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Phenotypic Diversity of Morphological Traits of Pitahaya (*Hylocereus* spp.) and Its Agronomic Potential in the Amazonas Region, Peru

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Abstract: Pitahaya (*Hylocereus* spp.) is an economically significant cactus fruit in Peru, renowned for its rich nutritional profile and antioxidant properties while exhibiting wide biological diversity. This study aimed to morphologically characterize seven pitahaya accessions using qualitative and quantitative descriptors related to the cladodes, flowers, and fruits. Univariate and multivariate (FAMD, PCA, MCA, and clustering) analyses were employed to identify and classify the accessions based on their morphological traits. The analyses revealed three distinct groups: one consisting solely of AC.07; another with AC.02, AC.04, and AC.06; and a third including AC.01, AC.03, and AC.05. The first group exhibited superior characteristics, particularly in fruit traits such as the stigma lobe count (23.3), number of bracts (26.5 mm), and length of apical bracts (15.75 mm). The second group recorded the highest spine count (3.21), bract length (16.95 mm), and awn thickness (5.12 mm). The third group had the highest bract count (37) and an average locule number (23.65). These findings highlight the significant morphological diversity among the accessions, indicating the potential for classification and selection in pitahaya cultivation. The potential of AC.07 stands out in terms of its agronomic qualities, such as its fruit weight (451.93 g) and pulp weight (292.5 g), surpassing the other accessions.

Keywords: biodiversity; characterization; descriptor; dragon fruit; genetic improvement; *Hylocereus* spp.

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1. Introduction

Pitahaya, or dragon fruit (*Hylocereus* spp.), stands out internationally for its delicious flavor and its multiple nutraceutical and functional properties, such as strengthening the immune system [1,2]. Recent studies show that the consumption of its fruits regulates blood sugar levels, contributing to diabetes control [3,4]. Due to its well-known nutritional and therapeutic qualities, pitahaya is also anticipated to rank among the most economically significant fruit species grown worldwide [5,6]. This fruit is gaining greater economic importance in Peru, due to its great national and international demand and its nutritional and antioxidant properties. This crop adapts well to different climatic and agricultural conditions [7,8], which gives it significant potential from an agronomic point of view. Peru's main pitahaya production areas cover regions such as Lima, Piura, Lambayeque, Amazonas, San Martin, and Junin, where the climatic and soil conditions are conducive to its development. However, there is growing interest in expanding the cultivation areas, motivated by the profitability and added value that this fruit offers to farmers [9].

The agronomic importance of pitahaya in Peru is highlighted, due to its ability to adapt to different climatic and agricultural conditions, its high demand both nationally and internationally, and its nutraceutical properties, which make it a prized crop.

Despite the growing interest, the expansion of dragon fruit cultivation faces challenges, including the limited availability of high-quality vegetative seeds and the need for specific technological packages for new production areas. Implementing appropriate agronomic practices and access to certified propagation material are essential to guarantee the success and sustainability of the crop in these new areas. By morphologically characterizing different promissory accessions of dragon fruit and highlighting their best attributes, this study provides valuable information that will contribute to the conservation, genetic improvement, and optimization of its agronomic management, thus benefiting farmers and promoting crop expansion in Peru.

This exotic fruit, with a seductive aroma, is located in the cactus family (Cactaceae), where, taxonomically, there are 17 species of *Hylocereus* [8,10,11]. Among these, *H. guatemalensis*, *H. polyrhizus*, *H. undatus*, and *H. megalanthus*, native to Central and North America in tropical and subtropical ecosystems [12,13], have greater economic relevance [13,14]. However, their genetic diversity is at risk due to adverse climate conditions, such as extreme temperatures, prolonged droughts and floods, damage to soil health, and habitat fragmentation [10]. *H. monacanthus* and *H. undatus* were the first species cultivated in Israel. These species bear fruit during the summer, whereas *H. megalanthus* (Vaup) Bauer bears fruit during the winter. The fruits of *H. monacanthus* and *H. undatus* are large (200–600 g), with red scales and purple and red or white flesh, respectively; the fruits of *H. megalanthus* are smaller (80–200 g) and have a spiny yellow peel [15,16].

Peru identifies the species as *H. megalanthus*; however, recent agro-morphological characterization studies worldwide have shown significant genetic and morphological heterogeneity in the traits of its fruits, such as the content of soluble solids (°Brix), size, shape, color, and number of bracts, as a result of inter- or intraspecific hybridization between different wild and cultivated materials, which reduce their quality standards [17]. Under this scenario, the reported morpho-agronomic variations can be used to determine variations between natural dragon fruit populations [17]. This constitutes the foundation for the development of the process of the identification and conservation of accessions with high genetic value, which would meet the needs of consumers and farmers [18].

Dragon fruit (*Hylocereus* spp.) is becoming increasingly popular in Peru [13], due to its nutritional value and productive potential. Recently, farmers have begun cultivating various genotypes or varieties in different areas of the country, from the coast to the jungle. It is important to take into consideration that, in Peru, there are dragon fruit accessions whose morphological and agronomic characteristics have not yet been studied, and it is essential to analyze the genetic diversity and agronomic potential [19] present within a specific population and describe how they adapt to environmental conditions [20]. Pitahaya is a valuable fruit with great future potential, hidden in the biodiversity-rich Amazonas region of Peru. With its distinct flavor and beneficial qualities, this exotic fruit offers a great opportunity to advance the social and economic development of the area. Its sustainable cultivation has the potential to boost agro-exports, provide jobs for the local population, and establish Peru as a global leader in producing premium tropical fruits.

Therefore, the present study aims to characterize the phenotypic traits of seven dragon fruit accessions in the Amazonas region and to determine their agronomic potential, which will be further developed with research that expands this study under the conditions of the Amazonas.

2. Materials and Methods

2.1. Location and Vegetal Material

The morphological description of pitahaya was carried out in the central producing provinces of the Amazonas region (Bongara, Luya, and Rodríguez de Mendoza), from 2022 to 2023. This region is located in the northeastern area of Peru, characterized by its varied relief, rich biodiversity, and impressive hydrography, between the meridians 77°9′ and 78°42′ west longitude and 2°59′ south latitude. For this study, seven *Hylocereus megalanthus* and *Hylocereus* spp. accessions were collected (Figure 1 and Table S1); then, ten plants per accession were randomly selected, recording their geographical coordinates using a GPS (GPS eTrex 20, Garmin, Olathe, KS, USA), and detailed information was collected from the passport data for each evaluated plant. The plant material in the collection was established at the Agrarian Experimental Station (EEA) Amazonas of the National Institute of Agrarian Innovation (INIA).

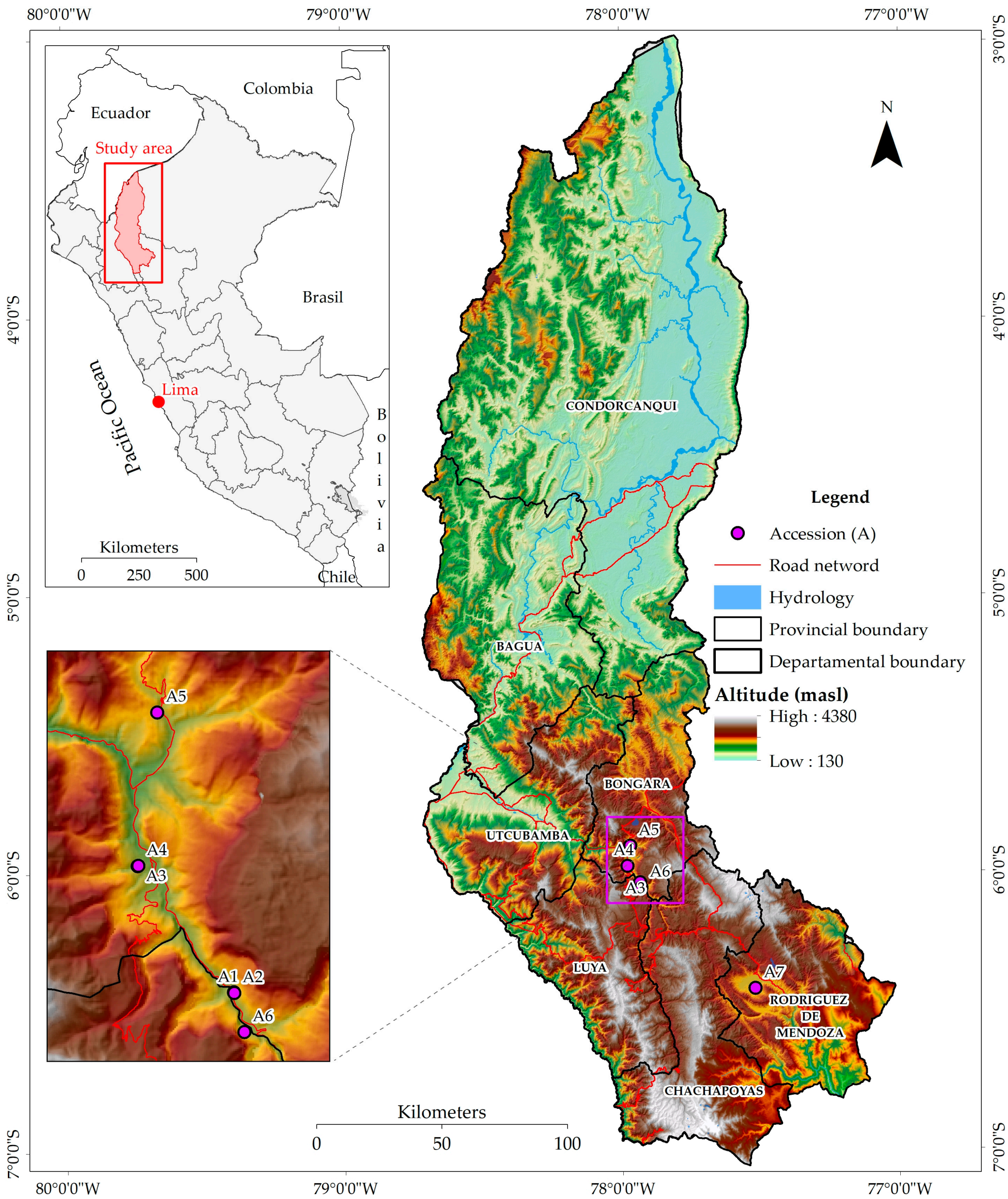

Figure 1. Location of the Department of Amazonas in Peru, EEA Amazonas—INIA, and the collection sites from the seven accessions (A1 = AC.01, A2 = AC.02, A3 = AC.03, A4 = AC.04, A5 = AC.05, A6 = AC.06 and A7 = AC.07).

Figure 2 shows images of seven pitahaya accessions collected and evaluated in the Amazonas, presenting the external appearance of the fruit and the color of its pulp. The accessions are numbered from AC.01 to AC.07, and each has a distinct appearance and pulp color.

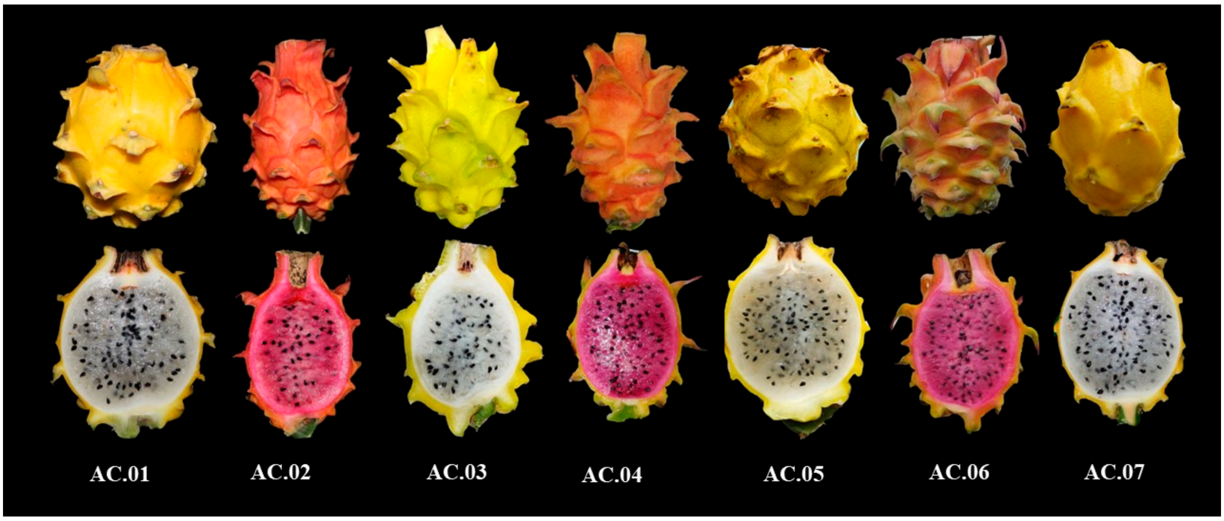

Figure 2. Images of whole fruits and pulp colors of seven pitahaya accessions collected and evaluated in the Amazonas region, Peru.

2.2. Variables Evaluated

For the evaluation of the qualitative (QL) and quantitative (QN) characteristics, the pitahaya descriptors of the International Union for the Protection of New Varieties of Plants (UPOV) [21] and the Embrapa descriptors were taken as references. Morpho-agronomic descriptors were used the inDUS tests of the pitahaya cultivars [22]. This research evaluated 19 qualitative and 21 quantitative characteristics: eleven characteristics for the cladodes, fourteen for the flowers, and fifteen for the fruits (Table 1). The measurements were carried out randomly, selecting ten plants with flowers and fruits. Each chosen plant was considered an experimental unit.

Table 1. Pitahaya cladode, flower, and fruit descriptors.

Descriptor	Acronym	Unit of Measurement	Characteristic
Young stem: reddish color	YSRC	——	QL
Length of segment	LS	mm	QN
Width	WI	mm	QN
Texture of surface	TS	——	QL
Distance between areoles	DBA	mm	QN
Arch height	AH	mm	QN
Margin of rib	MR	——	QL
Intensity of grey color of areoles	IGGA	——	QL
Number of spines	NS	#	QN
Length of spine	LS.1	mm	QN
Main color of spine	MCS	——	QL
Flower bud: shape	FBS	——	QL
Shape of apex	SA	——	QL
Color	C	——	QL
Length of pericarpel	LP	mm	QN
Width of pericarpel	WP	mm	QN
Length of perianth	LPt	mm	QN
Intensity of red color of bract	IRCB	——	QL
Petal: color	PC	——	QL
Sepal: main color	SMC	——	QL
Sepal: pattern of secondary color	SPSC	——	QL
Length of style	LE	mm	QN
Flower: number of stigma lobes	NSL	#	QN
Flower: color of stigma lobe	CSL	——	QL
Position of anthers in relation to stigma	PARS	——	QL

Table 1. *Cont.*

Descriptor	Acronym	Unit of Measurement	Characteristic
Fruit length	FL	mm	QN
Fruit width	FWd	mm	QN
Number of bracts	NB	#	QN
Fruit weight	FWe	g	QN
Fruit pulp weight	FPW	g	QN
Length of apical bracts	LAB	mm	QN
Position of bracts towards peel	PBTP	——	QL
Main color of middle bracts	MCMB	——	QL
Thickness of peel	TP	mm	QN
Color of peel	CP	——	QL
Color of flesh	CF	——	QL
Seed width	SeW	mm	QN
Seed length	SeL	mm	QN
Sweetness	SW	°Bx	QN
Apical cavity	AC	——	QL

QL: qualitative characteristic, QN: quantitative characteristic, # indicates the quantity in units.

2.3. Statistic Analysis

Statistical analyses were carried out, including an analysis of variance (ANOVA) for the quantitative descriptors and a Pearson correlation analysis to identify related descriptors. A comparison of the means was also carried out using the Student–Newman–Keuls (SNK test) for each variable. For the multivariate analyses, (i) a principal component analysis (PCA) was used, based on the correlation matrix between the quantitative descriptors, represented in a two-dimensional plane to group the accessions. Likewise, techniques such as (ii) multiple correspondence analysis (MCA) and Spearman correlation analysis were used for the qualitative descriptors. On the other hand, (iii) for the dendrogram, we used the Euclidean distance to carry out a cluster analysis using the Ward method and Gower distance; finally, (iv) a factor analysis of mixed data (FAMD) was carried out by combining the qualitative and quantitative data. All of these analyses were carried out using R programming codes with packages or libraries such as *agricolae* [23], *FactoMineR* [24], *factoextra* [25], *devtools* [26], *ggplot2* [26], *corrplot* [27], and *GGally* [28] of the R software ver. 4.4.1 [29] and the graphical interface of RStudio version 2024.04.2 + 764 [30], to integrate both the quantitative and qualitative variables. This allowed the extraction and visualization of the results obtained with various multivariate techniques, i.e., PCA, MCA, K-means, and FAMD.

3. Results

3.1. Morphological Characterization Using Quantitative Descriptors

The statistical analysis of 20 quantitative cladode descriptors for the flowers and fruits of the seven dragon fruit accessions showed statistically significant differences (Figure 3 and Table S2). The comparison of the means between the accessions showed differences (p-value < 0.0001) for all descriptors, except the sugar content (°Brix). The coefficient of variation (CV %) reflects the relative variability in each descriptor, highlighting that, among the variables of the fruit, the weight of the pulp exhibits variability (20.5%, minimum 115.6 g in AC.06 and maximum 297.61 g in AC.05), followed by the weight of the fruit (18.5%, minimum 198.91 g in AC.04 and maximum 451.93 g in AC.07) and the thickness of the peel (18.87%, minimum 78.16 mm in AC.04 and maximum 201.39 mm in AC.07). On the other hand, the length of the floral style (5.13%) and the length of the perianth (5.58%) show less variability, indicating a certain uniformity in these floral characteristics. The sweetness of the fruit (°Brix) has a low coefficient of variation (6.01%) and does not present significant differences (p-value = 0.1068), which suggests consistency in its sweetness between the different accessions. In the cladode variables, the greatest variability was observed in the width (mm) and arch height (mm) (CV: 26.45 and 23.26%, respectively), with greater dimensions of these cladode variables observed for AC.07 (Table S2).

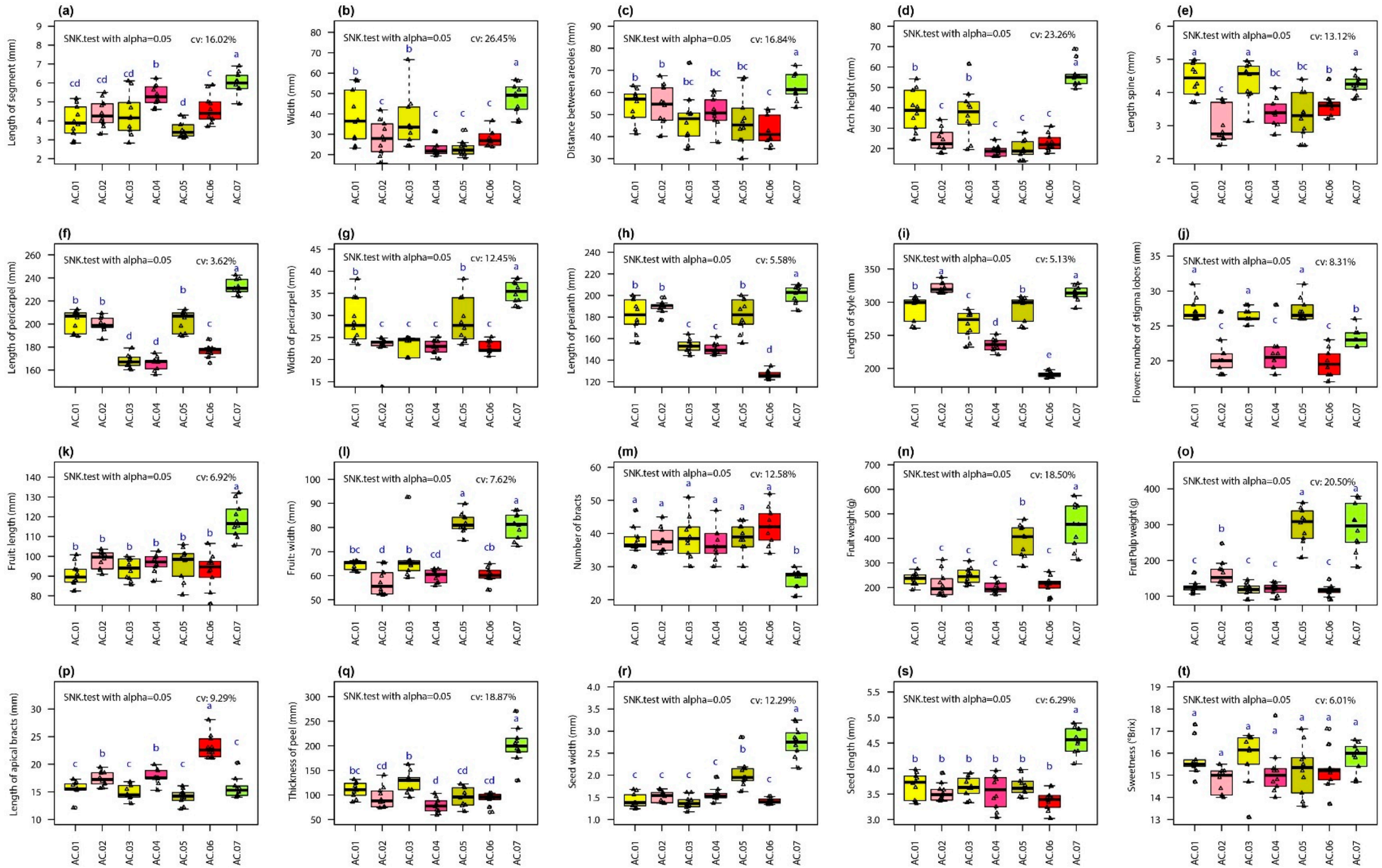

Figure 3. Boxplot with SNK test (grouped: a, b, c, bc . . ., to indicate statistical differences) and CVs for the 20 QL variables in the seven pitahaya accessions. The first five variables correspond to the cladode: length of segment (**a**), width (**b**), distance between areoles (**c**), arch height (**d**), and length of spine (**e**). The following five correspond to flower variables: length of pericarpel (**f**), width of pericarpel (**g**), length of perianth (**h**), length of style (**i**), and number of stigma lobes (**j**). Finally, the last 10 variables correspond to the fruit: fruit length (**k**), fruit width (**l**), number of bracts (**m**), fruit weight (**n**), fruit pulp weight (**o**), length of apical bracts (**p**), thickness of peel (**q**), seed width (**r**), seed length (**s**), and sweetness (**t**).

3.2. Multivariate Analysis Using Quantitative and Qualitative Data

In the Pearson-r correlation analysis, strong and significant correlations were found between the quantitative variables (Figures 3 and S1) (20: five for cladode, five for flower, and 10 for fruit). Pearson-r correlations > 0.7 were observed among the flower variables, such as the length of the pericarpel and the length of the perianth (r = 0.818 ***) (Figure 4); another was found between the length of the pericarpel and the length of the style (r = 0.705 ***) and finally between the length of the style and the length of the perianth (r = 0.903 ***). Regarding the fruit variables, the thickness of the peel and the arch height presented a strong correlation (r = 0.728 ***); another was observed between the fruit width and the fruit weight (r = 0.876 ***) and fruit pulp weight (r = 0.824 ***). Strong correlations were also observed between the fruit weight and the fruit pulp weight (r = 0.939 ***), thickness of the peel (r = 0.741 ***), and seed width (r = 0.723 ***). Finally, we highlight the strong correlation of the seed length and the shell thickness (r = 0.743 ***) and seed width (r = 0.764 ***).

The quantitative variables in this study also allowed us to conduct a PCA, which was able to explain 55.3% of the variance (Figures 5a and S2a,b) with the first two dimensions (Dim1 43.5 and Dim2 11.5% of the variance) and to explain more than 95% of the accumulated variance. It was observed with the contributions of up to 12 first components or dimensions (Table S3). The variables with the greatest contributions to the variance in Dim1 were the FW (8.22%), LP (7.99%), TP (7.84%), SeL (7.80%), and SeW (7.66%); for Dim2, the greatest variance was observed for the LPt (7.56%), AH (5.65%), TP (5.65%), WI (4.96%), LS.1 (4.45%), and WP (4.44%). In this PCA, the groups formed by the accessions AC.01, AC.02, and AC.03 cannot be discriminated entirely; they overlap more between the ellipses formed (Figures 5a and S2b). In contrast, AC.04, AC.05, AC.06, and ACC.07 show clear separation and differentiated grouping based on these 20 evaluated variables. On the other hand, when performing the clustering analysis and determining the number of groups of these dragon fruit accessions, we obtained four groups (Figure S2c). Group 2 was the best discriminated from the rest, corresponding to AC.07; group 1 was composed of accessions AC.01 and AC.03; group 3 was composed of AC.06, AC.04, and AC.02; finally, group 4 was composed of AC.05 and an individual from AC.02. These determined groups were used to perform PCA in a biplot, in which the largest values of the quantitative variables were observed in group 2 (Figure S2d). Group 3 had higher LAB and NB values. On the other hand, group 4 was characterized by having higher values of the variables NSL, LE, and LPt.

The MCA revealed that 70.8% of the total variability was observed and explained by the first two components, Dim1 (53.6%) and Dim2 (17.2%). Individuals within each accession showed similar characteristics, overlapping in the MCA graph (Figure 5b). Regarding the differences due to qualitative characteristics, AC.07 and AC.05 are more noticeable, followed by AC.02. On the other hand, AC.01 and AC.03 show greater closeness, as is also observed between accessions AC.04 and AC.06. This same grouping is reflected when considering the classification dendrograms with the Euclidean distance and the Ward method from the quantitative data (Figure 5c). These distances and closeness between the accessions evaluated are better consolidated with the FAMD analysis (Figure 5d and Table S4), finally forming three groups, with one group consisting only of AC.07; another with accessions AC.02, AC.04, and AC.06; and the last group consisting of accessions AC.01, AC.03, and AC.05. Then, groupings were created using the characteristics of each qualitative variable (Figure S3), which allowed the visual description and classification of the seven accessions with this FAMD analysis.

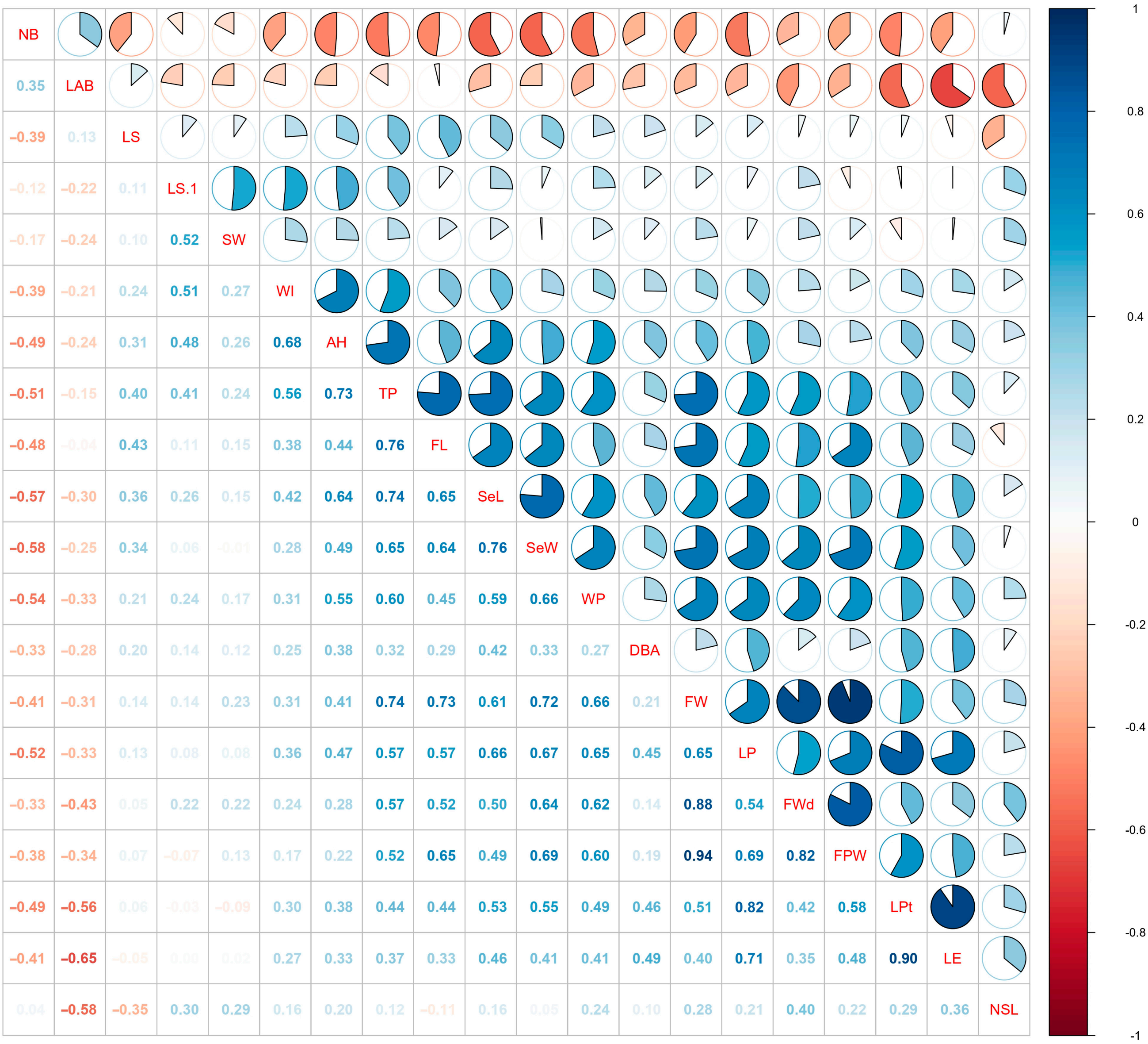

Figure 4. Correlogram with Pearson-*r* of the quantitative descriptors for the seven dragon fruit accessions in the Amazonas region of Peru. Blue indicates a positive (directly proportional) trend and red indicates a negative (inversely proportional) trend between two variables. The Pearson-*r* numeric values are also represented in pie charts, where the value of 1 is a whole pie chart and portions of the same pie have values >0 but <1. The variables included are the number of bracts (NB), length of apical bracts (LAB), length of segment (LS), length of spine (LS.1), sweetness (SW), width (WI), arch height (AH), thickness of peel (TP), fruit length (FL), seed length (SeL), seed width (SeW), width of pericarpel (WP), distance between areoles (DBA), fruit width (FWd), length of pericarpel (LP), fruit weight (FW), fruit pulp weight (FPW), length of perianth (LPt), length of style (LE), and number of stigma lobes (NSL).

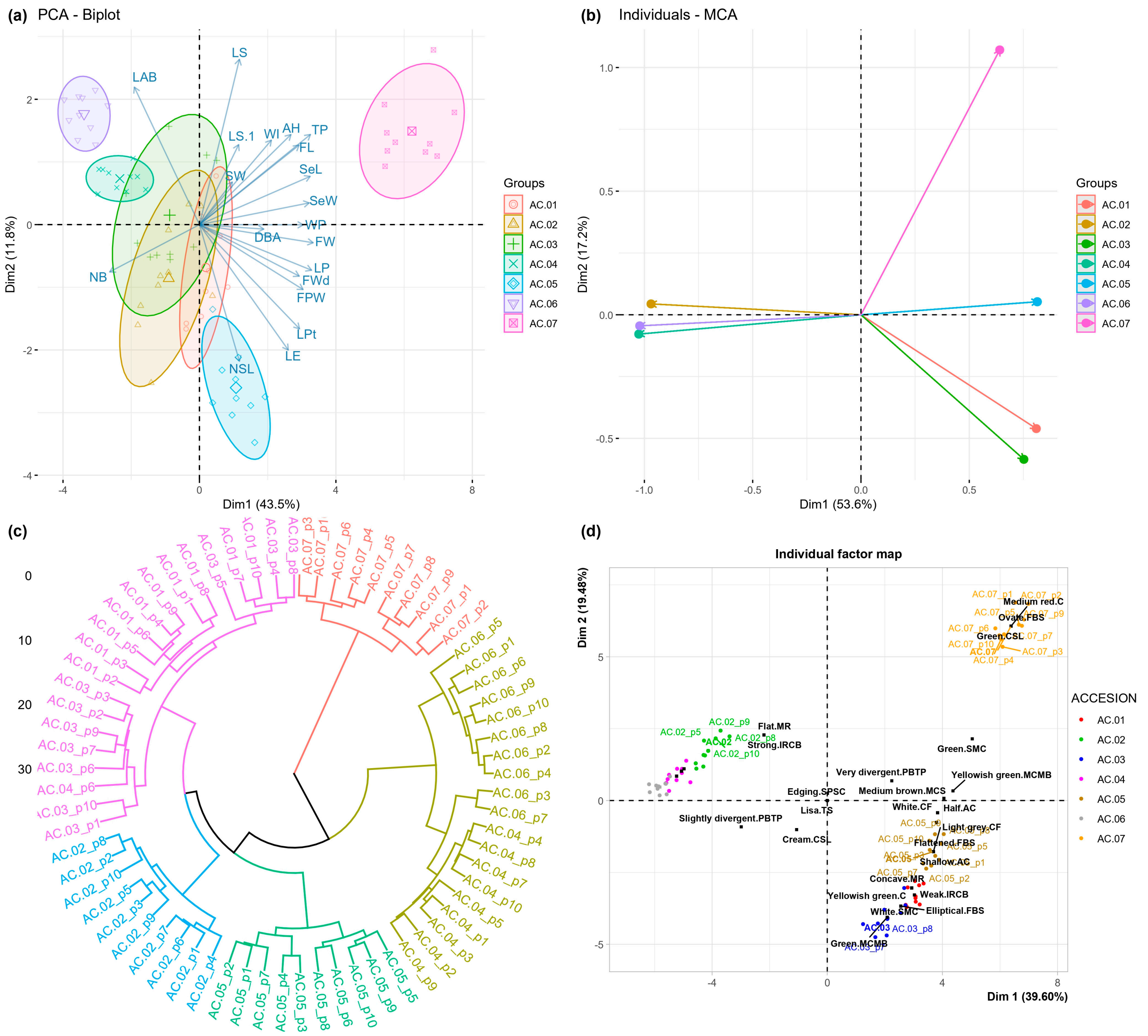

Figure 5. Multivariate analysis graphs. PCA in biplot (**a**) for the quantitative variables and grouped by accession; MCA for qualitative data (**b**) for seven accessions; classification dendrograms (**c**) using a clustering function, "hclust"; and FAMD with qualitative and quantitative data (**d**) of all individuals from seven accessions.

4. Discussion

Dragon fruit (*Hylocereus* spp.) is becoming increasingly popular in Peru due to its nutritional value and productive potential. Recently, farmers have begun cultivating various genotypes or varieties in different areas of the country, from the coast to the jungle. It should be noted that, in Peru, there are dragon fruit accessions whose morphological and agronomic characteristics have not yet been studied, and it is essential to analyze the genetic diversity and agronomic potential present within a specific population and describe how they adapt to the environmental conditions. This research shows the potential of these pitahaya accessions in the production fields in the Amazonas region, Peru, continuing with the evaluations in the experimental field and other existing local and commercial accessions for this pitahaya crop. This also reflects studies in the field of genetic improvement that seek to use a larger pool of genes of agronomic importance for pitahaya with promising accessions [31–33] (and future hybridizations of the same for the selection and massive multiplication of the material of interest in a clonal manner).

The morphological description of these dragon fruit accessions, among the 20 quantitative traits analyzed, revealed significant differences between the accessions. The statistical analysis (Figure 2, Table S2) shows that most traits present significant variations (p-value < 0.0001 ***), except the sugar content (°Brix). Studies on the morphology of pitahaya indicate remarkable diversity in its shape and biochemical composition, highlighting high levels of vitamin C, fiber, and quercetin, as well as differences in flavor, cladodes, and yield between the different cultivated varieties [14,17,18,34].

Each trait's coefficient of variability (CV %) highlighted the relative variability, showing significant differences mainly in fruit-related variables. Specifically, the pulp weight presented a CV of 20.5%, which ranged between a minimum of 115.6 g in AC.06 and a maximum of 297.61 g in AC.05. Similarly, the fruit weight exhibited variability of 18.5%, ranging from 198.91 g in AC.04 to 451.93 g in AC.07. These findings coincide with research carried out in Colombia and Mexico that highlights morphological diversity and quality differences among yellow pitahaya genotypes, identifying superior genotypes in terms of weight, size, acidity, and soluble solid content [7,18].

The thickness of the peel also presented notable variability (18.87%), with measurements that varied from 78.16 mm in AC.04 to 201.39 mm in AC.07. In contrast, the floral aspects, such as the lengths of the floral style and perianth, showed lower variability (5.13% and 5.58%, respectively), suggesting uniformity in these traits among the evaluated accessions. The fruit sweetness (°Brix) had a low coefficient of variation of 6.01% and no significant differences were observed (p-value = 0.1068 n.s.), indicating consistency in fruit sweetness among the accessions. Regarding the cladode variables, the width (26.45%) and height of the arch (23.26%) presented the greatest variability, with AC.07 being the specimen with the largest dimensions for these characteristics (Table S2). These results contrast what was observed in [18,22,34], evidencing significant diversity in the weight, size, and acidity of pitahaya fruits and °Brix levels ranging between 14.66 and 15.7, which are critical factors determining their quality and optimal maturity.

The Pearson-r analysis (Figures 3 and S1) revealed significant correlations between the quantitative variables, covering the cladode, flower, and fruit characteristics. Strong correlations were noted particularly between the flower variables (0.903 *** > r > 0.723 ***), such as the pericarpel length with the perianth length and style length. Additionally, the style length exhibited a strong correlation with the perianth length. For the fruit variables, a strong correlation was observed between the shell thickness and arch height, as well as between the fruit width and fruit weight and the weight of the fruit pulp. Other strong correlations included the fruit weight with the fruit pulp weight, shell thickness, and seed width. On the other hand, the seed length was also significantly correlated with the shell thickness and seed width. These results align with what was mentioned in [14,17,18,34,35], which highlight the importance of understanding the pitahaya's morphology and biochemical variability to improve the fruit's production and quality. Genotype identification with superior characteristics and correlation evaluations between morphological and biochemical traits are essential in developing genetic breeding programs that respond to production needs and achieve effective selection [32].

The PCA offered a comprehensive view of the quantitative data [36,37], explaining a high degree of the variability (Figures 5a and S2a,b). To reach more than 95% of the accumulated variability, contributions up to dimension 12 were considered (Table S3). Among the variables with the greatest influence (between 9 and 4% of the variance) in Dim1 were the fruit weight, perianth length, shell thickness, seed length, and seed width. For Dim2, the largest contributions were found for the petal length, arch height, shell thickness, cladode width, and spine length. These results confirm the diversity shown by [3,17,22,38], with *Hylocereus* and *Selenicereus* standing out both biochemically and morphologically and *H. costaricensis* being the one that exhibits the greatest antioxidant capacity.

Notable variability was observed between the different accessions of dragon fruit, in both the quantitative and qualitative characteristics, which highlights the importance of selective breeding and genetic improvement. Consistency and stability in specific traits, such as sweetness, are desirable aspects for commercial cultivation. On the other hand, the wide variation in aspects related to the fruit morphology offers opportunities to select specific ecotypes that meet particular agricultural and commercial requirements. While uniformity in fruit sweetness is favorable in maintaining commercial stability, diversity in the fruit morphology allows varieties to be chosen that satisfy specific market demands. This underlines the relevance of selective breeding programs to enhance the successful cultivation of dragon fruit [10,11].

Strong relationships between certain traits suggest that the choice of one trait could inadvertently affect others. For example, the close relationship between the fruit weight and pulp weight means that selecting larger fruits could also increase the pulp yield, which is beneficial for processing industries. Similarly, connections between floral attributes could guide breeding programs in improving the pollination efficiency and floral morphology. Furthermore, understanding the relationships between floral attributes can help to design programs that optimize the flowers' pollination and morphological quality [33,39,40].

The various groupings identified through the multivariate analysis provide a framework for the classification of accessions based on their qualitative and quantitative morphological traits. This classification can guide breeding programs by identifying accessions with desirable characteristics for hybridization. Group 2 (AC.07) accessions can be prioritized for factors such as a larger fruit size and a greater amount of pulp. In contrast, those from group 3 (AC.06, AC.04, and AC.02) could be valuable for their traits related to the flower morphology and the shell thickness. This simplifies the choice of accessions with specific characteristics for future genetic improvement programs in upcoming research [11,17,18].

The results of the analysis of the accessions reveal that AC.07 stands out for its outstanding agronomic qualities, registering the highest values in critical aspects such as the fruit weight (451.93 g) and pulp weight (292.5 g), surpassing the other accessions. These characteristics suggest its potential to produce larger and better-quality fruits, making it an ideal market option. In addition, AC.07 exhibited notable thickness in its peel (201.39 mm), which could contribute to its resistance and facilitate its transport. This accession presents a greater length in the apical bracts (23.18 mm), similar to accession AC.05; this characteristic could protect the fruit and reduce possible damage during its handling and transport in the agricultural field. Although no significant differences in the soluble solid content (° Brix) were observed among the different varieties analyzed (ranging from 14.76 to 15.82 ° Brix), this consistency would be commercially beneficial by ensuring uniformly good fruit quality. The consistency of these cultivars and the diversity in the fruit size and weight in the AC.07 and AC.05 accessions highlight their ability to meet both the market needs and the agricultural requirements of local farmers.

5. Conclusions

The variability in different pitahaya accessions in the Amazonas region, Peru indicated notable differences in their qualitative and quantitative morphological traits. Using techniques such as PCA and MCA, distinctive groups could be identified between the different accessions, with marked disparities in aspects such as the fruit weight, the pulp weight, and the thickness of the shell. These observations were confirmed by FAMD, which allowed three distinct groups to be established. These discoveries highlight the possibility of obtaining new genetic combinations and selecting the most beneficial accessions to meet agricultural and market needs. Likewise, the importance of implementing appropriate agronomic practices and using certified material for vegetative propagation is emphasized to optimize the production and quality of pitahaya in Peru. These seven pitahaya accessions stand out for their fruit qualities, with AC.07 being the largest and heaviest.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/agriculture14111968/s1, Table S1: Places of origin of pitahaya in Department of Amazonas, Peru; Table S2: Descriptive statistics of quantitative descriptors of pitahaya cladode, flower, and fruit; Table S3: Contributions to variance in quantitative variables in PCA and accumulated variance for each component; Table S4: Contributions to variance in quantitative and qualitative variables in FAMD and accumulated variance for each component; Figure S1: Correlogram of quantitative descriptors for seven dragon fruit accessions in Amazonas region; Figure S2: Multivariate analysis graphs. Principal components analysis (PCA) by variable (a) for quantitative variables, individuals—PCA with groups by access (b). Clustering by k-means (c) and PCA biplot with four clusters with quantitative data (d); Figure S3: Multivariate analysis graphs. Factor analysis of mixed data (FAMD) with qualitative and quantitative data, grouped by accession: (a) young stem—reddish color (b), margin of rib (c), intensity of grey color of areoles (d), main color of spine (e), flower bud—shape (f), shape of apex (g), color (h), intensity of red color of bract (i), petal—color (j), sepal—main color (k), flower—color of stigma lobe (l), position of anthers about stigma (m), position of bracts towards peel (n), main color of middle bracts (o), color of peel (p), color of flesh (q), and apical cavity (r).

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