New Zealand Journal of Crop and Horticultural Science

REVIEW OPEN ACCESS

Forgotten Fruit, Infinite Potential: History, Genetics, Cultivation, and Future Perspectives for *Feijoa sellowiana*

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Received: 19 October 2025 | **Revised:** 23 January 2026 | **Accepted:** 3 February 2026

Keywords: *Acca sellowiana* | bioactive compounds | breeding programs | domestication | genetic diversity | phytosanitary challenges

ABSTRACT

Feijoa sellowiana (O. Berg), known as feijoa, is a South American fruit native to southern Brazil and northeastern Uruguay, with agronomic, nutritional, and industrial potential. Once restricted to its native range, the species is now cultivated in New Zealand, Colombia, and Georgia, where breeding programs and market chains are advancing its domestication. This review summarizes scientific advances regarding the species' origin, genetic diversity, improvement strategies, cultivation, pest and disease management, and industrial uses. Natural populations and germplasm banks preserve genetic variability, providing opportunities to select genotypes adapted to different environments. The main phytosanitary challenges include anthracnose, caused by *Colletotrichum theobromicola*, and fruit flies (*Anastrepha* spp.), both requiring integrated control. Feijoa fruits are rich in fiber, phenolics, vitamins, and aromatic volatiles, adding value to the food, pharmaceutical, and cosmetic industries. Future perspectives include the application of genomic tools, improved propagation methods, and the inclusion of feijoa in agroecological and bioeconomic systems. Strengthening *F. sellowiana* as a crop in its center of origin requires collaboration among researchers, policymakers, and producers to conserve diversity and realize its potential.

1 | Introduction

Feijoa sellowiana (O. Berg) O. Berg, also classified as *Acca sellowiana* (O. Berg) Burret, is a species of the Myrtaceae family, commonly known as feijoa, goiabeira-serrana, guayabo del país, and pineapple guava (Mattos 1986; Ducroquet, et al. 2000; Thorp and Bieleski 2002). Native to southern Brazil and Uruguay (Ducroquet et al. 2000), it produces aromatic fruits and shows potential for agricultural, food, pharmaceutical, and industrial applications, which has motivated advances in applied research in different countries (Vatrano et al. 2022).

The species stands out for the chemical composition of its fruits, which are characterized by significant levels of dietary fiber, phenolic compounds, vitamins, and organic acids (Zhu 2018; Almeida et al. 2020). The interaction among these metabolites confers antioxidant and functional properties that support its use in food, cosmetic, and phytotherapeutic formulations. Recent studies also highlight the potential for utilizing by-products such as peels, leaves, and seeds in industrial applications and circular economy practices (Sun-Waterhouse et al. 2013; Pasquariello et al. 2015; Silva 2022).

Although Brazil and Uruguay are the species' center of origin, the commercial exploitation of *F. sellowiana* has been more prominent in countries such as New Zealand, the United States of America, and Colombia, where genetic breeding programs and structured production chains have been established (Thorp and

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Bieleski 2002; Moretto et al. 2014a). In Brazil, cultivation remains restricted and fragmented, characterized by small-scale production and limitations related to management practices, propagation, and phytosanitary resistance.

In Uruguay, cultivation has been maintained on a small scale, with a cultivated area estimated at 3 hectares, out of more than 25,000 hectares committed to fruit trees in the country (Dini et al. 2025). For this reason, efforts have been promoted between the public and private sectors toward improving production and expansion of cultivation.

Natural populations of the species exhibit broad phenotypic variability, reflecting both environmental selective pressures and anthropogenic influences over time (Bogoni et al. 2018; Rivas et al. 2024). This diversity has been explored in germplasm banks and selection programs aimed at developing cultivars with improved agronomic performance and adaptability to different climatic conditions (Ducroquet et al. 2007; Saifert et al. 2020).

This review aims to compile and discuss scientific advances related to the domestication and genetic breeding of *F. sellowiana*. Through an interdisciplinary approach, it seeks to discuss challenges and prospects for establishing the species as a strategic crop within the context of sustainable agriculture, highlighting experiences from the Brazilian and Uruguayan bioeconomy and discussing their relevance and potential lessons for New Zealand growers, particularly regarding germplasm diversity, breeding strategies, and adaptation to marginal environments.

2 | Origin and Geographic Distribution

Native to the southern South America, the origin of *Feijoa sellowiana* is believed to be associated with high-altitude regions, predominantly characterized by basaltic soils rich in calcium, magnesium, and potassium, which favor its development (Nodari et al. 1996; Ducroquet 2000). In Brazil, its occurrence is primarily associated with Mixed Ombrophilous Forest formations at elevations above 1,000 m in southern States (Santos et al. 2005). However, it can also be found in lower-altitude regions associated with Seasonal Deciduous Forest and Southern Grasslands, where it typically exhibits reduced productivity (Moretto, Nodari; Nodari 2022). Studies indicate that abiotic factors such as altitude, temperature, and water availability influence the species' geographic distribution and phenotypic expression, including traits such as fruit size and soluble solids content (Fischer and Parra-Coronado 2020).

In Uruguay, the species is primarily recorded in subtropical ecosystem regions (Rivas et al. 2024). Local adaptations to diverse edaphoclimatic conditions in these areas reflect the species' ecological plasticity and underscore the importance of regional studies for understanding its distribution and phenotypic variation (Puppo et al. 2014).

There are historical records of spontaneous occurrence in regions of Argentina and Paraguay (Parodi, L. R. 1923; Keller and Tressens 2007). However, the lack of consistent evidence, along with the edaphoclimatic differences between these regions and species' center of origin, has limited the validation of these areas as part of their primary diversity center (Rivas et al. 2024).

The introduction of *F. sellowiana* to countries outside its natural range (Figure 1) began in the late 19th century. In 1898, Édouard Andre reported the arrival of specimens from the La Plata region (Uruguay) to France, where the species was first cultivated and later distributed to other parts of Europe, including the French Riviera, Italy, and Spain (André 1898). In 1900, the species was introduced to Crimea, subsequently expanded to the Caucasus region, particularly Azerbaijan and Georgia, where it is still cultivated on a regional scale (Moretto et al. 2014a). In the United States, its introduction occurred in 1901 by Francesco Franceschi in California (Morton 1987).

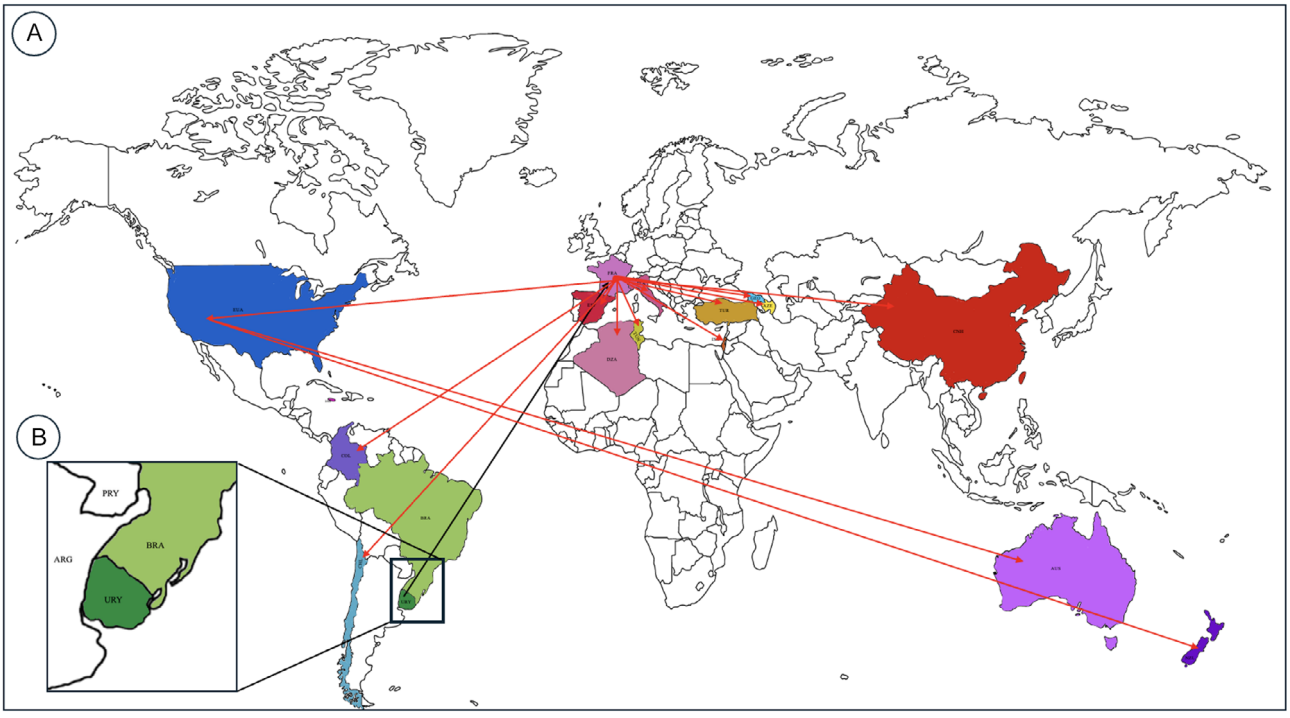


FIGURE 1 | (A) Dispersal of *Feijoa sellowiana* around the world; (B) Center of Origin of *Feijoa sellowiana*.

In 1903, *F. sellowiana* plants were transferred to Florida, where they were used primarily as ornamentals. It is likely the feijoa first arrived in New Zealand from California in 1908, marking the beginning of one of the most significant domestication programs for the species (Thorp and Bieleski 2002; Santos et al. 2005). Feijoa was also introduced from California to Australia, but has remained a minor crop. In South America, Colombia emerged as a relevant center for production and breeding only at the end of the 20th century, with the development of cultivars adapted to local edaphoclimatic conditions (Fischer 2003; Rodríguez et al. 2006).

Other countries also recorded the introduction of the species throughout the 20th century, including Israel (1930), Jamaica (1912), Tunisia, and Algeria, with varying degrees of agronomic success (Canhoto 1995; Weston 2010). In China, *F. sellowiana* was initially introduced at the Shanghai Botanical Garden, with subsequent expansion to the provinces of Jiangsu, Sichuan, and Hunan (Tang et al. 2016). In Japan, the species was introduced to subtropical regions such as Okinawa, where the climate favors its development.

Although cultivation is still limited, there is growing interest in its expansion, driven by the fruit's nutritional properties and its market value as a nontimber forest product, which can aid in forest conservation (Tang et al. 2016). In Turkey, *F. sellowiana* was introduced in 1988 through the Yalova Atatürk Horticultural Research Center. Since then, acclimatization and genetic selection studies have been conducted for the development of cultivars adapted to different regions of the country (Beyhan et al. 2010).

3 | Species Domestication and Genetic Breeding

In its center of origin, the domestication of *F. sellowiana* occurred in an incipient and likely dispersed manner. Paleoethnobotanical evidence suggests that pre-Columbian human groups, such as the Xokleng, Kaingang, and Guarani, influenced landscape structure and plant population composition through selective harvesting practices and native vegetation management (Nodari et al. 2012). Recurrent fruit collection and use may have exerted selection pressure on traits such as size, sweetness, and pulp yield, promoting shifts in gene frequencies over time (Moretto et al. 2014a).

In addition to anthropogenic dispersal, the association of feijoa with traditional agricultural systems, often intercropped with species such as *Zea mays*, *Araucaria angustifolia*, and *Ilex paraguariensis*, supports the hypothesis of a cultural management process linked to its domestication (Klanovicz 2009). Such practices may have contributed to the conservation and diversification of the species within its center of origin, establishing a broad genetic base that today represents a strategic resource for breeding and conservation programs.

New Zealand leads advances in the genetic breeding of feijoa, with breeding programs formally initiated in the 1950s, supported by both public and private institutions (Moretto et al. 2014a). The first commercial cultivars from these efforts were released in the 1980's ("Apollo", "Unique", "Gemini" and "Opal Star"), all derived from "Uruguay"-type accessions (Dawes and Pringle 1983; Thorp and Bieleski 2002).

In Colombia, the National Feijoa Center (CENAF) maintains a germplasm bank with more than 1,500 accessions, which are used in phenotypic selection programs and controlled crosses. Cultivars such as "Quimba" and "clone 8-4" were developed through local selection based on agronomic and sensory attributes (Rodríguez et al. 2006; Moretto et al. 2014a).

In Uruguay, since 2000, the Native Fruits Breeding Program developed by Universidad de la República (Udelar), Instituto Nacional de Investigación Agropecuaria (INIA), and Ministerio de Ganadería, Agricultura y Pesca (MGAP) has conducted agronomic evaluations, propagation studies, assessed genetic diversity, and focused on genetic improvement based on local germplasm (Cabrera et al. 2018). As a result of efforts in collecting material from wild populations, urban and rural gardens, and parks, two ex situ germplasm collections were established in the north (EFFAS-Udelar) and in the south (Las Brujas-INIA) region of the country (Dini et al. 2025). The INIA collection contains over 300 accessions that have been phenotypically characterized for production and fruit quality variables, with the aim of identifying accessions with larger fruit size and aromatic flavor, according to the demand of the local market (Lopes et al. 2023). One of the main results of this Breeding Program is the release of four cultivars: "INIA-Fagro Isleña", "INIA-Fagro Cerrillana", "INIA-Fagro Artillera", and "INIA-Fagro Armonía" (see Table 1), as an option for local farmers, promoting the sustainable use of native genetic resources and the diversification of the fruit-growing system (Cabrera et al. 2018; Rivas et al. 2024; Dini et al. 2025).

In Brazil, the first efforts began in 1985, led by the Agricultural Research and Rural Extension Company of Santa Catarina (EPAGRI) and the Federal University of Santa Catarina (UFSC), with a focus on selecting native genotypes and developing cultivars adapted to the conditions of the Santa Catarina Highlands (Cabrera et al. 2018; Rivas et al. 2024). Between 2007 and 2008, the cultivars "Alcântara", "Helena", "Mattos", and "Nonante" (see Table 1) were released (Ducroquet et al. 2007, 2008). More recently, cultivars "Jade" (used as rootstock), "Pierri", and "Camila" were developed (see Table 2), contributing to the expansion of the genetic base available for the crop (Ministry of Agriculture, Livestock, and Food Supply, 2025).

Institutions such as the State Center for Diagnosis and Research of Family Farming (CEAFA), in Rio Grande do Sul, and the EPAGRI Experimental Station, in São Joaquim, Santa Catarina, hold field collections for the ex situ conservation of the species. CEAFA maintains a collection of 279 accessions, while EPAGRI maintains an active germplasm bank with 313 accessions, all characterized genetically and phenotypically (Saifert et al. 2020).

These accessions, together with natural populations, are used in selection programs based on morphological and molecular descriptors, aiming at the development of cultivars with better adaptability, resistance to pathogens, and fruit quality (Nodari et al. 1996; Santos et al. 2011a; Saifert et al. 2020). Collaboration between institutions and agriculture through participatory breeding programs is extremely important, both for maintaining genetic variability and for defining selection criteria (Santos et al. 2018).

4 | Phenotypic Variation, Genetic Diversity, and Local Adaptations

Natural populations of *F. sellowiana* exhibit broad phenotypic diversity, particularly in morphoagronomic traits such as fruit size, peel thickness, epidermis color, pulp proportion, seed yield, and post-harvest behavior. Preliminary studies on chemical composition and postharvest behavior showed great variability in

TABLE 1 | Morphological and phenological characteristics of ripe fruit of feijoa (*Feijoa sellowiana*) cultivars according to the cultivar's center of origin.

Cultivar	Origin	°Soluble solids concentration	Pup yield (%)	Flowering[a] (start/end)	Harvest[b] (start/end)	Release year
Alcântara	Brazil	10.1 – 13.2	24 - 32	30/10 - 21/11	01/03 - 30/03	2007
Helena	Brazil	8.8 – 14.6	28 - 34	29/10 - 25/11	30/03 - 30/04	2007
Mattos	Brazil	9.8 – 13.3	28 - 35	04/11 - 12/12	15/03 - 15/04	2008
Nonante	Brazil	9.9 – 14.8	30 - 34	05/11 - 30/12	10/04 - 10/05	2008
Jade	Brazil	10.0 – 14.0	26 - 30	06/11 - 07/12	15/03 - 15/04	2021
Pierri	Brazil	9.0 – 11.1	23 - 55	04/11 - 03/12	15/03 - 07/04	2021
Camila	Brazil	*	*	01/11 - 30/12	10/03 – 10–04	2025
Islenã	Uruguay	11.0–15.0	40–60	10/10 -10/11	15/03 -15/04	2017
Cerrillana	Uruguay	10.0 –13.5	40–60	26/10 -04/12	29/03-30/04	2017
Artillera	Uruguay	10.0–13.0	30–40	01/11- 22/11	03/04 -05/05	2017
Armonía	Uruguay	10.0–14.0	25–45	11/10 -09/11	25/04 -20/05	2024

[a]Flowering period: beginning and end of anthesis.
[b]Harvest period: beginning and end of fruit maturation.
Note: *Data not available yet.

TABLE 2 | Comparison of fruit weight, fruit length, fruit diameter, and seed weight between Brazilian- and Uruguayan-type *Feijoa sellowiana*.

Feijoa-type	Fruit weight (g)	Fruit-lenght (cm)	Fruit diameters (cm)	Seeds weight (g)	Reference
Brazilian-type	32–80	4.2–6.5	3.5–4.8	0.45–0.60	(Ducroquet 2000; Moretto et al. 2014b)
Uruguayan-type	25–75	5.0–6.0	4.0–4.5	0.14–0.22	(Rivas et al. 2024; Dini et al. 2025; López et al. 2025)

parameters such as respiration rate, weight loss, and total antioxidant capacity for a limited number of genotypes (Silveira and Zaccari 2023). This variability reflects both the species' evolutionary history in its center of origin and the influence of environmental factors and regional anthropogenic management (Santos et al. 2005; Fischer and Parra-Coronado 2020; Citadin et al. 2022).

The species can be morphologically classified into two main groups, referred to as the Brazilian and Uruguayan types (Thorp and Bieleski 2002; Saifert et al. 2020). The Brazilian type predominates at higher altitudes, typically between 1,200 and 1,600 m, and is commonly found on basaltic soils. Plants belonging to this group are characterized by fruits with thicker peels and seeds with greater individual mass, as well as leaves exhibiting a light green abaxial surface with short, whitish pubescence (Figure 2). In addition, Brazilian-type plants generally present longer phenological cycles and show greater adaptability to lower temperature conditions.

In contrast, the Uruguayan type is mainly associated with lower altitudes and crystalline soils. This group is distinguished by fruits

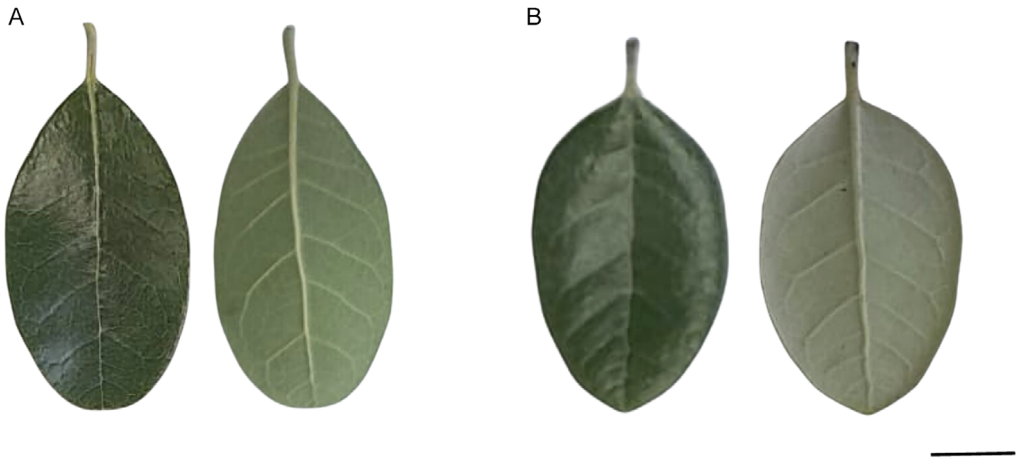


FIGURE 2 | Leaf morphology of *Feijoa sellowiana* representing the two main morphological types. (A) Brazilian-type leaves, showing a light green abaxial surface with sparse, short pubescence. (B) Uruguayan-type leaves are characterized by a grayish-white abaxial surface with dense pubescence. Scale bar = 1 cm.

with thinner peels, higher soluble solids content, and greater pulp yield, traits that are of particular interest for fresh consumption and processing. Leaves of Uruguayan-type plants display a grayish-white abaxial surface with dense pubescence (Figure 2). Ecophysiologically, these plants demonstrate higher tolerance to thermal and water stress, suggesting enhanced adaptation to warmer and drier environments (Ducroquet, et al. 2000; Santos et al. 2005; Moretto et al. 2014b; Dini et al. 2025; López et al. 2025). A comparative summary of the main fruit and seed morphological attributes distinguishing the Brazilian and Uruguayan types is presented in Table 2.

Environmental factors such as altitude, soil type, light, temperature, and nutrient availability are key determinants in the phenotypic expression of reproductive and productive traits of feijoa. Differences in fruit chemical composition and bioactive compound profiles among genotypes cultivated in distinct regions highlight the significance of genotype x environment interactions in shaping agronomic performance and functional quality (Pasquariello et al. 2015; Fischer and Parra-Coronado 2020; Silva et al. 2024).

In addition to environmental influence, the current genetic structure of populations has been shaped by historical processes, including dispersal through biological corridors, geographic isolation, and fragmentation events (Pennington et al. 2000; Turchetto-Zolet et al. 2013). These processes, combined with founder effects and population bottlenecks, contributed to divergence between "Brazil" and "Uruguay" type populations (Fahrig 2003; Frankham 2005). Furthermore, human practices such as landscape management, unintentional dispersal, and settlement during the Holocene, between 8,000 and 10,000 years ago, may have initiated incipient domestication processes that contributed to regional variability (Piperno 2006; Clement et al. 2015).

Studies using molecular markers (see Table 3) have revealed moderate to high levels of genetic diversity in natural populations, populations held by small farmers, "quilombolas" and indigenous people, and germplasm banks, suggesting that genetic variability is still largely preserved in Mixed Ombrophilous Forest ecosystems and traditional agroforestry systems (Borsuk et al. 2017; Saifert et al. 2020). Informal selection performed by family farmers, along with traditional management and intentional dispersal in managed landscapes, has modified gene frequencies and contributed to local adaptation.

This genetic diversity constitutes a strategic resource for breeding programs, enabling the selection of genotypes with desirable traits

TABLE 3 | Genetic diversity studies using molecular markers in *F. sellowiana* and their main findings.

Markers used	Material Origin	Genetic Diversity Index*	Observed Results	Reference
SSRs (Codominant)	309 genotypes from the Active Germplasm Bank / EPAGRI	A = 15 (7 - 27) Ho = 0.620 (0.303 −0.809) He = 0.746 (0.491 - 0.899) PIC = 0.718 (0.466 −0.890)	Confirms the genetic differentiation between "Brazil" and "Uruguay" types	(Saifert et al. 2020)
SSRs (Codominant)	352 samples (Managed and wild populations) from Brazil	A = 11.75 (8.0 - 14.8) Ae = 6.22 (5.2 - 7.4) AR = 9.23 (8.0 - 10.5) Ho = 0.713 (0.60 - 0.79) He = 0.80 (0.77 - 0.82) *f* = 0.106 (−0.002 - 0.229)	Managed populations maintain high levels of genetic diversity compared to wild populations.	(Donazzolo et al. 2020)
SRAPs (Dominant)	12 cultivars grown in Italy	TF = 13.9 (10 - 19) PF = 9.9 (8 - 14) P% = 73.7% (47.1 - 100) PIC = 0.347 (0.299 - 0.372)	Genetic variability observed among feijoa cultivars, both genetically and phenotypically.	(Pasquariello et al. 2015)
RAPDs (Dominant)	4 wild populations from Uruguay	TF = 26.0 (9 - 44) P% = 62%	High genetic diversity among wild populations.	(Rivas et al. 2024)
SSRs (Codominant)	5 wild populations from Brazil	A = 3.46 (2.90 - 4.10) Ho = 0.42 (0.34 - 0.49) He = 0.48 (0.43 - 0.53) *f* = 0,14 (−0.10 - 0.31)	Wild populations showed considerable genetic diversity and low inbreeding	(Santos et al. 2011b)
AFLPs (Dominant)	20 cultivars from different countries and 6 wild accessions	*h* = 0.27 (0.26 - 0.30) I = 0.43 (0.41 - 0.46) Ae = 1.43	Wild accessions greater genetic diversity compared to commercial cultivars	(Bini et al. 2024)
RAPDs (Dominant)	25 cultivars from different countries maintained in Italy	TF = 12 (6 – 17) P% 50.2%	RAPD markers proved effective in identifying feijoa genotypes, suggesting a common ancestry among most accessions.	(Dettori and Palombi 2000)

*Genetic diversity indices were estimated differently across time and germplasm and should not be directly compared.
Abbreviations: A, average number of alleles; Ae, effective number of alleles; AR, allelic richness; f, inbreeding coefficient; h, Nei's genetic diversity index; He, expected heterozygosity; Ho, observed heterozygosity; I, Shannon index; PF, polymorphic fragments; PIC, polymorphism information content; P%, percentage of polymorphic loci; TF, total fragments.

such as resistance to biotic and abiotic stresses, improved nutritional quality, and favorable sensory attributes. In situ conservation, particularly in areas managed by local communities, along with the maintenance of active germplasm banks, such as those maintained by EPAGRI and CEAFA (Brazil) and Fagro-INIA (Uruguay) are fundamental to ensure the genetic base necessary for the sustainable use of the species at both regional and global scales (Amarante and Santos 2011; Donazzolo et al. 2020; Saifert et al. 2020; Dini et al. 2025). Additionally, the development of next-generation molecular markers specific for feijoa provides the opportunity for research involving genetic diversity, relatedness, and a wide range of applications such as linkage mapping, *quantitative trait loci mapping* (QTL) mapping, and marker-assisted selection (Quezada et al. 2021).

5 | Agronomic Aspects and Phytosanitary Challenges

In Brazil, the cultivation of *F. sellowiana* in commercial systems has primarily been established in high-altitude regions with strongly acidic (low pH) basaltic soils. These soils need liming with calcium to increase pH and ensure adequate nutrient availability (Figure 3A) (Nava et al. 2016). The species responds well to organic farming and the adoption of sustainable practices and has been the focus of studies aiming at regional adaptation and the selection of more productive and resistant cultivars. In Uruguay, the cultivation of *F. sellowiana* has been established on a small scale, alongside production areas of traditional commercial fruits (e.g., apple, pear).

The cultivation environment and post-harvest practices also influence the sensory characteristics of the fruits. In protected cultivation, a higher proportion of herbaceous-profile terpenes is observed, whereas open-field conditions favor the biosynthesis of fruity esters. Cold helps preserve key volatile compounds such as methyl benzoate and geraniol, contributing to the maintenance of the species' characteristic aroma (Hendges et al. 2022).

Hermaphroditic flowers (Figure 3B), although non-nectariferous, attract pollinators by offering pollen and fleshy petals (Finatto et al. 2011; Ramírez and Kallarackal, 2017). Pollinators' presence and efficiency have a direct impact on fruit sets and must be considered in cultivation planning, since cross-pollination generally increases both fruit set and fruit size, even in self-compatible cultivars. *F. sellowiana* fruits (Figure 2C) vary from rounded to oblong in shape, with a green, semi-wrinkled to wrinkled peel, and ice-colored pulp (Figure 3D) with a distinctive sweet-acidulated flavor and aroma (Amarante et al. 2013; Amarante and Santos 2011; Fachinello and Nachtigal 1992; Zhu 2018; Amarante et al. 2018).

Fungal diseases and insect pests represent the main phytosanitary challenges to commercial feijoa production. Among these, anthracnose, caused by species of the genus *Colletotrichum*, has economic relevance due to its direct impact on fruit quality and marketable yield. Typical symptoms include sunken lesions on fruits, which may develop sporulation under conditions of high humidity and temperature. In southern Brazil and Uruguay, Fantinel et al. (2020) identified five pathogenic *Colletotrichum* species associated with *Feijoa sellowiana*: *C. theobromicola*, *C. siamense*, *C. fructicola*, *C. nymphaeae*, and *C. pseudoacutatum*. The authors reported variation in aggressiveness among isolates and differences in cultivar susceptibility, with "Mattos" being the only cultivar resistant to all species tested. In contrast, Lopes et al. (2023), based on multilocus phylogenetic analysis of 40 isolates from both commercial and natural feijoa populations in Brazil, detected only *C. theobromicola* as the causal agent of anthracnose, with no occurrence of the other species reported by Fantinel et al. (2020). These contrasting results highlight not only the importance of accurate species identification but also the need to further investigate the distribution and prevalence of different *Colletotrichum* species. Anthracnose management relies on integrated practices, including orchard sanitation, removal of infected fruits, and the use of fungicides registered for other crops, as no chemical products are specifically registered for feijoa. In addition, antagonistic endophytic fungi associated with resistant cultivars have been shown to inhibit Colletotrichum spp., supporting the use of biological control as a complementary management strategy (Fantinel et al. 2020). Resistance to anthracnose remains a key criterion in genetic selection and breeding programs.



FIGURE 3 | Morphological aspects of *Feijoa sellowiana* (Berg.) O. Berg. (A) Adult plant in the fruiting stage. (B) Flowers (C) Whole fruit (D) Transverse section of the fruit showing the ice-colored pulp. Scale bar: 1 cm. Source: (A,C,D) Suelen Martinez Guterres; (B) Danielle da Silva.

Other diseases that may affect the *F. sellowiana* include gray mold (*Botrytis cinerea*), most commonly found in the Andes region, rust (*Puccinia psidii*), and fruit rot caused by *Phomopsis* spp. and *Alternaria* spp. These pathogens typically develop under conditions of high humidity, poor air circulation, and inadequate phytosanitary management, potentially compromising postharvest fruit quality and shelf life (Vatrano et al. 2022).

Various plant organs, such as fruits, leaves, and flowers, serve as shelter and food sources for a diverse arthropod community, comprising over 30 recorded species. Among the most concerning pests are fruit flies (*Anastrepha* spp.), weevils (*Conotrachelus* spp.), thrips (*Phrasterothrips* spp.), shoot moths (*Huacapia* spp.), beetles (*Paraulaca dives*), lace bugs (*Ulotingis nitor* Drake & Hambleton), and scale insects (*Chrysomphalus ficus* Asmead) (Hickel and Ducroquet 1993; Carmona et al. 2023). Other visitors, such as birds that consume flower petals, have also been reported, but these do not cause disease and may even play roles in pollination ecology.

Fruit flies, mainly those of the genus *Anastrepha*, are key pests in feijoa and global fruit production systems, affecting fruit quality and yield through direct and indirect damage. Direct damage results from oviposition and larval feeding, leading to pulp degradation, premature fruit drop, and fruit unsuitable for fresh consumption and industrial processing (Alves et al. 2019). Indirect damage occurs when pathogenic microorganisms enter through oviposition wounds, increasing postharvest losses, and reducing marketability. Tephritid species such as *Bactrocera dorsalis*, *Zeugodacus cucurbitae*, and *Ceratitis capitata* are associated with this type of damage in fruit crops worldwide (Follett et al. 2019).

Economic impacts include yield reduction and costs related to pest management and quarantine restrictions. In unmanaged orchards, infestations may cause losses exceeding 30–50% of production. At broader scales, fruit flies account for annual losses above US$ 1 billion globally and approximately US$ 242 million per year in Brazil (Oliveira et al. 2013; Leonardo and Faria 2019).

The presence of tannins in feijoa fruits has been associated with possible resistance to larval development and is considered a promising biochemical marker for selection (Santos et al. 2022). However, controlled laboratory studies suggest the existence of volatile compounds that attract *Anastrepha* spp., which are differentially produced among cultivars (unpublished data).

Fruit fly management combines cultural, biological, and chemical practices. Core strategies include orchard sanitation, population monitoring using attractant traps, bait applications, and biological control with parasitoids. Integrated pest management, including area-wide approaches, reduces reinfestation and limits the use of insecticides. Future control strategies may include the expansion of biological control, improved attractants, and the incorporation of host resistance traits into breeding programs. The sustainability of feijoa cultivation depends on integrating genetic selection with management practices, combined with coordinated efforts among applied research institutions, public support, and effective transfer of technology to production systems.

6 | Chemical Composition, Bioactive Compounds, and Industrial Applications

F. sellowiana presents a complex and functionally relevant chemical profile, characterized by a broad range of primary and secondary metabolites with potential applications in the food, pharmaceutical, cosmetic, and bioenergy sectors.

The pulp contains between 10 and 12 g/100 g of soluble carbohydrates, mainly glucose and fructose, while total dietary fiber content ranges from 15 to 30 g/100 g (dry weight). The peel exhibits even higher fiber density, exceeding 50 g/100 g (dry weight), making it promising for use in functional food formulations, such as fiber-enriched bakery products, cereal bars, beverages, and dietary supplements (Almeida et al. 2020). The protein fraction, although modest (0.6–1.2 g/100 g), contributes essential amino acids to the nutritional profile. Lipid content ranges from 0.4 to 0.6 g/100 g, and is predominantly composed of unsaturated fatty acids, including linoleic acid, which provides both nutritional value and technological functionality (Ruberto and Tringali 2004).

The vitamin profile is notable, with vitamin C ranging from 27.9 to 62.8 mg/100 g fresh weight (FW) (Phan et al. 2019), comparable to that reported for of citrus fruits (25.4–45.3 mg/100g FW;(Magwaza et al. 2017) and overlapping with values reported for green kiwifruit (*Actinidia deliciosa*), particularly the commercially dominant cv. Hayward (~65.5 mg/100g FW), despite the wide genotypic variation observed among *Actinidia* (Nishiyama et al. 2004), β-carotene levels range from 0.1 to 0.3 mg/100 g, while vitamins B1, B2, and B3 are found at concentrations up to 0.05 mg/100 g. Among minerals, potassium is most abundant (up to 300 mg/100 g), followed by calcium, magnesium, iron, and zinc, reinforcing the classification of the species as a functional food (Ruberto and Tringali 2004; Pasquariello et al. 2015; Buratto et al. 2019).

The bioactive fraction is dominated by phenolic compounds, grouped into four major classes: hydroxybenzoic acids (e.g., gallic acid), flavan-3-ols (e.g., catechin, epicatechin), hydroxycinnamic acids (e.g., chlorogenic acid, p-coumaric acid), and flavonols (e.g., quercetin, rutin) (Buratto et al. 2019). The total phenolic content in fruits ranges from 92.88 to 251.02 mg gallic acid equivalents (GAE)/100 g FW, with variations influenced by genetic and environmental factors (Schmidt et al. 2020). In leaves, major compounds include catechin (46.45 mg/g), quercetin (42.03 mg/g), ellagic acid (41.69 mg/g), and gallic acid (32.25 mg/g), with demonstrated antimicrobial activity against *Candida albicans* (Cebi and Sagdic 2022). In flowers and leaves, the expression of enzyme-encoding genes for pathways involved in the synthesis of secondary metabolites (phenylpropanoid, flavonoid, anthocyanin, flavone, and flavonol) was identified using transcriptomic methods. Specifically, in floral tissues, 17 enzymes within the flavonoid pathway and 28 transcripts (three enzymes) within the anthocyanin pathway were described, a key result for understanding the pathway of high-valued nutraceuticals (Oberti et al. 2024).

The aromatic volatiles profile of feijoa comprises over 150 identified compounds, including esters, terpenes, alcohols, aldehydes, and ketones. Methyl benzoate, ethyl benzoate, and benzaldehyde are primarily responsible for their characteristic aroma. Volatile composition is strongly modulated by genetic factors (e.g., cultivar), environmental conditions (e.g., UV radiation, temperature), fruit maturation stage, and storage conditions (Peng et al. 2019; Silveira and Zaccari 2023). The nutritional and morphological differences observed between Brazilian and Uruguayan feijoa types, which represent distinct centers of origin and domestication and form the genetic basis of cultivars currently grown in New Zealand, together with local climatic adaptation, may help explain the differences in peel thickness, pulp yield, and flesh

composition reported among cultivars from different countries (Moretto et al. 2014b; Saifert et al. 2020; Rivas et al. 2024).

The industrial potential of *F. sellowiana* lies in the synergistic presence of bioactive compounds and aromatic constituents. In the food industry, pulp and its derivatives are used in the production of juices, jams, and nutraceuticals. Phenolic compounds and flavonoids function as natural preservatives, while peels and seeds, rich in fiber and tannins, are incorporated into dietary supplements, flours, and whole-food products (Sun-Waterhouse et al. 2013).

In the cosmetic industry, essential oils extracted from leaves and peels, rich in linalool, geraniol, α-terpineol, and nerolidol, are utilized in perfumes, lotions, and personal care products, valued for their natural appeal and antioxidant and antimicrobial activities (Mosbah et al. 2018; Vuotto et al. 2000; Leon et al. 2020). In the pharmaceutical sector, hydroethanolic extracts have demonstrated in vitro anti-inflammatory and antitumor activities, especially in cultivars with high concentrations of pedunculagin, epicatechin, and gallic acid (Cimmino et al. 2022; Schmidt et al. 2022).

An integrated perspective on the chemical composition, bioactivity, and technological applicability of *F. sellowiana* underscores its value as a strategic phytogenetic resource. Full biomass utilization, in conjunction with genetic improvement programs and advances in bioprocesses, reinforces the species' role as an emerging crop in sustainable and technologically advanced agro-industrial systems.

7 | Perspectives

Although scientific knowledge on *Feijoa sellowiana* has advanced considerably in recent decades, critical knowledge gaps still limit its full application as a strategic resource for agricultural innovation, bioindustrial development, and biodiversity conservation. On the other hand, advances in genomic studies promise to boost the species utilization.

A reference genome is currently being assembled and annotated for the cultivar "Pierri" (Guterres et al. unpublished data), which is expected to support advances in selection and breeding programs aimed at developing more productive cultivars with enhanced nutritional profiles and improved resistance to pests and diseases. Moreover, a transcriptomics study based on controlled fruit fly infection of fruits aims to understand the biochemical mechanisms related to both insect and plant responses to this interaction (Guterres et al. unpublished data). The generation of multi-omics datasets, combined with advanced bioinformatics tools, is essential for the identification of regulatory genes, biosynthetic pathways, and molecular markers applicable to genetic improvement and the development of value-added products.

Given the incipient stage of *feijoa* domestication in Brazil, there is an urgent need for investments in propagation technologies and conservation of genetic resources. Optimized tissue culture protocols, such as organogenesis and somatic embryogenesis (Stefenon et al. 2020), are being developed to accelerate the multiplication of superior genotypes, ensure in vitro conservation, and enable the establishment of specialized biofactories. The development of appropriate management techniques is also necessary. In the future, the integration of these protocols with genome editing platforms such as CRISPR/Cas may open new avenues for the targeted modulation of agronomic and nutritional traits, such as enhanced resistance to pests and diseases, improved fruit quality, and increased shelf life.

The expansion of feijoa cultivation in its center of origin requires production systems adapted to regional edaphoclimatic conditions and local sociotechnical contexts. The adoption of agroforestry models, intercropping, and organic management practices promotes environmental sustainability and enhances the economic resilience of farming communities.

Beyond fresh fruit production, the valorization of by-products such as leaves, seeds, and peels represents a relevant pathway for strengthening a native species-based bioeconomy. These materials are rich in bioactive compounds with potential pharmaceutical, nutraceutical, and cosmetic applications, supporting the development of value-added industrial chains in South America and New Zealand. Such applications may generate higher economic returns than the commercialization of fresh fruit alone, particularly when associated with local processing and short supply chains.

However, the large-scale use of feijoa bioactives remains constrained by technical and economic factors. High volumes of raw material are required to achieve industrial viability, and both pulp and peel are highly susceptible to rapid oxidation, which necessitates immediate processing or the adoption of specific stabilization technologies. These limitations also restrict the expansion of fresh fruit export markets, as the short postharvest shelf life and sensitivity to mechanical damage pose challenges for long-distance transport. Consequently, international trade opportunities are currently more favorable for processed products and by-products, such as frozen pulp, dehydrated materials, and extracts, which offer greater shelf stability, reduced losses, and higher added value.

As the center of origin of *F. sellowiana*, Brazil and Uruguay hold a central responsibility for the conservation and sustainable use of its genetic diversity. The consolidation and expansion of active and ex situ germplasm banks, accompanied by comprehensive phenotypic, agronomic, biochemical, and molecular characterization, are strategic for maintaining genetic variability and supporting breeding initiatives. The continuous evaluation of new genotypes and incorporation of promising accessions in directed crosses will allow expanding the genetic base of cultivated materials, thereby enhancing their adaptability and market value.

The sustainable development and valorization of *F. sellowiana* requires coordinated action among research institutions, rural extension programs, public policy initiatives, and market stakeholders. The establishment of interinstitutional collaborative platforms can foster the generation of applied knowledge, the training of specialized human resources, and the transfer of technologies to production systems. In this context, feijoa emerges as a promising species to consolidate as a strategic crop for agricultural diversification, the valorization of native genetic resources, and the transition toward biotechnology-based, sustainable agro-industrial systems.

Acknowledgements

The Article Processing Charge for the publication of this research was funded by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brasil (CAPES) (ROR identifier: 00x0ma614).

Funding

This work was supported by CAPES (Process 001) and CNPq (Processes 440301/2022-0 and 305608/2024-0).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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