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Leaf Epidermal Properties of Two *Bougainvillea spectabilis* Willd. Cultivars (Red Bract and White Bract) Cultivated in Sana'a University New Campus

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Abstract:

This study investigated the taxonomic significance of 24 leaf epidermal characters, in two cultivars of *Bougainvillea spectabilis*: red bract and white bract cultivars. Our analysis revealed eight quantitative properties that significantly differentiated between the two cultivars. These included five quantitative properties observed on both the adaxial and abaxial surfaces: the number of epidermal cells per 400x field of view, the number of trichomes per 400x view, the trichome index, the number of stomata per 400x view, and the percentage of Tetracytic stomata. Additionally, three quantitative properties specific to the adaxial surface were determined: epidermal cell width, stomatal index, and percentage of Polycytic stomata (five subsidiary cells). To further assess the taxonomic relationship between cultivars, two-way cluster analysis (TWCA) was employed on the 24 leaf epidermal characters, resulting in a dendrogram that segregated the two cultivars at a high similarity level of 93.85%. These findings indicated that the two cultivars represent distinct taxa within the same species.

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INTRODUCTION

Bougainvillea Comm. ex Juss. (1789) (Nyctaginaceae; Bouginvilleeae) is a commonly cultivated plant group which are popular ornamental plants mainly grown for its attractive colorful bracts that splash color to the surrounding. It is popular among parks, homes, and institutional gardens grown mainly as the bush, climber, hedge, topiary, standard, pot plant, bonsai, on pergolas and trees (Salam *et al.*, 2017; Bautista *et al.*, 2022), this genus includes 14–18 species which are scandent shrubs or small trees often armed with simple or forked thorns characterized by colorful structures which are actually modified bracts and often mistaken as flowers while the flowers are small tubular and attached to the inner surface of each bract (Kobayashi *et al.*, 2007; Bautista *et al.*, 2022). The genus *Bougainvillea* was divided into two subgenera: subg. *Tricycla* and subg. *Eubougainvillea*. (Standley, 1937; Bautista *et al.*, 2022), the subg. *Tricycla* included only one species *Bougainvillea spinosa* while the rest of the *Bougainvillea* taxa were classified into subg. *Eubougainvillea* (Standley, 1931; 1937). On the other hand, the subg. *Eubougainvillea* was divided into two unnamed groups: the first group, includes taxa with large (4 cm long), brightly colored bracts ranging between 2.5 to 4cm long among them *B. pachyphylla*, *B. peruviana*, *B. glabra*, and *B. spectabilis*; However the second group includes taxa with smaller ((<2.5 cm long) and less conspicuous bracts, among them *B. berberidifolia*, *B. campanulata*, *B. infesta*, *B. praecox*, and *B. stipitata* (Standley, 1931; 1937; Bautista *et al.*, 2022).

Bougainvillea spectabilis, which is a native of Brazil (Lack, 2012; Salam *et al.*, 2017) and reported to be found wild in all provinces of that large country (Forzza *et al.*, 2010), is an extremely popular ornamental, cultivated and traded today on all five continents (Lack, 2012; Salam *et al.*, 2017). *Bougainvillea spectabilis* is the type species of the genus *Bougainvillea* (Bautista *et al*., 2022) it was first collected by Philibert Commerson who was one of the members of Bougainville voyage (Bougainville expedition) which was named after the commander Louis-Antoine de Bougainville who was the leader of this expedition on Étoile ship which was one of two ships flying French colors (Lack, 2012; Bautista *et al*., 2022). The expedition arrived in Brazil (Rio de Janeiro) in 1767. In this expedition Philibert Commerson collected five *B. spectabilis* specimens; four were kept in the Muséum National d'Histoire Naturelle in Paris (two at the General Herbarium of the Muséum and two at the Jussieu Herbarium) while the fifth specimen was kept at General Herbarium of the Institute de Botanique of Montpellier University (Lack, 2012). In 1789 Antoine Laurent de Jussieu validated the generic name *Bougainvillea* (since de Bougainville was the commander of the voyage, the newly discovered genus was named after him) in his famous book "Genera Plantarum" where he described the genus *Bougainvillea* based on Commerson specimens which were collected from Rio de Janeiro during the Bougainville expedition (Jussieu, 1789) but he did not provide a specific epithet for Commerson specimens (Lack, 2012). Furthermore, in 1799 Carl Ludwig Willdenow published the name *Buginvillaea spectabilis* with a full description in the second volume of the fourth edition of Linnaeus's "Species Plantarum" (Willdenow, 1799; Lack, 2012).

Bougainvillea spectabilis is a climbing shrub with spines, producing small white flowers and colored bracts (Shaiq *et al.*, 2005). Based on the pigment / or color of the bracts there are many cultivars of *B. spectabilis* including; white, yellow, orange, red, purple, and violet cultivars (Shaiq *et al.*, 2005; Zhang *et al.*, 2024) this variation in the bract color in the different cultivars is due to the different ratios of two pigments known by; betaxanthin (yellow to orange) pigment and betacyanin (red-violet) pigment (Lan *et al.*, 2023) which belongs to Betalains pigments which are a plant secondary metabolites derived from the metabolism of

amino acid l-tyrosine (Mueangnak *et al.*, 2025). Moreover, in 2023, Lan *et al.* mentioned that the white bract and the red bract *B. spectabilis* cultivar exhibited a different amount of betacyanin and betaxanthin pigments where the red cultivar displayed a higher amount of betaxanthin than betacyanin (Lan *et al.*, 2023).

On the other hand, former studies cited that leaf epidermal characteristics including qualitative and quantitative properties of the epidermal cells and stomata complex showed a high taxonomical significance value in distinguishing between different taxa that belong to the same genera (Ibrahim and Ayodele, 2013; Ibrahim *et al.*, 2016; Ibrahim *et al.*, 2018) or the same species rank (Ibrahim *et al.*, 2021). Most of the previous studies concentrate on the chemical differences between the white bract and the red bract *B. spectabilis* cultivar; however, no attempts seem to have been made to illustrate the taxonomical relationship between the two *B. spectabilis* cultivars. Therefore, the current study was conducted to investigate the leaf epidermal characteristics of the two *B. spectabilis* cultivars and to evaluate their taxonomic significance in studying the relationships between the two cultivars.

MATERIALS AND METHODS

Plant material

During September and October 2024, plant specimens and fresh leaves of two *B. spectabilis* cultivars (red bract and white bract) were collected from the new campus of Sana'a University (Figure 1 and Table 1). The plant material was identified using the available taxonomical references, specifically Wood (1997) and Al Khulaidi (2013). The identified specimens were assigned herbarium numbers, BHSS 990 & BHSS 1010 for the red bract cultivar, and BHSS 995 and BHSS 1016 for the white bract cultivar, and were stored at the Faculty of Science, Sana's University Herbarium for future reference.

Fig.1. *B. spectabilis* cultivars (red bract and white bract): A. General view of the two *B. spectabilis* cultivars (red bract and white bract), B. Flowers and leaves of the red bract *B. spectabilis* cultivar; C. Flowers and leaves of the white bract *B. spectabilis* cultivar.

Table 1. Locality and Sample collection of the investigated *B. spectabilis* cultivars (red bract and white bract).

No.	*B. spectabilis* cultivars	Herbarium No.	Date of collection	Coordinates		Altitude	Location
				Longitude	Latitude		
1	Red Bract Cultivar	BHSS 990	15/9/2024	44°11'16.71"E	15°21'46.94"N	2274m	Sana'a University, New Campus
		BHSS 1010	10/10/2024	44°10'41.39"E	15°22'19.41"N	2262m	
2	White bract Cultivar	BHSS 995	20/9/2024	44°11'17.13"E	15°21'47.04"N	2274m	
		BHSS 1016	18/10/2024	44°10'41.76"E	15°22'19.11"N	2261m	

Epidermal investigation

Approximately ten mature and fully expanded leaves from each cultivar of *B. spectabilis* (both red bract and white bract) were cut into pieces measuring about 2 cm (modified after Ibrahim *et al.*, 2018; Ibrahim *et al.*, 2021). Each leaf piece was immersed in concentrated nitric acid for 2 to 10 hours until air bubbles appeared on the surface, indicating that the adaxial epidermis was ready to be separated from the abaxial epidermis. Subsequently, the leaf pieces were placed in a Petri dish filled with water, and the epidermal layers were carefully separated using fine forceps and a dissecting needle. Each epidermal layer was cleaned with a camel hair brush in water (Ibrahim and Ayodele, 2013; Ibrahim *et al.,* 2016). The layers were then stained with Safranin, rinsed with clean water to remove any excess stain, and mounted in glycerol on clean slides; a cover slip was placed over each slide (Ibrahim *et al.*, 2016; Ibrahim *et al.*, 2021). Nearly 30 replicates of the upper (adaxial) and lower (abaxial) epidermal layers for each cultivar were prepared. A light microscope (Leica ATC 2000) was utilized to observe the slides at a magnification of ×400. Photographs of the epidermal views were taken at this magnification using a Canon (IXUS255 HS) digital camera to assess the qualitative and quantitative characteristics of the epidermal layers (Tables 2 and 3). Additionally, quantitative characteristics were measured using an ocular micrometer calibrated with a stage micrometer (magnification ×400, where one ocular minor division equals 2.5 µm) and analyzed with Image J software (Ibrahim *et al.*, 2021; Ibrahim *et al.*, 2024). Based on the epidermal layer nomenclature outlined by Dilcher (1974) and the Leaf Architecture Working Group (1999), about 24 epidermal characteristics (four qualitative and 20 quantitative) were examined (Tables 2 and 3).

Statistical analysis:

The taxonomic value of quantitative epidermal properties was assessed by a T-test conducted with the Graph Pad Prism 6.01 program; if the P-value < 0.05, then the quantitative leaf features are significantly different. The relationship between the two investigated *B. spectabilis* cultivars has been illustrated using a dendrogram based on the obtained leaf epidermal properties (Tables 2 and 3) by creating a data matrix for numerical analysis (TWCA) with a PC-ORD Windows version 7.09 (Ibrahim *et al.*, 2024).

Table 2. List of the Investigated leaf epidermal qualitative characters of the two *B. spectabilis* cultivars (red bract and white bract) under investigation.

1	Shape of Epidermal cells	Isodiametric/ Polygonal [1]	Rectangular [2]	
2	Epidermal Cell wall patterns	Anticlinal [1]	Undulate [2]	
3	Type of leaf based on stomata ratio	Hypostomatic [1]	Hypoamphistomatic [2]	Amphistomatic [3]
4	Type of stomata.	3 types of stomata Tetracytic, Polycytic (5 subsidiary cells), Polycytic (> 5 subsidiary cells)) [1]	4 types of stomata (Anisocytic, Tetracytic, Polycytic (5 subsidiary cells), Polycytic (>5 subsidiary cells)) [2]	

Table 3. List of the examined epidermal leaf quantitative characters of the two *B. spectabilis* cultivars (red bract and white bract) under investigation.

1	Epidermal cells		No. of cells in 400x view
2			Diameter 1 (µm)
3			Diameter 2(µm)
4			Size (µm2)
5			Wall thickness (µm)
6	Trichomes		No. of Trichomes in 400x view
7			Trichom Index
8	Stomata		No. of Stomata in 400x view
9			Stomata Index
10		Percentage of Stomata Type	% Polycytic (5 <)
11			% Polycytic (=5)
12			%Tetracytic
13			% Anisocytic
14			Guard cell length (µm)
15			Guard cell width (µm)h (µm)
16			Guard cells size (μm^2)
17			Guard cells area (μm^2)
18			Stomata length (µm)
19			Stomata width(µm)
20			Size of stomata (μm^2)

RESULTS

A total of 24 leaf epidermal characters, comprising four qualitative and 20 quantitative properties, were examined in two cultivars of *B. spectabilis* (red bract and white bract) to assess their taxonomic significance in distinguishing between the two cultivars. The qualitative properties of the leaf epidermis, as shown in Table 4 and Figure 2, indicate that the epidermal cells of the studied taxa are isodiametric or polygonal in shape, with an anticlinal cell wall pattern. Moreover, Tables 4, 5, and Figure 3, display that the leaf surfaces of the red bract (adaxial and abaxial surface) and the adaxial surface of the white bract are characterized by the presence of four types of stomata: anisocytic, tetracytic, polycytic (5 subsidiary cells), and polycytic (>5 subsidiary cells). In contrast, the abaxial leaf epidermis of the white bract is characterized by three types of stomata: tetracytic, polycytic (5 subsidiary cells), and polycytic (> 5 subsidiary cells). Furthermore, Table 4 shows that the red bract cultivar has a hypoamphistomatic leaf type based on stomatal distribution, while the white bract cultivar is hypostomatic. In addition, the adaxial and abaxial surface of the two *B. spectabilis* cultivars contains non-glandular multicellular rounded head Trichomes (Table 5 and Figure 4).

Table 4. Qualitative characters of the Adaxial and Adaxial Surface of two *B. spectabilis* cultivars (Red bracts and White bracts) leaves.

No.	Characters	Epidermal layer	*B. spectabilis* (red bracts)	*B. spectabilis* (white bracts)
1	**Shape of Epidermal cells**	Ad	1	1
		Ab	1	1
2	**Epidermal Cell wall patterns**	Ad	1	1
		Ab	1	1
3	**Type of leaf based on stomata ratio**		2	1
4	**Type of stomata**	Ad	2	2
		Ab	2	1

Table 5. Quantitative characters of the Adaxial and Adaxial Surface of two *B. spectabilis* cultivars (Red bracts and White bracts) leaves.

No.	Characters		Epidermal layer	*B. spectabilis* (red bracts)	*B. spectabilis* (white bracts)	P. value
1	Epidermal cells	No. of cells in 400x view Min (Mean ±SD) Max	Ad	171(188 ±8) 199	219(231±6.1) 240	<0.0001(****)
			Ab	272(287±9)308	311(334±11) 350	<0.0001(****)
2		Length (µm) Min (Mean ±SD) Max	Ad	23.3(32.4 ±4.2)40.5	22.9(27.8±3.9)39.3	0.0002(***)
			Ab	20.4(27.5±4.3)36.4	19.3(24.7±3.2)32.1	0.0151 (*)
3		Width (µm) Min (Mean ±SD) Max	Ad	17.1(25.6 ±3.5) 33.3	16(20.5±2.9) 26.1	<0.0001(****)
			Ab	13.6(18.9±3) 26.6	11.7 (16.7±2) 21	0.0080 (**)
4		Size (µm2) Min (Mean ±SD) Max	Ad	453.3(830.2±195.8)1180.2	362.9(575.1±153.8)1032.3	<0.0001(****)
			Ab	274.7(534.1±152.9) 838.9	246.5(427.7±89.9) 627.7	0.0043(**)
5		Wall thickness (µm) Min (Mean ±SD) Max	Ad	1.2 (1.6 ±0.3) 2.1	1.2(1.6±0.2)2	0.5654
			Ab	1.2(1.7±0.4)2.3	1.1503(1.9±0.4) 2.8	0.0620
6	Trichomes	No. of Trichomes in 400x view Min (Mean ±SD) Max	Ad	0 (2 ±1.2) 4	0 (1 ±0.6) 2	<0.0001(****)
			Ab	2(4±1.2) 6	0(2 ±0.9)4	<0.0001(****)
7		Trichom Index (%) Min (Mean ±SD) Max	Ad	0 (0.9 ±.6) 2.2	0(0.2±0.3) 0.9	<0.0001(****)
			Ab	0.79(1.2±0.4) 2.1	0(0.5±0.3) 1.2	<0.0001(****)
8	Stomata	No. of Stomata in 400x view Min (Mean ±SD) Max	Ad	2 (6 ±1.5) 9	0 (1±0.7) 2	<0.0001(****)
			Ab	20(25± 2.5) 29	25(30±3.3)38	<0.0001(****)
9		Stomata Index (%) Min (Mean ±SD) Max	Ad	1.2 (3.2 ±0.7) 4.7	0(0.3±0.3) 0.9	<0.0001(****)
			Ab	6.1(7.9±0.8) 9.5	7.1(8.1±0.8) 10	0.2774
10		%age of Stomata Type: % Polycytic (> 5 subsidiary cells) Min (Mean ±SD) Max	Ad	0 (10.7±12.7) 50	0(14±33.9) 100	0.6531
			Ab	4.6(19.7±9) 35	8(24.2±7.7)43.5	0.0667
11		%age of Stomata Type: % Polycytic (5 subsidiary cells) Min (Mean ±SD) Max	Ad	0 (39.8±18.4) 80	0 (24±41.1) 100	0.0868
			Ab	5(34.9±12.1)62.5	33.3(48.8±7) 63.3	<0.0001(****)
12		%age of Stomata Type: %Tetracytic Min (Mean ±SD) Max	Ad	0(43.7±16.6) 77.8	0(10±28.9) 100	<0.0001(****)
			Ab	13.6(39.9 ±12.6) 65	12.5(25.9±7.5)40.7	<0.0001(****)
13		%age of Stomata Type: % Anisocytic Min (Mean ±SD) Max	Ad	0 (5.8±13.6) 60	0	0.0368 (*)
			Ab	0(5.5 ±6.1)23.5	0 (1.1±2.2) 8.3	0.0017(**)
14		Guard cell length (µm) Min (Mean ±SD) Max	Ad	17.3 (22.5 ±3.7) 30.4	12.8(22.1±5.3)41.8	0.7838
			Ab	17.7 (24 ±3.1) 31.3	18.2(25.6±4.4) 33.5	0.1291
15		Guard cell width (µm) Min (Mean ±SD) Max	Ad	4.5(6.9±1.2) 8.9	3.9 (7.7±1.7)11.89	0.0476(*)
			Ab	5.7 (7.5 ±0.9) 9.4	5.3(7.5±1.3) 10	0.9244
16		Guard cells Size (μm^2) Min (Mean ±SD) Max	Ad	88.9 (157.4± 47.8) 260.6	50.3(177±82.9)496.4	0.3110
			Ab	104.2(180.4±37.2)295.2	115.2(196.3±61.1) 310.5	0.2750
17		Guard cells area (μm^2) Min (Mean ±SD) Max	Ad	69.8 (123.6 ±37.5) 204.6	39.5(139±65.1) 389.8	0.3110
			Ab	81.8 (141.7±29.2) 231.8	90.5(154.1±48.1) 243.8	0.2750
18		Stomata length (µm) Min (Mean ±SD) Max	Ad	17.3 (22.5 ±3.7) 30.4	12.8(22.1±5.3) 41.8	0.7838
			Ab	17.7 (24 ±3.1) 31.3	18.2(25.6±4.4) 33.5	0.1291
19		Stomata width(µm) Min (Mean ±SD) Max	Ad	13.1(16.7 ±2.6) 22.2	10.5(18.5±4.2)29	0.0622
			Ab	13.6(18.3±2.4) 24.1	13.1(18.7±3.1)24.3	0.4303
20		Size of stomata (μm^2) Min (Mean ±SD) Max	Ad	231.3(381.5 ±116.5) 628.6	133.9(426±204.8) 1213.7	0.3498
			Ab	240.8 (440.9±101.6)753.9	248.3(492.7±150.4) 753.8	0.1605

Ad: Adaxial surface; Ab: Abaxial surface.

According to Table 5, the abaxial surface of the white bract cultivar exhibits the highest mean number of epidermal cells (334 epidermal cells) in a view field of ×400 followed by the abaxial surface of the red bract cultivar, and the adaxial surface of the white bract cultivar with a mean number of epidermal cells 287 and 231 in a view field of ×400 respectively, while the adaxial surface of the red bract cultivar showed the lowest mean number of epidermal cell (188 epidermal cell) in a view field of ×400. However, the adaxial surface of the red bract cultivar displays the highest size of epidermal cells (Table 5) with a mean size of about 830.2µm^2 tailed by the abaxial surface of the red bract cultivar, and the adaxial surface of the white bract cultivar (575.1 and 534.1µm^2 correspondingly), whereas the abaxial surface of the white bract cultivar illustrate the lowest size of cells epidermal (with a mean size of 427.7 µm^2). Moreover, the abaxial surface of the white bract cultivar shows the highest wall thickness of

the epidermal cell with a mean wall thickness of about 1.9 µm (Table 5) followed by the abaxial of the red bract cultivar (1.7 µm), while the adaxial of the red bract and the white bract cultivars exhibit the lowest cell wall thickness (1.6 µm). Additionally, the abaxial surface of the red bract cultivar displays the highest mean number of trichomes (4 trichomes) in a view field of ×400 followed by the abaxial surface of the white bract cultivar and the adaxial surface of the red bract cultivar (with a mean number of trichomes of about 2 trichomes in a view field of ×400), while the adaxial surface of the white bract cultivar showed the lowest mean number of trichomes (one trichome) in a view field of ×400 (Table 5).

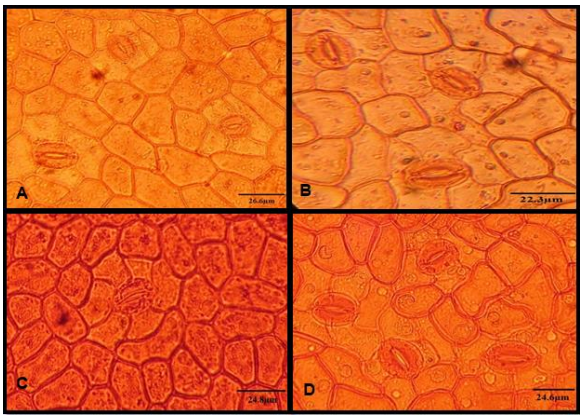

Fig. 2. Leaf Adaxial and Abaxial surface of the two forms of *Bougainvillea spectabilis:* A. Adaxial surface of Red bract *Bougainvillea spectabilis*, B. Abaxial surface of Red bract *B. spectabilis*, C: Adaxial surface of White bract *B. spectabilis*, D. Abaxial surface of White bract *B. spectabilis*.

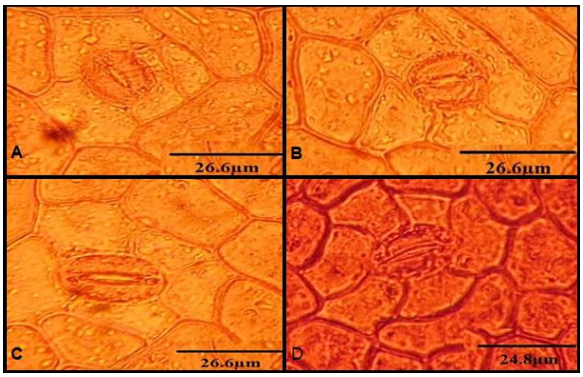

Fig. 3. Type of stomata in the Adaxial and Abaxial surface of the two *B. spectabilis* cultivar leaves: A. Anisocytic type, B. Tetracytic type, C. Polycytic (5 subsidiary cells) type, D. Polycytic (> 5 subsidiary cells) type.

Fig. 4. Trichomes in the Adaxial and Abaxial surface of the two *B. spectabilis* cultivar leaves: A. Trichome in the adaxial surface of the red bract *B. spectabilis*, B. Trichome in the abaxial surface of the red bract *B. spectabilis*, C. Trichome in the adaxial surface of the white bract *B. spectabilis*, D. Trichome in the abaxial surface of the white bract *B*. *spectabilis*.

On the other hand, the abaxial surface of the white bract cultivar exhibits the highest mean number of Stomata (30 stomata) in a view field of ×400 followed by the abaxial and adaxial surface of the red bract cultivar with a mean number of stomata 25 and 6 sequentially in a view field of ×400, while the adaxial surface of the white bract cultivar showed the lowest mean number of Stomata (one stoma) in a view field of ×400 (Table 5). Moreover, Table 5, illustrates that the abaxial surface of the white bract cultivar exhibits the highest Guard cells area with a mean Guard cells area of about 154.1µm^2 tailed by the abaxial surface of the red bract cultivar, and the adaxial surface of the white bract cultivar with a mean Guard cells area of about 141.7 and 139 µm^2 respectively, whereas the adaxial surface of the red bract cultivar shows the lowest Guard cells area (with a mean of guard cells area of about 123.6 µm^2). Furthermore, Table 5, demonstrates that the abaxial surface of the white bract cultivar displays the highest size of Stomata with a mean size of Stomata of about 492.7 µm^2 followed by the abaxial surface of the red bract cultivar, and the adaxial surface of the white bract cultivar with a mean size of Stomata of about 440.9 and 426µm^2 correspondingly, while the adaxial surface of the red bract cultivar exhibited the lowest size of stomata with a mean of the size of Stomata of about 381.5 µm^2.

In addition, Table 5 reveals that eight quantitative characters show high significance in

distinguishing between the two *Bougainvillea spectabilis* (red bract cultivar and the white bract) cultivar. These properties comprise five quantitative properties observed on both the adaxial and abaxial surfaces: the number of epidermal cells per 400x field of view, the number of trichomes per 400x view, the trichome index, the number of stomata per 400x view, and the percentage of tetracytic stomata, and three quantitative properties specific to the adaxial surface were determined: epidermal cell width, stomatal index, and percentage of polycytic stomata (five subsidiary cells). Using Two-way cluster analysis (TWCA), the relationship between two *B. spectabilis* cultivars (red bract cultivar and white bract cultivar) was evaluated based on 24 (4 qualitative and 20 quantitative traits) epidermal characteristics (Tables 4 and 5). The generated similarity matrix was used to construct a dendrogram (Figure 5), which separated the cultivars into two distinct groups at a relative similarity level of 93.85%. Group I comprised the red bract cultivar, while Group II comprised the white bract cultivar.

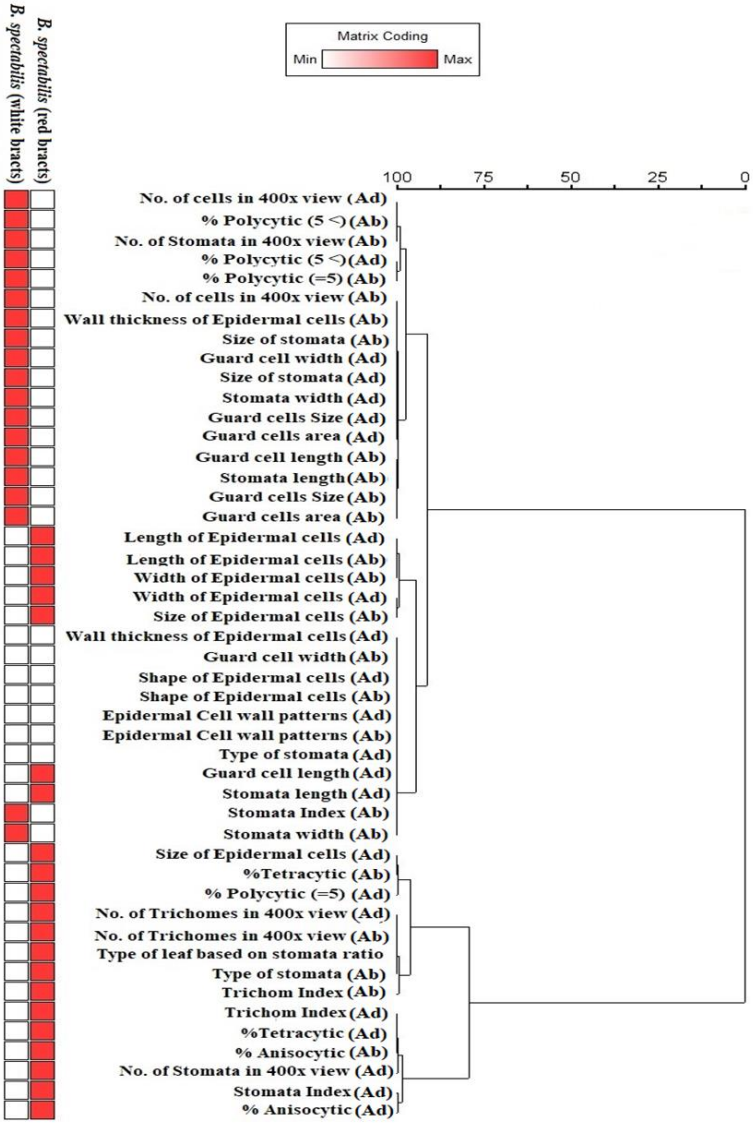

Fig. 5. Cluster analysis illustrates the relationship among the two investigated *Bougainvillea spectabilis* cultivars (red bract cultivar and white bract cultivar) based on 24 (4 qualitative and 20 quantitative) leaf epidermal characters by using the Two-Way Cluster Analysis (TWCA) - Group average.

DISCUSSION

Based on previous observations, the epidermal cells of both cultivars of *B. spectabilis* (red-bracted and white-bracted) are either isodiametric or polygonal in shape, with straight anticlinal walls. Stomata are present on both leaf surfaces, which is consistent with the findings of Xuan et al. (2011), who reported that in normal leaves, stomata are distributed on both the adaxial and abaxial surfaces and that the epidermal cells on both sides exhibit a polygonal shape and straight anticlinal cell wall patterns. *B. spectabilis* is a foundational species in the genus *Bougainvillea* and displays significant morphological and horticultural diversity, primarily due to natural hybridization and somatic mutations. This species has played a crucial role in the development of numerous ornamental cultivars through interspecific hybridization, resulting in a wide variety of novel bract colors and plant forms (Datta, 2021). Moreover, hybridization leads to the formation of intermediate taxa that are genetically distinct from their parental species. These intermediate taxa often exhibit characteristics that blend features from the parental species, indicating that hybridization can produce taxa that are genetically more similar to each other than to their original species (Aldridge and Campbell, 2009). This aligns with the numerical analysis previously mentioned, which showed a similarity level of 93.85% between the two investigated *B. spectabilis* cultivars (the red bract cultivar and the white bract cultivar). This illustrates that the two cultivars are different taxa within the same species.

CONCLUSION

The adaxial and abaxial epidermal cells of both cultivars of *B. spectabilis* (red and white bracts) are either isodiametric or polygonal, characterized by straight anticlinal walls. Stomata are present on both surfaces of the leaves. Furthermore, approximately eight quantitative properties show significant differences between the two cultivars, emphasizing their usefulness in distinguishing between the two cultivars.

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CONFLICT OF INTEREST

Authors hereby declare that they have no conflict of interest.

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