



## Location of pitahaya (*Selenicereus* spp.) accesses in Cuba through participatory plant breeding

### Localización de accesiones de pitahaya (*Selenicereus* spp.) en Cuba a través del fitomejoramiento participativo

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**ABSTRACT:** The pitahaya (*Selenicereus* spp.) is widely distributed in tropical and subtropical regions of the world. In Cuba with the arrival of the colonizers it had already been introduced, although it is found wild, there are few studies carried out and its use in the national territory is minimal. The objective of this research was to locate and identify pitahaya plant material, to enrich the Germplasm Bank of the UCTB (Scientific and Technological Base Unit) - Alquizar, promote cultivation and contribute to the increase in the diversity of fruit trees in the country. Through the virtual national contest for participatory breeding of pitahaya accessions, more than 200 people were randomly surveyed and the GPS Cuba offline was used to locate the reported accessions. It was possible to locate more than 154 accessions, in 71 areas of the Cuban geography (38.03 % in the West, 39.44 % in the Center and 22.54 % in the East of the country), and identify the predominant species, some of them not yet reported in Cuba such as *Selenicereus megalanthus* and *Selenicereus undatus* subsp. *luteocarpus*. The presence of various genotypes in terms of sizes, colors and shapes was confirmed, some of which were prospected for establishment in collection. The work allowed us to identify five promising genotypes and five producers who practiced cultivation as an economic activity. With the experience, a participatory breeding strategy was drawn up to satisfy the short and medium term demand for cultivars, in order to diversify agriculture.

**Key words:** reports, identification, diversity, prospecting.

**RESUMEN:** La pitahaya (*Selenicereus* spp.) se encuentra ampliamente distribuida en las regiones tropicales y subtropicales del mundo. En Cuba, con la llegada de los colonizadores ya había sido introducida, aunque se encuentra de forma silvestre, son pocos los estudios realizados y es mínimo su aprovechamiento en el territorio nacional. El objetivo de la presente investigación fue localizar e identificar material vegetal de pitahaya, para enriquecer el Banco de Germoplasma de la UCTB - Alquizar, promover el cultivo y contribuir al incremento de la diversidad de frutales en el país. Mediante el concurso nacional virtual de mejoramiento participativo de accesiones de pitahayas, se encuestaron de forma aleatoria a más de 200 personas y se empleó el GPS Cuba offline para la ubicación de las accesiones reportadas. Se logró localizar más de 154 accesiones, en 71 zonas de la geografía cubana (38,03 % en el Occidente, 39,44 % en el Centro y el 22,54 % en el Oriente del país), e identificar las especies predominantes, algunas de ellas aún no reportadas en Cuba como la *Selenicereus megalanthus* y la *Selenicereus undatus* subsp. *luteocarpus*. Se corroboró la presencia de diversos genotipos en cuanto a tamaños, colores y formas, algunos de los cuales se prospectaron para su establecimiento en colección. El trabajo permitió identificar cinco genotipos promisorios y cinco productores que practicaban el cultivo como actividad económica. Con la experiencia se trazó una estrategia de mejoramiento participativo para satisfacer, a corto y mediano plazo, la demanda de cultivares, en aras de diversificar la agricultura.

**Palabras clave:** reportes, identificación, diversidad, prospección.

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## INTRODUCTION

The use of local cultivars contributes to stabilizing food production and income, especially in marginal environments, where the impact of modern varieties is limited due to their high cost, climate variability, lack of resources and access to them. Participatory plant breeding is a novel methodology that involves farmers as direct actors in the processes of technological innovation and crop improvement (1). This method began as a process in Cuba in 1999 for corn and bean crops, and was later incorporated to rice. At the beginning, it was implemented in the provinces of Pinar del Río and the former province of Havana, now Mayabeque province. Subsequently, it was disseminated to Villa Clara and Holguín provinces and it was implemented in these four provinces until 2005 (2-4). In the year 2020, research work was reinitiated in Cuba, for the promotion of pitahaya cultivation as an economic activity. These species belonging to the *Selenicereus* genus are the most widely distributed climbing cactus in the world (5,6). Their origin is attributed to the tropical and subtropical forest regions of Mexico, Central and South America. It is identified as an important native genetic resource of the continent, with wide distribution and variation. The pitahaya presents great polymorphism in the DNA, which implies finding a great variation of types that probably correspond to the same species and are distributed geographically in a wide form in places where the ecological conditions are limiting, which represents a serious danger for its survival by diverse causes of natural and anthropological origin (7).

Pitahaya is adaptable to diverse environmental conditions and has multiple uses, wide possibilities of industrialization, high productivity, profitability, and demand in international markets (8). Therefore, it is a new crop, with great potential for the agricultural and economic development of Cuba, the objective of this research was to locate and identify vegetal

material, to enrich the Germplasm Bank of the UCTB - Alquízar, to promote the crop and contribute to the increase of the diversity of fruit trees in the country.

## MATERIALS AND METHODS

With the support of social networks and the development of the Internet in the country, the national virtual contest on participatory breeding of pitahaya accessions in Cuba was launched in May 2021, sponsored by the Tropical Fruit Growing Research Institute (IIFT), the Alquízar Scientific and Technological Base Unit (UCTB) and the Youth Technical Brigades (BTJ), for the identification of pitahaya genotypes.

The study area was in Cuba and was carried out in 56 municipalities of the country. The four stages of participatory plant breeding, according to Cuban experiences, were applied (2):

Information collection: 117 people were surveyed, applying the Delphis or Expert Panel Method (9) on a five-point Likert scale and a nine-point RAND scale (Table 1).

Diagnosis: A database was created in which all the information collected was entered. The objective of the diagnostic was to obtain real and concrete information on the diversity of pitahayas in the country.

Collection of phylogenetic resources: one to three cladodes per accession (depending on availability) of 30 cm in length were taken for the collection.

Establishment of demonstration plots: an area of 0.28 ha was planted, with a 3 m x 4 m planting frame. Direct digging was carried out for planting without prior soil preparation and live tutors of almacigo (*Bursera simaruba* L.) were used. An agronomic evaluation plot (exhibition and socialization area) was also established, in which the seedlings were planted in plastic pots and cement tutors with iron hoops were used as supports. Six species were fostered, *Selenicereus undatus* subsp *undatus* (Haw) Britton & Rose, *Selenicereus undatus*

**Table 1.** Participant survey form

| Plant Passport data                                                        |                                                                                                                                 |
|----------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------|
| Number of plants owned or identified                                       |                                                                                                                                 |
| Type of material received or prospected                                    | 1 Seeds ( ), 2 parts of the vegetable ( ), 3 postures ( )                                                                       |
| How and what you use it for, if consumed, please state how you consume it. | 1 ornamental ( ), 2 fresh fruit ( ), 3 juice ( ), 4 sweet in syrup ( ), 5 jam ( ), 6 compotes ( ), 7 medicine ( ), 8 others ( ) |
| Cladode (stem)                                                             |                                                                                                                                 |
| Nerve edge                                                                 | 1 concave ( ), 2 flat ( ), 3 convex ( )                                                                                         |
| Presence of purine                                                         | 0 no ( ), 1 yes ( )                                                                                                             |
| Fruit                                                                      |                                                                                                                                 |
| Shape                                                                      | 1 Rounded ( ), 2 elongated ( ), 3 flattened ( )                                                                                 |
| Tamaño                                                                     | 1 small ( ), 2 medium ( ), 3 large ( )                                                                                          |
| External color                                                             | 1 pink ( ), 2 red ( ), 3 dark red ( ), 4 yellow ( ), 5 green ( )                                                                |
| Internal color                                                             | 1 white ( ), 2 pink ( ), 3 red ( ), 4 dark red ( ), 5 purple ( )                                                                |
| How did you get them?                                                      | 1 By entering ( ), 2 natural form ( )                                                                                           |
| Other names by which it is known                                           | 1 Pitahaya ( ), 2 pitaya ( ), 3 queen of the night ( )                                                                          |
| Flavor of the juice                                                        | 1 Insipid ( ), 2 sour ( ), 3 sweet ( ), 4 bitter ( )                                                                            |
| Handling data                                                              |                                                                                                                                 |
| How do you have it established or how have you observed it?                | 1 Farm ( ), 2 Field ( ), 3 Orchard ( ), 4 Garden or yard ( ), 5 Pasture ( ), 6 Market ( ), 7 Urban area ( )                     |
| Wild habitat                                                               | 1 forest/woodland ( ), 2 scrubland ( ), 3 grassland ( ), 4 desert ( )                                                           |

subsp *luteocarpus* (Haw) Britton & Rose, *Selenicereus purpusi* (Haw) Britton & Rose, *Selenicereus costaricensis* (Haw) Britton & Rose, *Selenicereus ocamponis* Britton & Rose and *Selenicereus triangularis* (L.) Britton & Rose. In the nursery area of the UCTB Alquizar, other species were introduced such as *megalanthus*, *guatemalensis* and several accessions of *undatus* and *purpusi*, all of the genus *Selenicereus* (5).

Farmer experimentation: allowed the selection at the farm level of accessions adapted to their edaphoclimatic conditions. Search for alternatives, based on increased diversity, to obtain better yields, lower production costs and reduce the incidence of pests and diseases, as well as joint alternatives between technicians and farmers to obtain new cultivars (10).

Participatory methodology of the contest: the photographs received had to be of plants, stems (cladodes), flowers and fruits, the latter present in the plants and harvested, placed next to a unit of measurement to verify the size, photos of fruits cut longitudinally showing the external and internal part of the same, as well as their colors and shapes. For the localization of the reported zones, the GPS, Cuba offline map version 2.6 (11) was used.

### Analysis of survey results

Using UPOV guidelines (12), the predominant species in the country were characterized and identified. For those of a promising nature, the following were taken into account: species, external and internal coloration of the fruit and flavor.

### Virtual platforms used

- Facebook (BTJ Alquizar page, Btj Alquizar profile and the Cuba Pitahaya group)
- WhatsApp platform
- E-mail
- UCTB Contacts - Alquizar

Media used to publicize the contest: BTJ Alquizar Facebook page, Btj Alquizar profile, Cuba Pitahaya group on Facebook. Press media, Radio Artemisa <http://radioartemisa.icrt.cu>, Radio Ariguanabo <http://www.ariguanaboradioweb.icrt.cu>, Radio

Reloj <http://www.radioreloj.cu>, el Artemiseño <http://artemisadiario.cu>, Cuban News Agency (ACN) website [www.acn.cu](http://www.acn.cu), Juventud Técnica Magazine <http://juventudtecnica.cu>, ArTV [www.tvartemisa.icrt.cu](http://www.tvartemisa.icrt.cu).

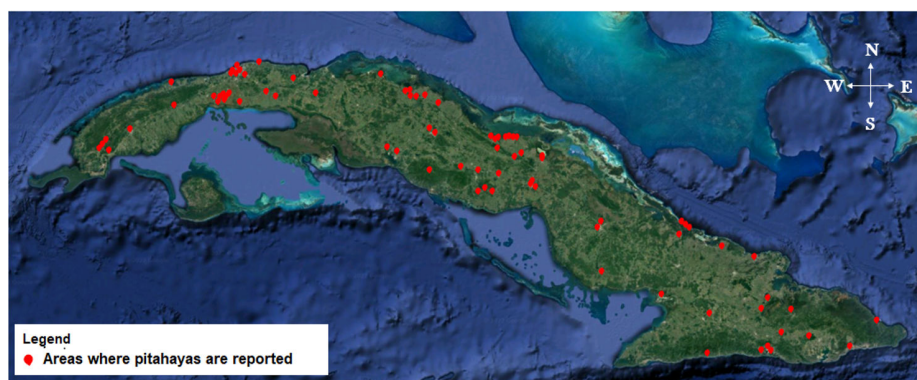
### Statistical analysis and data processing

According to the information received, a database was created in Microsoft Excel 2019. For each variable, abundance and frequency per province of the country were calculated. To see the association of utility and form of consumption by provinces, a contingency table was made, with these data a Principal Component Analysis (13) was executed, where the variables were utility and form of consumption (equal order to Table 1) and the classification criteria were the provinces. The identified accessions were grouped, using Multivariate Cluster Analysis, according to the method. Average linkage and distance (Gower (sqrt (1-S))). The statistical package InfoStat 2016 was used.

## RESULTS AND DISCUSSION

The launching of the national virtual contest on participatory breeding of pitahaya accessions in Cuba, had a reach of up to 250 people approximately, of which 46.80 % participated, and only 44.44 % of the participants provided information of interest. Although the contest was national in character, participation was accepted from several countries in the region, such as Mexico, the United States of America, Ecuador, Panama, Nicaragua and Puerto Rico, whose participants provided valuable information on the management of the crop and its characteristics.

During the surveys, it was evidenced that the cultivation of pitahaya is extended in almost all the country, it was possible to identify and locate with the use of GPS about 154 accessions reported in 71 areas of the Cuban geography, (38.03 % in the West, 39.44 % in the Center and 22.54 % in the East of the country) (Figure 1) (15), in Table 2 are shown the predominant species identified in the national territory. In Cuba there are reports of the species *Selenicereus undatus* since 1608, in the first Cuban literary work "Espejo de Paciencia", by the canary Silvestre de Balboa Troya y Quesada (14).



Author's own elaboration

**Figure 1.** Areas where pitahaya accessions were reported, located in the Cuban territory

**Table 2.** Distribution and identification of pitahaya species (*Selenicereus* spp) in the national territory

| Region  | Province         | Localized area                                                                           | Species                                     |
|---------|------------------|------------------------------------------------------------------------------------------|---------------------------------------------|
| Western | Pinar del Río    | Sábalo, Manaca (Guane)                                                                   | <i>S. undatus</i>                           |
|         |                  | Pinar del Río                                                                            | <i>S. undatus</i>                           |
|         |                  | San Diego, cañón del río Taco Taco (Los Palacios)                                        | <i>S. undatus</i>                           |
|         |                  | San Cayetano (Bahía Honda)                                                               | <i>S. undatus</i>                           |
|         |                  | Lavandero (Artemisa)                                                                     | <i>S. undatus</i>                           |
|         |                  | Dagame, Mallorquín, Sopapo, El Punto, Tumbadero, Dagame (Alquízar)                       | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. costaricensis</i>                     |
|         |                  |                                                                                          | <i>S. undatus</i> subsp. <i>luteocarpus</i> |
|         |                  | Carretera Pestana, cercanías de Playa Cajío (Güira de Melena)                            | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. purpusii</i>                          |
|         | La Habana        | Playa                                                                                    | <i>S. triangularis</i>                      |
|         |                  |                                                                                          | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. purpusii</i>                          |
|         |                  |                                                                                          | <i>S. ocamponis</i>                         |
|         |                  | National highway (Guanabacoa)                                                            | <i>S. undatus</i>                           |
|         |                  | Cotorro                                                                                  | <i>S. undatus</i>                           |
|         |                  | Guanabo (Habana del Este)                                                                | <i>S. undatus</i>                           |
|         |                  | Chacón Cojimar                                                                           | <i>S. undatus</i>                           |
|         | Mayabeque        | San Nicolás de Bari                                                                      | <i>S. undatus</i> y <i>S. purpusii</i>      |
|         |                  | Camacho (Batabanó)                                                                       | <i>S. undatus</i>                           |
|         |                  | Güines                                                                                   | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. purpusii</i>                          |
|         | Matanzas         | Ceiba Mocha (Matanzas)                                                                   | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. purpusii</i>                          |
|         |                  |                                                                                          | <i>S. costaricensis</i>                     |
|         |                  |                                                                                          | <i>S. megalanthus</i>                       |
| Central | Villa Clara      | Pedro Betancourt,                                                                        | <i>S. guatemalensis</i>                     |
|         |                  | Lutgardita, Corralillo, Loma Blanca, el Conde, la Curva, el Piojillo (Quemado de Güines) | <i>S. undatus</i>                           |
|         |                  | Santa Clara                                                                              | <i>S. undatus</i>                           |
|         |                  | San Miguel (Manicaragua)                                                                 | <i>S. purpusii</i>                          |
|         |                  | Sagua la Grande                                                                          | <i>S. undatus</i>                           |
|         |                  | Sipiabo (Fomento)                                                                        | <i>S. undatus</i>                           |
|         |                  | Calabazar de Sagua (Encrucijada)                                                         | <i>S. undatus</i>                           |
|         | Cienfuegos       | Abreu                                                                                    | <i>S. undatus</i>                           |
|         |                  | Pepe Rivas (Palmira)                                                                     | <i>S. purpusii</i>                          |
|         | Sancti Spiritus  | Iguara (Yaguajay)                                                                        | <i>S. purpusii</i> y <i>S. undatus</i>      |
|         |                  | La Sierpe (Las Nueva)                                                                    | <i>S. undatus</i>                           |
|         |                  | Guasimal (Santi Spiritus)                                                                | <i>S. undatus</i>                           |
|         |                  | Jatibonico                                                                               | <i>S. undatus</i>                           |
|         | Ciego de Ávila   | Punta judas and Victoria beach (Yaguajay)                                                | <i>S. undatus</i> subsp. <i>luteocarpus</i> |
|         |                  |                                                                                          | <i>S. undatus</i>                           |
|         |                  | Topes de Collantes                                                                       | <i>Selenicereus</i> spp.                    |
|         |                  | Santi Spiritus                                                                           | <i>S. undatus</i>                           |
|         |                  | Chambas                                                                                  | <i>S. purpusii</i>                          |
|         |                  | Florencia                                                                                | <i>S. undatus</i>                           |
|         |                  | Colorado (Baraguá)                                                                       | <i>S. purpusii</i> y <i>S. undatus</i>      |
|         |                  | Ciego de Ávila                                                                           | <i>S. purpusii</i>                          |
|         | Camagüey         | El embarcadero (Morón)                                                                   | <i>S. undatus</i>                           |
|         |                  | Monte Grande (Santa Cruz del Sur)                                                        | <i>S. undatus</i> y <i>S. purpusii</i>      |
|         |                  | Camagüey                                                                                 | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. undatus</i>                           |
| Eastern | Las Tunas        | Dumañuecos (Manatí)                                                                      | <i>S. undatus</i>                           |
|         |                  | Chapara (Jesús Menéndez)                                                                 | <i>S. undatus</i>                           |
|         | Holguín          | Cueto                                                                                    | <i>S. undatus</i>                           |
|         |                  | Fray Benito (Rafael Freyre)                                                              | <i>S. undatus</i>                           |
|         |                  | Birán (Cueto)                                                                            | <i>S. undatus</i>                           |
|         |                  | San Pedro de Caco Cum                                                                    | <i>S. undatus</i>                           |
|         | Granma           | Cauto Cristo                                                                             | <i>S. undatus</i>                           |
|         |                  | Mouth of the Cauto River                                                                 | <i>S. undatus</i>                           |
|         | Santiago de Cuba | South Coast                                                                              | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. undatus</i> subsp. <i>luteocarpus</i> |
|         |                  | El Caney                                                                                 | <i>S. undatus</i>                           |
|         |                  | Uvero (Guama)                                                                            | <i>S. undatus</i>                           |
|         | Guantánamo       | Santiago de Cuba                                                                         | <i>S. undatus</i>                           |
|         |                  | Jarahueca (Songo la Malla)                                                               | <i>S. undatus</i>                           |
|         |                  | San Benito (Segundo Frente)                                                              | <i>S. undatus</i>                           |
|         |                  | Jobo Dulce (Baracoa)                                                                     | <i>S. undatus</i>                           |
|         |                  |                                                                                          | <i>S. triangularis</i>                      |
|         |                  | Niceto Pérez                                                                             | <i>S. undatus</i>                           |
|         |                  | San Antonio del Sur                                                                      | <i>S. undatus</i>                           |

The largest number of accessions identified in the country is registered in the central region, in areas of the north coast of the province of Villa Clara, in the communities of Lugardita, Corralillo, San Miguel, Loma Blanca, El Conde, La Curva and El Piojillo in Quemado de Güines; Calabazar de Sagua in Encrucijada and in Sagua la Grande. According to the results of the surveys, in these areas of the country there is a lot of culture and tradition in the backyard cultivation, consumption and commercialization of pitahaya fruits, where they are abundant in the wild. Villagers report consuming it in juices, candies and homemade jams, also have high demand and sale in the months of July and August, the production season of pitahaya in Cuba.

In this same coastal strip, but towards the East, in the province of Sancti Spiritus, accessions of the species *Selenicereus undatus* (Haw) Britton & Rose (fruit with red, light red or pink exocarp and white mesocarp) and *Selenicereus undatus* subsp. *luteocarpus* (Haw) Britton & Rose (fruit with yellow exocarp and white mesocarp) were reported in the areas of Punta Judas and Victoria beach in Yaguajay. In the Botanical Garden of Villa Clara there are accessions of *S. undatus* (16).

*S. undatus*, with 73.43 % of the reports in the country, is the most represented species and has naturalized to our climatic conditions since its introduction (16). Studies have described pitahaya as an invasive plant in Cuba, including it in a list that classifies it as such (17). It is valid to clarify that the rest of the species of pitahayas that were located and identified in this article, do not have the same behavior as *S. undatus*, in terms of its propagation, adaptability, growth habit and development, therefore, it is not correct to call pitahayas, invasive as a whole.

The conservation status of the species has not been evaluated in Cuba and the destruction of evergreen forests has apparently reduced its area of distribution (18). Considering the form in which they have been observed, 26 % are reported from gardens and backyard crops, very little is seen in nature, but it is frequent in gardens (18). In forests and scrublands 20 % and 16 % respectively. They were also observed in relatively dry areas, pastures and local markets with 1 % each (Figure 2).

Pitahayas are very useful as ornamental, food and even medicinal plants (19). The principal component analysis was

significant according to the cophenetic correlation value. Two components were able to explain 79.5 % of the relationship between the provinces and the use of pitahaya. The first component differentiates the use of pitahaya as an ornamental and juice, and the second component differentiates the use of fresh and sweet fruit in syrup (Table 3).

According to the dimension of the variables in the biplot graph, it could be determined that in Cuba the greatest use is as an ornamental plant and its consumption in fresh fruit, followed by juices and sweet in syrup, and in smaller proportion it is used for the elaboration of syrup, compotes and a medicinal use. Artemisa and Havana are located to the right with the greatest ornamental use and Cienfuegos to the left, the province where pitahaya is least used, the greatest use as fresh fruit is in Ciego de Avila; while in Santiago de Cuba it is consumed mostly as sweet in syrup (Figure 3).

In Ciego de Avila province, the abundance of wild plants of the species *S. undatus* was reported in the communities "El Embarcadero", in Morón; Colorado in Baraguá and Florencia; in Chambas and in the city of Ciego de Avila, specimens of the species *S. purpusii* (Haw) Britton & Rose (fruit with intense pink, red or intense red exocarp and red or dark red mesocarp, purple almost black) were located. Further south in the central region of the country, in the provinces of Cienfuegos, Sancti Spiritus and Ciego de Avila, the abundance of accessions of pitahayas was also located in the areas of Abreu, Pepe Riva, La Sierpe and Topes de Collantes, places where altitudes of a few meters predominate, rising to more than 700 - 800 m.a.s.l. In the locality of Monte Grande in Santa Cruz del Sur, 45 km from Camagüey city, there is a small fruit producer with more than 150 species, among them the pitahayas *S. undatus* and *S. purpusii*.

In the west of the country 25 zones were located, six of them in Pinar del Río, in the communities of Manaca, Los Portales on the road to Luis Lazo and in Sábalo, Guane municipality, in the latter they grow and bear fruit in the wild and are known as "Alcar" or "Arcaria" fruit. In Guaniguanico mountain range, Sierra del Rosario, the abundance of wild plants was reported in the canyon of Taco Taco River (Figure 4 A), which reach up to 15 meters in height on local trees and on the top of hummocks in San Diego (Figure 4 B), both in Los Palacios municipality.

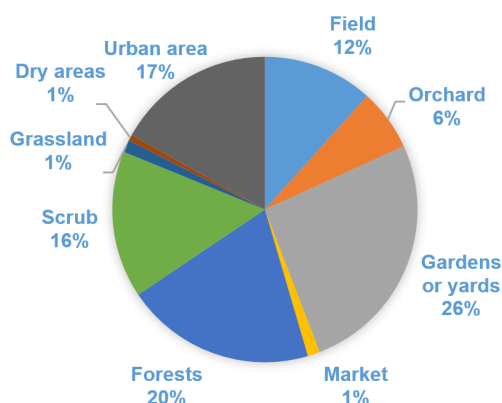
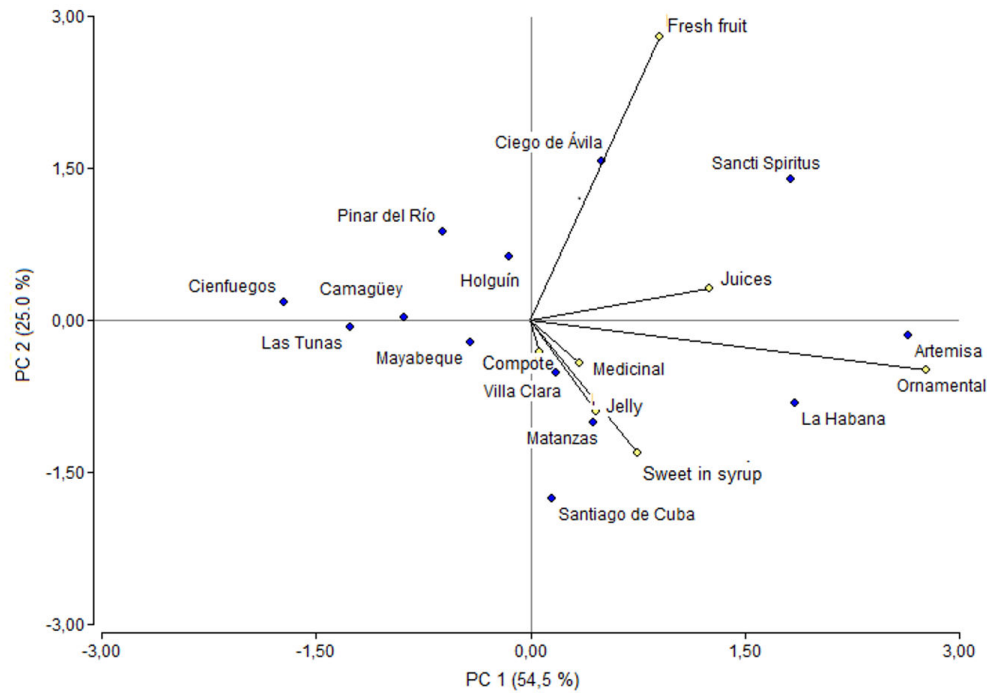


Figure 2. Percentage of Pitahaya distribution areas in Cuba

Table 3. Correlation of the components with the original variables proposed in the survey

| Variables              | PC 1        | PC 2          |
|------------------------|-------------|---------------|
| Ornamental             | <b>0.96</b> | -0.12         |
| Fresh Fruit            | 0.43        | <b>0.89</b>   |
| Juices                 | <b>0.72</b> | 0.12          |
| Sweet in syrup         | 0.6         | <b>- 0.71</b> |
| Jam                    | 0.43        | -0.58         |
| Medicinal              | 0.32        | -0.27         |
| Compote                | 0.09        | -0.32         |
| Explained Variance     | 54.5        | 25            |
| Total Variance         | 54.5        | 79.5          |
| Cophenetic Correlation | 0.963       |               |



**Figure 3.** Graphical representation of the main component for the use of pitahayas in Cuban provinces

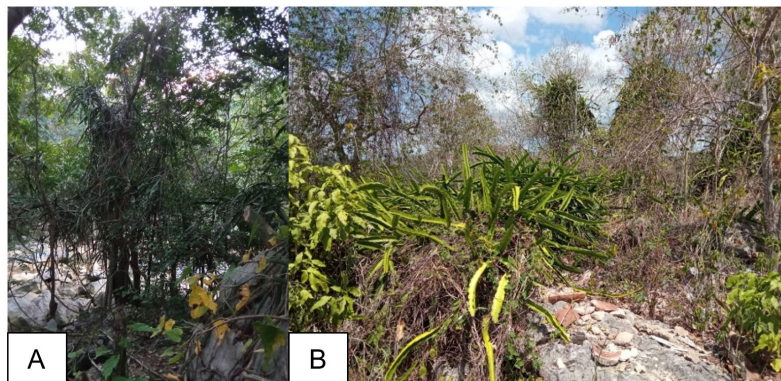


Photo taken by Javier Iglesias Camargo

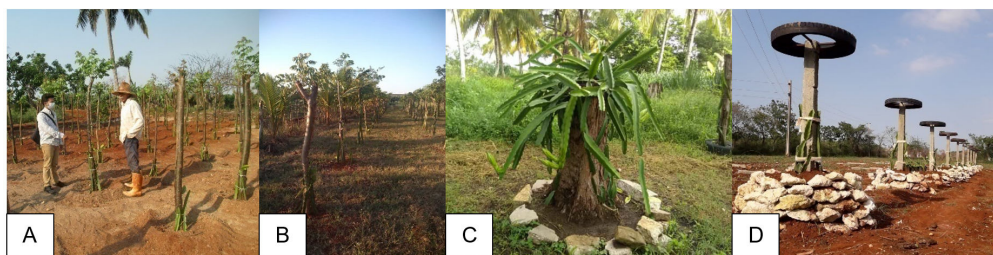
**Figure 4.** Pitahayas in Sierra del Rosario, Guaniguanico mountain range:  
(A) Taco Taco river Canyon; (B) hummocks in San Diego. Los Palacios, Pinar del Río

In Artemisa province, 10 zones were reported, with abundant accessions distributed in Soroa, Sierra del Rosario and in San Cayetano community to the north of Bahía Honda. They abound mainly in agricultural areas in Güira de Melena and Alquizar municipalities, in the wild near the community of Dagame and in the farms of producers on mango trees (*Mangifera indica* L.), avocado trees (*Persea americana* Mill.) and ceiba (*Ceiba pentandra* L.). In this last municipality, two producers were located who practiced the crop as an economic activity (Figure 5 A and B) and it could be said that they were the first in the country, as well as another producer in Guanabacoa and Havana municipality (Figure 5 C) and another who recently started in San Antonio de los Baños, Artemisa (Figure 5 D).

In Havana province was located 9.86 % of the accessions reported in the country, cultivated fundamentally by cactus

collectors, who conserve an incomparable treasure, have made important donations to the Germplasm Bank of the UCTB - Alquizar and use them as graft holders for cactus (13). One accession was located near the coastal strip in Guanabo community, Habana del Este, and it is presumed that they are abundant in the heights of Havana- Matanzas. Accessions were located in backyard crops in Camacho community in Batabanó, in San Nicolás de Bari and Güines, areas of Mayabeque province.

In the eastern region of the national territory, fewer areas were located due to the low percentages of reports obtained, but this does not mean that there is not the same or greater distribution of pitahayas in wild or cultivated form. Some reports from respondents locate accessions in the north of the province of Las Tunas, in areas near the communities of Dumañuecos and Chapara in Manatí and Jesús Menéndez municipalities, respectively.



Photos taken by Silvino Páez Rodríguez, Raúl Izquierdo Valdés, Tin Van Heche and the author

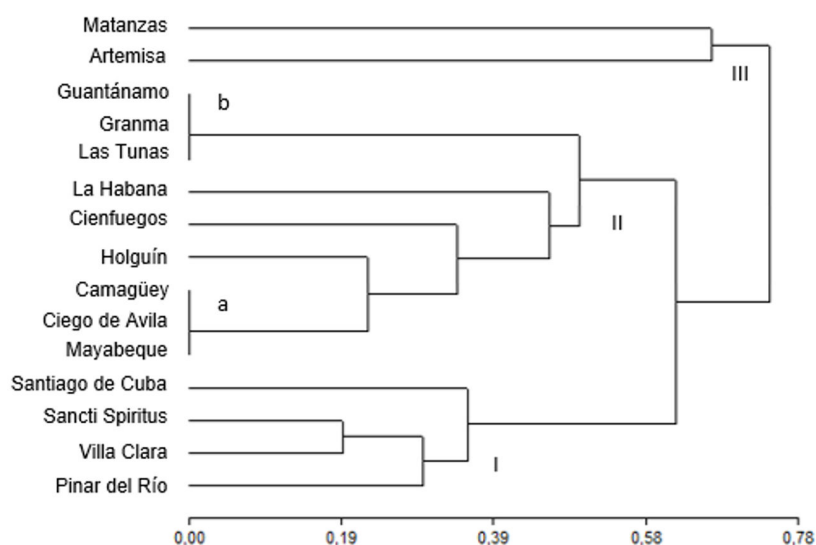
**Figure 5.** First plots of pitahaya destined for production in Cuba: (A) area belonging to the CCS “José A. Echevarría”, in Alquízar. (B) Area belonging to the CCS “Pedro R. Santana”, in Alquízar. (C) Plot at 10 km of the National Highway, Guanabacoa, Havana. (D) Plot in San Antonio de los Baños

From Holguín, zones were located in the community of Fray Benito in Rafael Freyre, areas where pitahayas abound among the semi-deciduous forests of Gibara to Mayarí, and as ornamental in Holguín city (17). In the farms of the Castro family in Biran and in another belonging to the CCS “Camilo Cienfuegos” of Cueto municipality, there are also located specimens of pitahayas, in this last one was identified a hybrid species apparently between (*Selenicereus undatus* x *Selenicereus purpusii*). Other reports came from the surroundings of the Cauto Cristo and Cauto rivers in Granma, province that with only 2.82 % of reports, is the one in which less zones were located of all the country, in previous studies on the flora in that oriental territory the species is not reported (20). Reportedly, pitahayas are distributed in the hot and stony areas of the southern coast of Santiago de Cuba, especially the subsp. *Luteocarpus*, although the respondents presented confusions with the species *Harrisia eriophora* (Pfeiff.) Britton, Bull, which were clarified during the research process, since they reported yellow fruits and corresponded to one or the other species; accessions were also located in the city of the province, in Jarahueca, Songo La Malla and in the mountainous area of San Benito in Segundo Frente, along the road to Mayarí Arriba. In the easternmost region of the country, pitahaya accessions were located in the

communities of Niceto Pérez, San Antonio del Sur and Jobo Dulce in Baracoa, Guantánamo, one of the driest and hottest areas of Cuba.

The accessions identified formed three groups according to the external and internal coloration of the fruits (Figure 6). In group I it was observed that the fruits of the accessions reported from the provinces of Villa Clara and Sancti Spíritus are very similar to each other, and in turn are similar to those from Pinar del Río, and these are related to those reported from Santiago de Cuba.

Group II was subdivided into two subgroups (a and b), in (a) we observed 100 % similarity between the predominant diversity in the provinces of Mayabeque, Ciego de Avila and Camagüey; at the same time fruit colorations of the accessions of Holguín, Cienfuegos and La Habana provinces showed similarities with the previous ones. In subgroup (b) are grouped the fruits of Las Tunas, Granma and Guantánamo provinces, which showed great similarity among themselves. In Group III were grouped the accessions reported from Artemisa and Matanzas, demonstrating that in this territory of the country is where the greatest diversity exists, in terms of external and internal coloration of pitahaya fruits.



**Figure 6.** Grouped representation of the diversity of pitahaya accessions in the country, taking into account the external and internal coloration of the fruits

## Pitahaya accessions located with promising characters

Popular participation and the work carried out in social networks made it possible to locate promising accessions, taking into account the species, fruit size and coloration, and the criteria of the owners. In the area of Playa municipality in Havana, one of the promising accessions cut in the country was identified, as well as in San Nicolás de Bari in Mayabeque, belonging to the species *Selenicereus purpusii*. The one located in Playa presented fruits with red exocarp and intense red mesocarp almost black (Figure 7 A and B) and the one identified in San Nicolás showed typical fruits of the species, but of large size and with dark reddish colorations with purple shades (Figure 7 C and D). In Güines an accession of the species *Selenicereus undatus* with large fruits and high production was located (Figure 7 E). The rest of the accessions of interest were found in Ceiba Mocha, community in the province of Matanzas, these belonging to the species *Selenicereus megalanthus* (Haw) Britton & Rose (fruit with yellow exocarp and with presence of thorns, black and big seeds, with white gelatinous mesocarp very sweet) (21,22) (Figure 8 A and B) according to the owner of the specimen, it has flavor similar to that of a Anón (*Annona scamosa* L. ), *S. guatemalensis* (Haw) Britton & Rose (fruit with pinkish-violet exocarp and purple mesocarp) (Figure 8 C and D). Some of the species located and identified are not reported or described in Cuba.

## Phases for participatory breeding of pitahaya

Given the scarcity of existing commercial cultivars in the country, the delay of research studies because they require it, a scheme is presented (Figure 9) with the phases for the

participatory breeding of pitahaya in Cuba, which satisfies in the short and medium term the demand for promising plant material for the beginning of cultivation in the country. The first phase consists of locating the accession through popular participation and geolocating it in order to know the edaphoclimatic conditions in which it has developed.

The second phase, prospecting the plant material for study (either by cutting or botanical seed) and collecting fruit samples; third phase, promotion in the Germplasm Bank; fourth phase, laboratory analysis of the fruit samples to determine the quality of the accession; fifth phase, establishment of an agromorphological evaluation plot; sixth phase, release of the cultivar; seventh phase, basic field promotion for the production of propagation material; eighth phase, production of seedlings; eighth phase, production of seedlings for propagation; fifth phase, establishment of an agromorphological evaluation plot; sixth phase, release of the cultivar; seventh phase, promotion of the basic field for the production of propagation material; eighth phase, production of certified pitahaya seedlings; ninth phase, putting into production.

This scheme is already being put into practice in the UCTB - Alquizar, with the first accessions located and identified 3 years ago, in the community of Mayorquín in Alquizar, another in the town of Güira de Melena and another that was introduced by the IIFT more than 20 years ago *Selenicereus costaricensis* (Haw) Britton & Rose (fruit with dark red exocarp and intense red mesocarp with purple tones). Although they are not yet considered commercial cultivars, propagation material is already being delivered for production, following the quality results issued by the laboratory and field studies.



Photos by Alex Pérez Borges, Walberto Loriga Peña and Ramón Omar Martínez Zubiaur

**Figure 7.** Promising pitahaya accessions located:

(A and B) *S. purpusii*, Playa La Habana; (C and D) *S. purpusii*, San Nicolás, Mayabeque, (E) *S. undatus*, Güines, Mayabeque

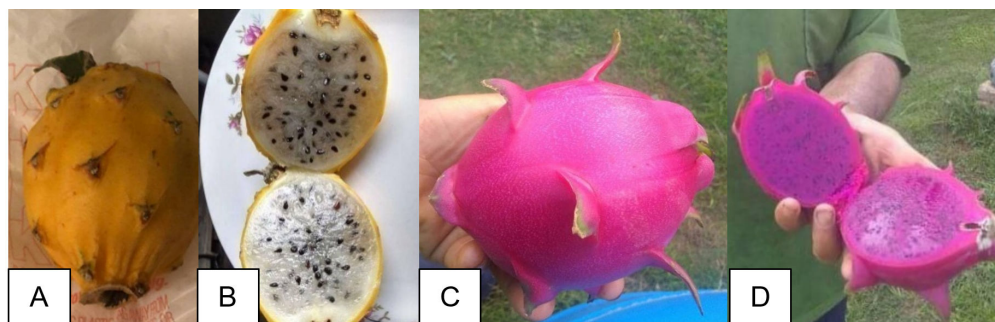


Photo taken by Oreine Santiesteban Cruz

**Figure 8.** Promising pitahaya accessions located: (A and B) *S. megalanthus* and (C and D) *S. guatemalensis*, Ceiba Mocha, Matanzas

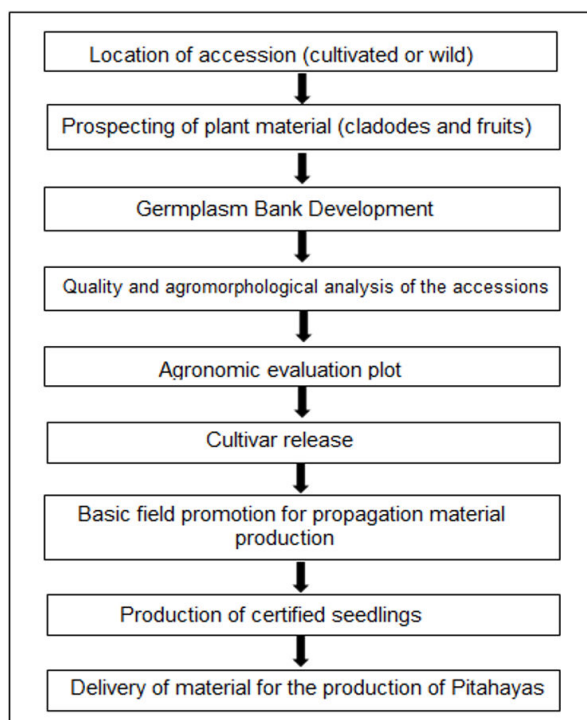


Figure 9. Scheme for Participatory Plant Breeding of pitahaya in Cuba

## CONCLUSIONS

Pitahaya (*Selenicereus* spp.) is widely distributed in the wild throughout the national territory and cultivated mainly as an ornamental plant. It was identified with great genetic variability in terms of species, shapes, colors and flavors of the fruits. Its potentialities are unknown by the majority of the population, which consumes it mostly in fresh fruit and juice. The greatest quantity of pitahayas was reported in the central region of the country, where they abound in wild or cultivated form, especially in Sancti Spiritus, Ciego de Avila provinces and the northern part of Villa Clara. In Havana, Mayabeque and Matanzas provinces, the greatest diversity of species and promising accessions were located. Five producers were located who had started cultivation as an economic activity. The Germplasm Bank of the UCTB - Alquizar was enriched. Cactus collectors and farmers of underutilized fruit trees treasure most of the diversity found in the country.

It is recommended to continue with the prospecting of plant material and fruit samples for quality analysis. Conduct studies on the behavior of the accessions in the edaphoclimatic conditions of the country and continue with the agromorphological characterizations of the specimens, as well as continue locating areas where accessions of pitahayas are found in Cuba, in search of the most promising ones.

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**through participatory plant breeding**

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