. mariae*. Most species had a height higher than 2 m. All species produced large inflorescences; remarking that *H. villosa*, *H. stella-maris* and *H. marginata* had the smallest inflorescences and *H. pogonantha*, *H. vellerigera* and *H. longissima* the largest inflorescence. The size of the inflorescences was compatible with plant height.

The type of rachis defines the plane of insertion of the bracts in the axis of an inflorescence. Most of the species were characterized by having a sinuous rachis, which places the insertion of bracts in different planes (Table 4).


**Figure 1**. Heliconia with pending inflorescences evaluated to define the suitability for commercialization as cut flower.

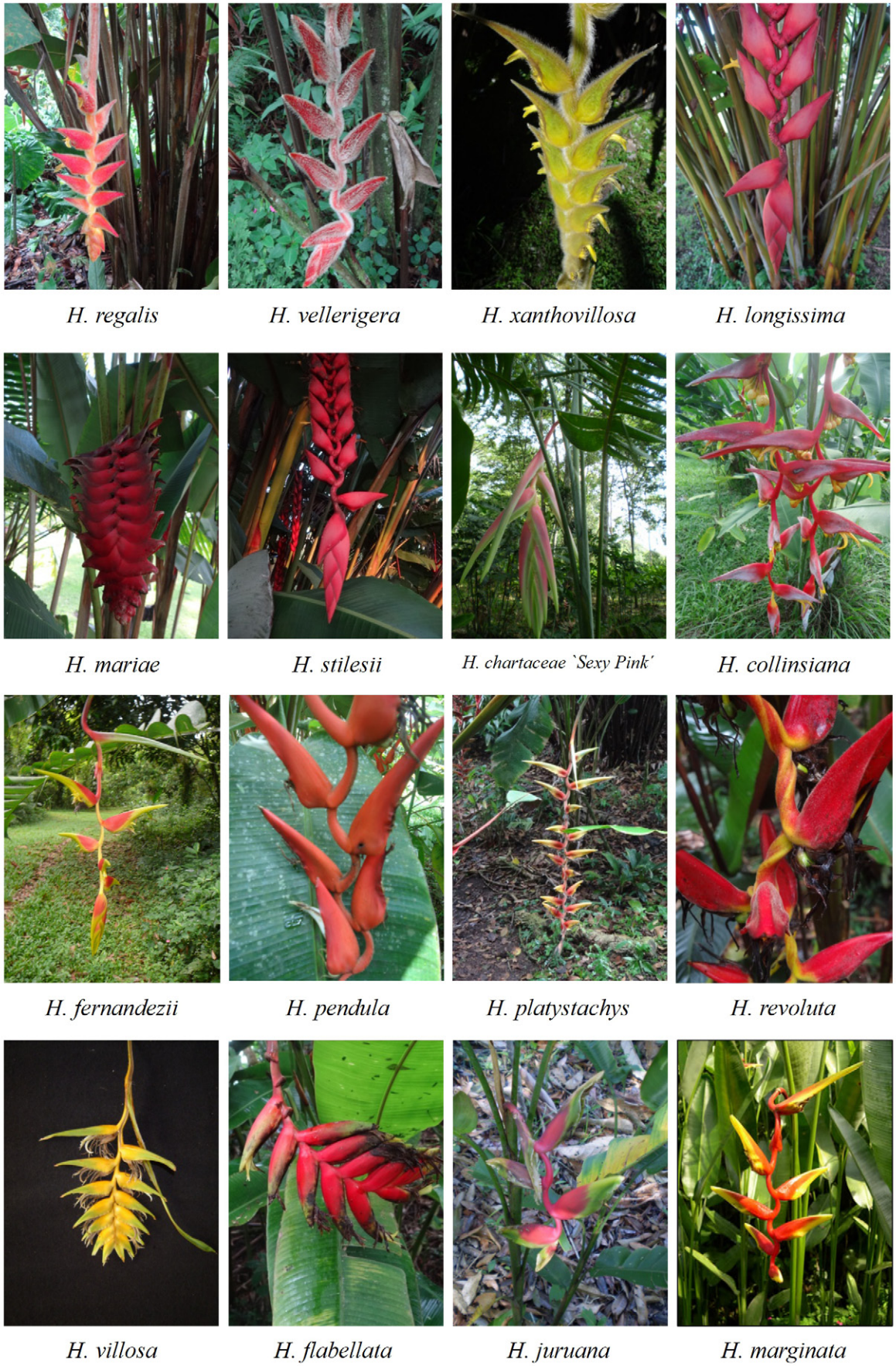


**Figure 1**. cont.

*H. rauliniana* *H. rostrata* *H. standleyi* *H. colgantea*

*H. dielsiana* *H. necrobracteata* *H. penduloides* *H. reptans*

*H. trichocarpa* *H. combinata* *H. laxa* *H. mutisiana*

*H. obscura* *H. nutans* *H. huilensis* *H. stella-maris*

**Figure 1**. cont.

**Table 3**. Data referring to the general characteristics of the plants of 36 Heliconia species.

| Specie | Section | Habit of the plant | Preferential exposure | Moisture of the soil | Sprouting and occupied area ($m^2$) | Plant height (m) | Inflorescence size (m) |
|---|---|---|---|---|---|---|---|
| *H. griggsiana* | *Griggsia* | musoid | Half shade | Medium | Medium (2.2) | 5-6 | 1.2 |
| *H. magnifica* | *Barbatae* | musoid | Shade | High | High (3.2) | 4-6 | 0.95 |
| *H. pogonantha* | *Barbatae* | musoid | Half shade | High | High (2.7) | 4-7.5 | 1.6 |
| *H. ramonensis* | *Barbatae* | musoid | Full sun | Medium to High | High (2.6) | 2.5- 6 | 0.9 |
| *H. regalis* | *Barbatae* | musoid | Half shade | Medium | High (2.7) | 4-6 | 1.0 |
| *H. vellerigera* | *Barbatae* | musoid | Half shade | High | High (3.2) | 4-7 | 1.0-1.5 |
| *H. xanthovillosa* | *Barbatae* | musoid | Half shade | High | High (3.6) | 3.5-4.5 | 0.86 |
| *H. longissima* | *Longae* | musoid | Half shade | Medium | High (2.4) | 2-4 | 1.8-2.1 |
| *H. mariae* | *Longae* | musoid | Half shade | High | Medium (2.3) | 4-7.5 | 0.65 |
| *H. stilesii* | *Longae* | musoid | Half shade | High | High (2.6) | 5-6 | 1.0 |
| *H. chartaceae* | *Pendulae* | musoid | Full sun | High | High (2.6) | 2-4 | 0.40 a 1.20 |
| *H. collinsiana* | *Pendulae* | musoid | Half shade | Medium | High (3.1) | 4-6 | 0.72 |
| *H. fernandezii* | *Pendulae* | musoid | Half shade | High | Medium (2.2) | 4-5 | 0.85-1.1 |
| *H. pendula* | *Pendulae* | musoid | Half shade | High | Medium (2.2) | 2.5-4.5 | 0.45-0.95 |
| *H. platystachys* | *Pendulae* | musoid | Half shade | High | Low (1.7) | 3-4 | 1.0 |
| *H. revoluta* | *Pendulae* | musoid | Shade | High | Medium (2.1) | 2-3 | 0.45-0.6 |
| *H. villosa* | *Pendulae* | musoid | Shade | High | Medium (2.0) | 1.5-4 | 0.25-0.3 |
| *H. flabellata* | *Rostratae* | musoid | Full sun | High | High (2.6) | 1.5-3 | 0.6-0.8 |
| *H. juruana* | *Rostratae* | canoide | Half shade | High | Medium (2.0) | 2-4 | 0.46 |
| *H. marginata* | *Rostratae* | musoid | Full sun | Extremely High | Low (1.7) | 2-3 | 0.4 |
| *H. rauliniana* | *Rostratae* | musoid | Half shade | High | High (2.5) | 2-3 | 0.28-0.3 |
| *H. rostrata* | *Rostratae* | musoid | Full sun | Medium | Medium (2.2) | 2-5 | 0.90 |
| *H. standleyi* | *Rostratae* | musoid | Half shade | Medium | Medium (2.2) | 5-6 | 0.55 |
| *H. colgantea* | *Sigmoideae* | musoid | Half shade | High | Media (2.3) | 2-3.5 | 0.4-0.7 |
| *H. dielsiana* | *Sigmoideae* | musoid | Half shade | High | High (2.4) | 2-4 | 0.8 |
| *H. necrobracteata* | *Sigmoideae* | musoid | Half shade | Medium | Medium (2.0) | 4-4.5 | 0.4-0.55 |
| *H. penduloides* | *Sigmoideae* | musoid | Half shade | Medium | Low (1.8) | 3 | 0.80 |
| *H. reptans* | *Sigmoideae* | musoid | Half shade | High | Medium (2.0) | 1.2-2.2 | 0.8-1.4 |
| *H. trichocarpa* | *Sigmoideae* | musoid | Half shade | High | Medium (2.3) | 2-4 | 0.65 |
| *H. combinata* | *Obscurae* | musoid | Half shade | High | Medium (2.2) | 2-3.5 | 0.8-1.6 |
| *H. laxa* | *Obscurae* | musoid | Half shade | High | Medium (2.0) | 1-2 | 0.6-0.85 |
| *H. mutisiana* | *Obscurae* | musoid | Shade | High | Medium (2.3) | 2.5-4 | 0.60 |
| *H. obscura* | *Obscurae* | musoid | Shade | High | Medium (2.3) | 1.5-2.5 | 0.50 |
| *H. nutans* | *Contortex* | musoid | Half shade | High | Medium (2.0) | 1-2.5 | 0.55 |
| *H. huilensis* | *Dromedarius* | musoid | Half shade | Medium | Medium (2.0) | 1.5-3 | 0.6-1.3 |
| *H. stella-maris* | *Retiformes* | musoid | Shade | Medium | Medium (2.2) | 1-1.2 | 0.3-0.6 |

**Table 4**. The characteristics of the rachis, bracts and flowers of 36 species of Heliconia.

| Specie | Type and color of the rachis | Number, insertion plan and imbricate bracts | Length of intermediate bracts (cm) and texture | Hairiness of bracts | Wax on bracts | Color of the bracts | Number of flowers/ bracts |
|---|---|---|---|---|---|---|---|
| *H. griggsiana* | Sinuous Red, sometimes yellow | 13-28 Diverse plans Free | 15-18 Firm | Few | Very | Green with base and borders yellow, or reds to dark purple | Up to 15 |
| *H. magnifica* | Sinuous red to purple | Up to 35 Diverse plans Free | 8-10 Firm | Very | Without | Red to purple | 10-15 |
| *H. pogonantha* | Sinuous red to yellow | 20-55 Diverse plans Free | 8-12.5 Firm | Few | Without | Red, orange and yellow | 10 a 30 |
| *H. ramonensis* | Sinuous red to pink to yellow | 20 to 40 Diverse plans Free | 7-11 Firm | Very | Without | Red to pink-yellow or pink | 10 a 30 |
| *H. regalis* | Sinuous yellow, orange or red | 15 to 30 Diverse plans Free | 18-20 Firm | Very | Without | Orange, red or pink | Up to 20 |
| *H. vellerigera* | Very Sinuous red and hairy with brown hairs | 20-45 Diverse plans Free | 8-12 Firm | Very | Without | Red, woolen, with wool with cream color | 20-35 |
| *H. xanthovillosa* | Sinuous shiny yellow | Up to 35 Same plan Free | 8-10 Firm | Very | Without | Bright yellow woolen | 12 a 20 |
| *H. longissima* | Sinuous red | 30-55 Diverse plans Free | 10-14 Firm | Without | Few | Red | 11 a 18 |
| *H. mariae* | Little Sinuous red yellow | 40-65 Same plan Imbricate | 5-6.5 Firm | Without | Few | Pink to red | 20-30 |
| *H. stilesii* | Very Sinuous red | 20-35 Same plan Free | 8.5-9 Firm | Few | Few | Pink-red, pubescent. | 10-20 |
| *H. chartaceae* | Sinuous Pink or red | 14-18 Diverse plans Free | 13-20 Flaccid | Without | Very | Red or pink with borders pink or green | 12 |
| *H. collinsiana* | Sinuous red, sometimes yellow | 7-18 Diverse plans Free | 15-20 Flaccid | Without | Very | Orange-red | 15-20 |
| *H. fernandezii* | Sinuous red | 15 to 20 Diverse plans Free | 10 a 12 Firm | Without | Few | Red, with yellow borders | 10 |
| *H. pendula* | Strait red | 8-15 Diverse plans Free | 13-14 Flaccid | Without | Very | Red | 10-15 |
| *H. platystachys* | Little Sinuous red and becoming yellow near the terminal bracts | 10-20 Diverse plans Free | 11 a 16 Firm | Very | Without | Red on base, yellow Apex and small spots on the sides | 6-15 |

**Table 4**. cont.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *H. revoluta* | Very Sinuous red | 10-15 Diverse plans Free | 8-15 Firm | Very | Without | Red | 8-15 |
| *H. villosa* | Sinuous red or yellow | 15 to 20 Diverse plans Imbricate | 14-20 Firm | Very | Without | Red or yellow | 10 a 12 |
| *H. flabellata* | Sinuous red-orange | 4-8 Diverse plans Free | 7-7.5 Flaccid | Very | Without | Red with Apex and borders yellow-green | 7-9 |
| *H. juruana* | Sinuous with red marks | 10-30 Diverse plans Free | 5-7 Flaccid | Few | Without | Red and one-third yellow-greenish on the upper third of apex | 3-4 |
| *H. marginata* | Sinuous red | 9-15 Diverse plans Free | 7-9.5 Firm | Without | Without | Red with yellow borders or greenish apex | 7-15 |
| *H. rauliniana* | Sinuous red | 7-10 Diverse plans Free | 10-15 Firm | Few | Without | Red with yellow borders with green stretch marks | 2-3 |
| *H. rostrata* | Sinuous red | 18-25 Same plan Free | 7-9.5 Firm | Few | Without | Red with yellow or green borders | 2-5 |
| *H. standleyi* | Straight to Sinuous red | 11 to 25 Diverse plans Free | 7-9.0 Firm | Few | Without | Red with yellow-green borders | 2-5 |
| *H. colgantea* | Sinuous pink | 8-10 Diverse plans Free | 8-12.0 Flaccid | Few | Without | Dark pink with green tones | Up to 15 |
| *H. dielsiana* | Sinuous red orange or yellow | 18-25 Same plan Free | 10-13.5 Firm | Very | Without | Orange-red to red | 10-15 |
| *H. necrobracteata* | Sinuous dark red | 10-20 Diverse plans Free | 7-8 Firm | Few | Without | Red becoming necrotic right after anthesis | 10 a 30 |
| *H. penduloides* | Sinuous pink | 20-25 Diverse plans Free | 10-14 Flaccid | Without | Very | Pinky | 10 a 30 |
| *H. reptans* | Sinuous red brown | 34-45 Same plan Free | 7-11 Firm | Without | Without | Red-brown | Up to 20 |
| *H. trichocarpa* | Sinuous red | 6-11 Diverse plans Free | 10-12 Flaccid | Without | Without | Pinky | 20-35 |
| *H. combinata* | Sinuous red | 15-45 Diverse plans Free | 8.5-10 Firm | Very | Without | Red with early necrotic margins | 12 a 20 |
| *H. laxa* | Sinuous red | 18 Same plan Free | 8-13 Firm | Very | Without | Red | 11 a 18 |
| *H. mutisiana* | Sinuous red-orange | 16-20 Same plan Imbricate | 8.5-10 Firm | Very | Without | Red to orange | 20-30 |

**Table 4**. cont.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *H. obscura* | Sinuous<br>red or yellow-green | 10-14<br>Diverse plans<br>Free | 10-12<br>Firm | Very | Without | Red opaque with black necrotic apexes | 10-20 |
| *H. nutans* | Sinuous<br>red to red-orange | 5-13<br>Diverse plans<br>Free | 7-11<br>Flaccid | Very | Without | Red-orange | 12 |
| *H. huilensis* | Sinuous<br>red | 12-20<br>Same plan<br>Free | 10-16<br>Firm | Very | Without | Red | 15-20 |
| *H. stella-maris* | Sinuous<br>red-orange | 14-28<br>Diverse plans<br>Free | 10-24<br>Firm | Very | Without | Red | 10 |

The texture of the bracts was evaluated by the resistance of the bract to a light pressure applied by fingers. The insertion of bracts impacts inflorescence harvesting, handling and transport, but above all, it is important in packaging process, as inflorescences with bracts in different planes difficult the packing in boxes and cause less resistance during transport, causing friction between inflorescences, causing damage to the inflorescences reducing its quality. *H. xanthovillosa*, *H. mariae*, *H. stilesii*, *H. rostrata*, *H. dielsiana*, *H. reptans*, *H. laxa*, *H. mutisiana* and *H. huilensis* have inflorescences with bracts distributed in a single same plane.

Size and texture of the intermediate bracts have similar influences and consequences on the most varied procedures (Loges et al., 2014). *H. collinsiana*, *H. rauliniana*, *H. colgantea*, *H. dielsiana* and *H. stela-maris* have large intermediate bracts. The procedures between harvesting and transport resistance were also affected by the flaccid texture of intermediate bracts that are very susceptible to physical injuries, commoly seen in *H. chartacea*, *H. collinsiana*, *H. pendula*, *H. flabellata*, *H. juruana*, *H. colgantea*, *H. penduloides*, *H. trichocarpa* and *H. nutans*.

Hairiness is a factor that improves the ornamental aspect of the inflorescence; however, its difficult handling, once insects and dirt can be retained among the hairs, requiring a more meticulous cleaning process. The species showed varying degrees of hairiness, as well as the absence of hair in several. The presence of wax on the bracts does not only affect the packaging process. Waxiness can come off the bract during the handling and harvesting process, causing stained areas and can cause stains on contiguous flower stems in the same package during transport. *H. chartacea*, *H. collinsiana*, *H. pendula* and *H. penduloides* showed high quantities of wax on the inflorescences.

The color of rachis and bracts are attributes that valorize the ornamental aspects of heliconia inflorescences, either for the intense and vibrant colors, or for the contrast of the mixture of colors. Damages resulting from friction occurred in the different stages between harvest and commercialization are more evident on inflorescences with yellow or pink bracts as occurs in *H. chartacea*, *H. xanthovillosa*, *H. colgantea*, *H. penduloides* and *H. trichocarpa*. The main indicator of this damage was the darkening of the affected area.

The diameter of the floral stem can be associated with complications in harvesting, handling, packaging and transporting, once stems with larger diameter difficult and slow these processes. The species that had disadvantaged due to large stem diameter were *H. magnifica*, *H. vellerigera*, *H. xanthovillosa*, *H. mariae*, *H. stilesii*, *H. dielsiana*, *H. mutisiana*, *H. obscura*, *H. nutans*, and *H. huilensis* (Table 5).

**Table 5**. Characteristics of inflorescences and flower stems of 36 *Heliconia* species.

| Specie | Diameter of floral stem (cm) | Height of floral stem (g) | Stem firmness | Flowering season | Number of inflorescences/ cycle | Senescence signs and post-harvest longevity (days) | Purchase impulse (%) |
|---|---|---|---|---|---|---|---|
| *H. griggsiana* | Medium (1-2 cm) | Heavy 540.0 | Firm | May to September | 20-35 | Fall of flowers, Loss of brightness, Bracts wilt - 10 (Medium) | 78 |
| *H. magnifica* | Large (2.5-4) | Heavy 620.0 | Firm | March to September | 36-48 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 12 (Medium) | 88 |
| *H. pogonantha* | Medium (1.5-3) | Heavy 560.0 | Firm | All year | 40-60 | Loss of brightness Extern darkness of bracts, Bracts wilt, Apical dryness - 14 (High) | 92 |
| *H. ramonensis* | Medium (1.1 a 2) | Heavy 520.0 | Firm | All year | 40-60 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 10 (Medium) | 76 |
| *H. regalis* | Medium (1.5-2.5) | Heavy 550.0 | Firm | May to August | 16-35 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 12 (Medium) | 96 |
| *H. vellerigera* | Large (2.5-5.0) | Heavy 600.0 | Firm | April to September | 28-50 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 12 (Medium) | 94 |
| *H. xanthovillosa* | Large (6 a 6.5) | Heavy 620.0 | Firm | May to November | 30-60 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 12 (Medium) | 100 |
| *H. longissima* | Medium (1.5-3.0) | Heavy 520.0 | Firm | September to December | 20-42 | Loss of brightness, Extern darkness of bracts, Bracts wilt -14 (High) | 92 |
| *H. mariae* | Large (6-8) | Heavy 600.0 | Firm | All year | 25-40 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Apical dryness - 14 (High) | 76 |
| *H. stilesii* | Large (6-7) | Heavy 580.0 | Firm | June to September | 20-36 | Loss of brightness Extern darkness of bracts, Bracts wilt - 10 (Medium) | 84 |
| *H. chartacea* | Medium (1.5-2.5) | Heavy 520.0 | Firm | August to January | 24-40 | Fall of flowers, Loss of brightness, Extern and intern darkness of bracts, Bracts wilt, Borders wilt, fall of bracts - 15 (High) | 100 |
| *H. collinsiana* | Medium (2.5-3) | Heavy 540.0 | Medium | January to August | 36-60 | Fall of flowers and fruits, Intern and extern darkness of bracts, Loss of brightness, Bracts wilt, Apical dryness - 5 (Low) | 86 |

**Table 5**. cont.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *H. fernandezii* | Medium (1-2.5) | Medium 400.0 | Firm | October to February | 28-50 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 16 (High) | 90 |
| *H. pendula* | Medium (1.5-2.5) | Medium 320.0 | Medium | April to October | 16-30 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 3 (Low) | 68 |
| *H. platystachys* | Medium (1-1.3) | Medium 300.0 | Firm | April to October | 14-20 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Borders wilt, Apical dryness - 12 (Medium) | 86 |
| *H. revoluta* | Medium (1.8-3.0) | Heavy 560.0 | Firm | October to February | 20-36 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 9 (Medium) | 62 |
| *H. villosa* | Medium (1.5-3.0) | Medium 340.0 | Firm | October to February | 16-24 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 5 (Low) | 54 |
| *H. flabellata* | Medium (2.0-3.0) | Medium 420.0 | Firm | July to February | 25-40 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Apical dryness - 6 (Low) | 36 |
| *H. juruana* | Large (2.0-3.2) | Light 210.0 | Medium | All year | 20-40 | Fall of bracts, Loss of brightness, Extern darkness of bracts, Bracts wilt - 3 (Low) | 38 |
| *H. marginata* | Large (2.0-3.5) | Medium 440.0 | Firm | July and August | 12-20 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Apical dryness - 4 (Low) | 42 |
| *H. rauliniana* | Medium (2.0-3.0) | Heavy 580.0 | Firm | November to February | 24-40 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Apical dryness - 16 (High) | 88 |
| *H. rostrata* | Large (1.8-3.5) | Medium 410.0 | Firm | All year | 40-70 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Withering of the pointer - 15 (High) | 92 |
| *H. standleyi* | Large (1.5-3.2) | Medium 400.0 | Firm | All year | 25-30 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Fall of bracts, Withering of the pointer - 8 (Medium) | 78 |
| *H. colgantea* | Medium (2.0-3.0) | Medium 440.0 | Firm | May to November | 24-40 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Borders wilt, Apical dryness - 9 (Medium) | 68 |
| *H. dielsiana* | Large (2.5-4.0) | Medium 480.0 | Firm | August to October | 15-30 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Drop fruits -11 (Medium) | 78 |

**Table 5**. cont.

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| *H. necrobracteata* | Medium (1.8-3.0) | Medium 320.0 | Firm | April to August | 20-35 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 10 (Medium) | 86 |
| *H. penduloides* | Medium (1.5-3.0) | Medium 360.0 | Medium | October to February | 12-20 | Loss of brightness, Extern and intern darkness of bracts, Bracts wilt, necrose das bordas, Apical dryness - 3 (Low) | 58 |
| *H. reptans* | Medium (1.0-2.5) | Medium 310.0 | Flaccid | November to February | 25-30 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 10 (Medium) | 44 |
| *H. trichocarpa* | Medium (1.4-2.5) | Medium 360.0 | Firm | July to November | 16-25 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Borders wilt - 8 (Medium) | 46 |
| *H. combinata* | Medium (1.8-3.0) | Heavy 560.0 | Firm | May to August | 20-30 | Loss of brightness, Extern darkness of bracts, Bracts wilt, Borders wilt - 8 (Medium) | 78 |
| *H. laxa* | Medium (2.0-2.8) | Heavy 520.0 | Firm | August to December | 20-35 | Loss of brightness, Extern and intern darkness of bracts, Bracts wilt, Borders wilt, Apical dryness - 10 (Medium) | 68 |
| *H. mutisiana* | Large (2.2-3.5) | Heavy 560.0 | Firm | August to December | 25-32 | Loss of brightness, Extern darkness of bracts, Bracts wilt 12 (Medium) | 52 |
| *H. obscura* | Large (2.5-3.5) | Heavy 580.0 | Firm | October to February | 15-25 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 10 (Medium) | 32 |
| *H. nutans* | Large (2.2-3.4) | Light 240.0 | Firm | February to August | 18-35 | Loss of brightness, Extern and intern darkness of bracts, Bracts wilt, Borders wilt, Apical dryness - 3 (Low) | 18 |
| *H. huilensis* | Large (2.0-3.4) | Light 240.0 | Medium | August to October | 20-30 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 4 (Low) | 84 |
| *H. stella-maris* | Medium (2.0-3.0) | Light 220.0 | Medium | October to February | 15-25 | Loss of brightness, Extern darkness of bracts, Bracts wilt - 9 (Medium) | 54 |

The inflorescence height is related to the number of stems per package, in addition to hindering other processes from harvest to commercialization (Loges et al., 2005). Exotic shaped cut flowers as *Heliconia* are packed in way to prevent friction damage during transport (Dubey and Mishra, 2018). Thin inflorescences were observed on *H. juruana*, *H. nutans*, *H. huilensis* and *H. stella-maris*.

The stem firmness is an essential attribute for transport since this process in boxes is not viable and the inflorescences are transported in containers with a capacity of 10-20 inflorescences in vertical position. *H. collinsiana*, *H. pendula*, *H. juruana*, *H. necrobracteata*, *H. penduloides*, *H. reptans*, *H. huilensis* and *H. stella-maris* showed flaccid stems.

The flowering season or period is essential to ensure flower supply to the market, for two main reasons: the offer of products in which few species are commercialized and the period in which the market is supplied. *H. pogonantha*, *H. ramonensis*, *H. mariae*, *H. rostrata*, *H. juruana* and *H. standley* are produced continuously, the other species have seasonal production that varies from three to eight months. There is a wide variation on *Heliconia* for vegetative and floral characteristics; thus, different species and varieties have no uniformity on flowering behavior (Malakar and Biswas, 2019).

The number of inflorescences per cycle, a characteristic essential for the proposed selection, as it ensures that market is supplied with products in sufficient quantity and is directly related to plant sprouting. *H. magnifica*, *H. pogonantha*, *H. ramonensis*, *H. vellerigera*, *H. xanthovillosa*, *H. collinsiana* and *H. rostrata* were very productive species.

Loss of brightness and wilt of the bracts was common for all species evaluated, and most important visual effect of senescence in *Heliconia psittacorum* L. f. cv. Trópica is wilting or abscission of tepals (Bañuelos-Hernández, 2016). During the senescence process and depending of the species, loss of brightness of the bracts with or without color diminishing, fall of flowers and fruits, internal and/or external darkening of the bracts, necrosis of the edges, dryness of bract apex, wilt and fall of bracts or wilt of the pointer were observed. Post-harvest longevity was over two weeks for *H. longissima*, *H. mariae*, *H. chartacea*, *H. fernandezii*, *H. rauliniana* and *H. rostrata*. Data is comparable with *Heliconia psittacorum* x *H. spathocircinata* cv. Golden Torch (Amaral et al., 2015; Sardinha et al., 2019), and higher than *H. psittacorum* and *H. densiflora* (Silva et al., 2019). The postharvest longevity is one of the leading characteristics of cut flowers that should be considered as pre-requisite for flower quality and selling achievement (Folha et al., 2016).

The data of the morphological and agronomic characterizations and other evaluations (Tables 3, 4, 5), allowed the attribution of points to the inflorescences of the 36 *Heliconia* species (Table 6).

**Table 6**. Scores attributed to the inflorescences of 36 *Heliconia* species evaluated for recommendation of use as a cut flower.

| Specie | FS | CP | FS | PHL | H | P | TE | RT | PI | TOT |
|---|---|---|---|---|---|---|---|---|---|---|
| *H. griggsiana* | 4 | 3 | 4 | 4 | 6 | 5 | 5 | 2 | 2 | 35 |
| *H. magnifica* | 4 | 3 | 4 | 4 | 5 | 4 | 5 | 2 | 3 | 34 |
| *H. pogonantha* | 4 | 3 | 4 | 6 | 6 | 4 | 5 | 3 | 3 | 38 |
| *H. ramonensis* | 4 | 3 | 4 | 4 | 6 | 5 | 6 | 2 | 2 | 36 |
| *H. regalis* | 4 | 3 | 4 | 4 | 6 | 5 | 6 | 2 | 3 | 37 |
| *H. vellerigera* | 4 | 3 | 4 | 4 | 5 | 4 | 5 | 2 | 3 | 34 |
| *H. xanthovillosa* | 4 | 3 | 4 | 4 | 6 | 5 | 6 | 1 | 3 | 36 |
| *H. longissima* | 4 | 3 | 4 | 6 | 6 | 3 | 5 | 3 | 3 | 37 |
| *H. mariae* | 4 | 3 | 4 | 6 | 7 | 5 | 6 | 3 | 2 | 40 |
| *H. stilesii* | 4 | 3 | 4 | 4 | 7 | 5 | 6 | 2 | 3 | 38 |
| *H. chartaceae* | 4 | 3 | 4 | 6 | 5 | 4 | 4 | 1 | 3 | 34 |
| *H. collinsiana* | 4 | 3 | 2 | 2 | 3 | 2 | 2 | 1 | 3 | 22 |
| *H. fernandezii* | 4 | 3 | 4 | 6 | 9 | 8 | 9 | 3 | 3 | 49 |
| *H. pendula* | 4 | 2 | 2 | 2 | 5 | 5 | 5 | 1 | 2 | 28 |
| *H. platystachys* | 4 | 2 | 4 | 4 | 7 | 7 | 8 | 1 | 3 | 40 |
| *H. revoluta* | 4 | 3 | 4 | 4 | 6 | 5 | 6 | 2 | 2 | 36 |
| *H. villosa* | 4 | 2 | 4 | 2 | 7 | 7 | 8 | 1 | 2 | 37 |
| *H. flabellata* | 4 | 3 | 4 | 2 | 7 | 7 | 8 | 1 | 1 | 37 |
| *H. juruana* | 4 | 3 | 2 | 2 | 6 | 5 | 6 | 1 | 1 | 30 |
| *H. marginata* | 2 | 2 | 4 | 2 | 7 | 5 | 6 | 1 | 1 | 30 |
| *H. rauliniana* | 4 | 3 | 4 | 6 | 7 | 5 | 6 | 3 | 3 | 41 |
| *H. rostrata* | 4 | 3 | 4 | 6 | 9 | 8 | 9 | 3 | 3 | 49 |
| *H. standleyi* | 4 | 2 | 4 | 4 | 8 | 7 | 8 | 2 | 2 | 41 |
| *H. colgantea* | 4 | 3 | 4 | 4 | 6 | 4 | 5 | 1 | 2 | 33 |
| *H. dielsiana* | 2 | 2 | 4 | 4 | 6 | 6 | 7 | 2 | 2 | 35 |
| *H. necrobracteata* | 4 | 3 | 2 | 4 | 8 | 7 | 8 | 2 | 3 | 41 |
| *H. penduloides* | 4 | 2 | 2 | 2 | 5 | 4 | 4 | 0 | 2 | 25 |
| *H. reptans* | 4 | 2 | 0 | 4 | 8 | 7 | 8 | 3 | 2 | 38 |
| *H. trichocarpa* | 4 | 2 | 4 | 4 | 7 | 5 | 6 | 1 | 2 | 35 |
| *H. combinata* | 4 | 2 | 4 | 4 | 6 | 5 | 6 | 2 | 2 | 35 |
| *H. laxa* | 4 | 3 | 4 | 4 | 7 | 7 | 8 | 2 | 2 | 41 |
| *H. mutisiana* | 4 | 3 | 4 | 4 | 6 | 6 | 7 | 2 | 2 | 38 |
| *H. obscura* | 4 | 2 | 4 | 4 | 5 | 4 | 5 | 2 | 2 | 32 |
| *H. nutans* | 4 | 3 | 4 | 2 | 5 | 4 | 5 | 1 | 0 | 28 |
| *H. huilensis* | 4 | 2 | 2 | 2 | 6 | 6 | 7 | 2 | 3 | 34 |
| *H. stella-maris* | 4 | 2 | 2 | 4 | 6 | 5 | 6 | 2 | 2 | 33 |

FS - Flowering season; CP - Clump production; FS - Firmness of stem; PHL - Post-harvest longevity; H - Handling; P - Packaging; TE - Transport easiness; RT - Resistance to transport; PI - Purchase impulse; TOT - Total points.

The results are compatible with those obtained by Castro (1993) as cited by Loges et al. (2016) for *H. chartacea*, *H. collinsiana*, *H. marginata*, *H. pendula*, and *H. rostrata*, which were shown to be moderately adequate and by Castro et al. (2007), Loges et al. (2005) and Loges et al. (2016), although the evaluation criteria used in these studies have included a smaller number of parameters evaluated.

Our results demonstrated that all heliconia accessions are suitable for cut flowers use. The species that most stood out as a cut flower were *H. mariae*, *H. fernandezii*, *H. platystachys*, *H. standley*, *H. necrobracteata* and *H. laxa*. *H. rauliniana* and *H. rostrata* were also very suitable as cut flower and are already commercially explored. Some accessions are of species not yet commercially exploited and may increase the demand market for novelties.

## Conclusions

Heliconias with pendent inflorescences can be used as cut flowers, although the processes from harvest to storage are more laborious and there is great variation in post-harvest longevity.

### Author Contribution

**C.G.**: establishment of the research hypothesis, experimental design, implementation of experiments, data collection, data analysis, article writing; **C.E.F.C.**: establishment of the research hypothesis, experimental design, implementation of experiments, data collection, data analysis, article writing; **A.R.T.**: data collection, data analysis, article writing; **S.M.R.V.**: implementation of experiments, maintenance of the experimental area, data collection, data analysis, review of article writing; **D.M.**: implementation of experiments, maintenance of the experimental area, data collection, data analysis, review of article writing.

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