Traditional knowledge on *Vanilla pompona* in Totonacapan, Mexico: An analysis of its management, use and generational transmission in systems in secondary vegetation (*acahual*)

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Research

Abstract

Background: The study of local knowledge about vanilla provides a theoretical basis for understanding the impact of social and cultural factors on the use and management of this crop. This study documents the traditional knowledge associated with the management and use of *Vanilla pompona*.

Methods: With a qualitative approach, we conducted 17 semi-structured interviews with people who have *V. pompona* plants in some locations in Puebla and Veracruz, Mexico. Information from the interviews was processed using descriptive statistics.

Results: The results reveal that *V. pompona* is predominantly tolerated and conserved in homegardens with minimal management. The growers recognize its phenology, pollinate manually or rely on natural pollinators, and harvest the fruits guided by the yellow color at the base and by their aroma. Its value resides in specific cultural uses: as a food flavoring, air freshener, medicinal plant (for infertility and menstrual problems) and ornamental/ritual element. Although commercialization is still limited, almost half of the interviewees believe that its cultivation is potentially profitable if a stable market and fair price are guaranteed. Traditional knowledge of *V. pompona* is transmitted orally within the family. However, the interviewees are concerned that traditional knowledge on *V. pompona* may be lost because of the lack of interest on the part of younger generations and because sale of the product is not guaranteed.

Conclusions: There is little agronomic management *V. pompona*, and some of their uses are ornamental, medicinal, for flavoring certain beverages. Furthermore, conservation of this species in these traditional acahual and homegarden systems is linked more to its cultural value and specific uses than to a direct economic benefit. It is crucial to revalue this plant genetic resource, strengthening its local market and creating policies that reward farmers for preserving agrobiodiversity.

Keywords: Acahual, ethnobotany, livelihoods, México, traditional ecological knowledge, *Vanilla pompona*

Resumen

Antecedentes: El estudio del conocimiento local sobre la vainilla proporciona una base teórica para comprender el impacto de los factores sociales y culturales en el uso y manejo de este cultivo. Este estudio documenta el conocimiento tradicional asociado con el manejo y uso de *Vanilla pompona*.

Métodos: Mediante un enfoque cualitativo, realizamos 17 entrevistas semiestructuradas con personas que poseen plantas de *V. pompona* en diversas localidades de Puebla y Veracruz, México. La información obtenida en las entrevistas se procesó mediante estadística descriptiva.

Resultados: Los resultados revelan que *V. pompona* se tolera y conserva predominantemente en huertos familiares con un manejo mínimo. Los agricultores identifican su fenología, polinizan manualmente o recurren a polinizadores naturales y cosechan los frutos guiados por el color amarillo de la base y su aroma. Su valor reside en usos culturales específicos: como aromatizante de alimentos, ambientador, planta medicinal (para la infertilidad y problemas menstruales) y elemento ornamental/ritual. Aunque la comercialización aún es limitada, casi la mitad de los entrevistados cree que su cultivo es potencialmente rentable si se garantiza un mercado estable y un precio justo. El conocimiento tradicional sobre *V. pompona* se transmite oralmente dentro de la familia. Sin embargo, a los entrevistados les preocupa que el conocimiento tradicional sobre *V. pompona* pueda perderse debido a la falta de interés de las generaciones más jóvenes y a que la venta del producto no está garantizada.

Conclusiones: Existe un manejo limitado de *V. pompona*, y algunos de sus usos son ornamentales, medicinales y para aromatizar ciertas bebidas. Además, la conservación de esta especie en estos sistemas tradicionales de cultivo en huertos familiares y acahuales está más ligada a su valor cultural y usos específicos que a un beneficio económico directo. Es crucial revalorizar este recurso fitogenético, fortaleciendo su mercado local y creando políticas que recompensen a los agricultores por preservar la agrobiodiversidad.

Palabras clave: Acahual, etnobotánica, medios de vida, México, conocimiento ecológico tradicional, *Vanilla pompona*

Background

The genus Vanilla comprises approximately 110 species (Soto Arenas & Cribb 2010). Of these, only three are widely exploited commercially for the quality of their aroma: *Vanilla planifolia* Jacks. ex Andrews, *V. × tahitensis* J.W. Moore and *V. pompona* Schiede. Both *V. planifolia* and *V. pompona* are distributed in Mexico, center of origin and diversification of the genus (Soto-Arenas & Dressler 2010). In Mexico, commercial production of vanilla has historically been linked to the Totonaca people in the region of Totonacapan (Puebla-Veracruz), who have been the main custodians and generators of TK associated with *V. planifolia*. They have maintained and enriched this genetic resource in their production systems for centuries (Bory *et al*. 2007; Hágsater *et al*. 2005). Therefore, most scientific research in Mexico has focused on *V. planifolia*, addressing aspects such as its aromatic composition (Pérez-Silva *et al*. 2006; Salazar-Rojas *et al*. 2012) and traditional knowledge (Lima-Morales *et al*. 2018) associated with agronomic management, processing, and storage of the fruit (Barrera-Rodríguez *et al*. 2009; Espinoza-Pérez *et al*. 2018), as well as manual pollination of the flowers (Karremans 2024). However, this level of knowledge of *V. planifolia* contrasts with other emerging producing regions, such as the Huasteca region of Hidalgo, where traditional knowledge is limited and cultivation does not overlap as much with local cultural identity (Andrade-Andrade *et al*. 2018). However, this species is markedly vulnerable to biotic and abiotic factors, such as climate change, fungal diseases (Hernández-Hernández & Lubinsky 2011), changes in the distribution patterns of *V. planifolia* due to climate change (Armenta-Montero *et al*. 2022) and premature fruit drop (Hernández-Miranda *et al*. 2018), which threaten its sustainability.

The vulnerability of *V. planifolia* underscores the need for conservation and investigative efforts directed toward other species of the genus, particularly those wild species with agroecological potential, such as *V. pompona*. This species, native to Mesoamerica (Soto-Arenas & Dressler 2010; Watteyn *et al*. 2021), has significant phytosanitary advantages including resistance to pathogens such as *Collectotrichum* sp. (anthracnose) and *Fusarium oxysporum* Schltdl. (root rot), as well as tolerance to xerophytic conditions (Soto-Arenas 1999; Soto-Arenas & Dressler 2010). Indeed, its genetic potential has been used in plant improvement programs in Central America to develop hybrids with *V. planifolia* to increase resistance to Fusarium (Bélanger & Havkin-Frenkel 2011). In Mexico, the registers of *V. pompona* correspond mainly to wild populations distributed in the states of Veracruz, Oaxaca, Chiapas, Puebla, Nayarit, Michoacán, Guerrero and Jalisco, where its fruits are harvested extractively (Herrera-Cabrera *et al*. 2020) but where there is a vacuum of information on its agronomic management and systematic cultivation.

Traditional knowledge (TK) is a set of knowledge, practices, beliefs and uses related to the environment and its natural resources, which are learned through direct experience and are transmitted collectively from generation to generation (Luna-Morales 2002; Toledo & Barrera-Bassols 2008; Bruchac 2014; Onyancha 2022). In the context of phytogenetic resources, delving deeper into TK is fundamental to understanding the processes of domestication, management, and conservation. For *V. planifolia*, this knowledge is manifest in traditional systems of cultivation (Espinoza-Pérez *et al*. 2018; Lima-Morales *et al*. 2018), in criteria for selection of cuttings based on sensorial and cultural attributes (Azofeifa-Bolaños *et al*. 2018; Andrade-Andrade *et al*. 2018; Hernández *et al*. 2019), and in conservation of vanilla's diversity, both morphological (morpho-types) (Hernández-Ruíz *et al*. 2020) and aromatic (chemo-types) (Salazar-Rojas *et al*. 2012). This assemblage of knowledge has been the basis of socioeconomic and cultural development in producer regions, holistically integrating the human-plant-environment relationship (Herrera-Cabrera *et al*. 2012; Salazar-Rojas *et al*. 2012).

The background information presented highlights a critical knowledge gap: while the traditional knowledge of *V. planifolia* is well documented in the Totonacapan region, there is limited information on the traditional knowledge associated with *V. pompona*. Although its morphological variation is beginning to be documented (Viveros-Antonio *et al*. 2023), as are the uses of its fruits in Guadeloupe, France, some regions of Brazil, and Belize (Dean 2025), there is no information in Mexico on the uses people give to the fruits. Crucial aspects of its reproductive biology, optimal agroclimatic requirements, and appropriate agronomic management practices are also unknown. Understanding TK is the basis for in situ management and conservation of genetic resources by local indigenous communities that depend on these species (Berkes & Turner 2005). Moreover, interspecific hybridization emerges as a promising strategy to incorporate resistance alleles from wild species, such as *V. pompona*, into the relatively narrow genetic base of *V. planifolia* (Hu *et al*. 2019) for purposes of conservation and genetic improvement.

Therefore, the objective of this study was to identify and document traditional knowledge related to the use and management of *Vanilla pompona* Schiede in acahual systems in the region of Totonacapan, Puebla-Veracruz, Mexico.

Materials and Methods

Study site

Traditional knowledge of V. pompona was characterized in 11 localities of three municipalities of the states of Veracruz and Puebla, Mexico (Figure 1).

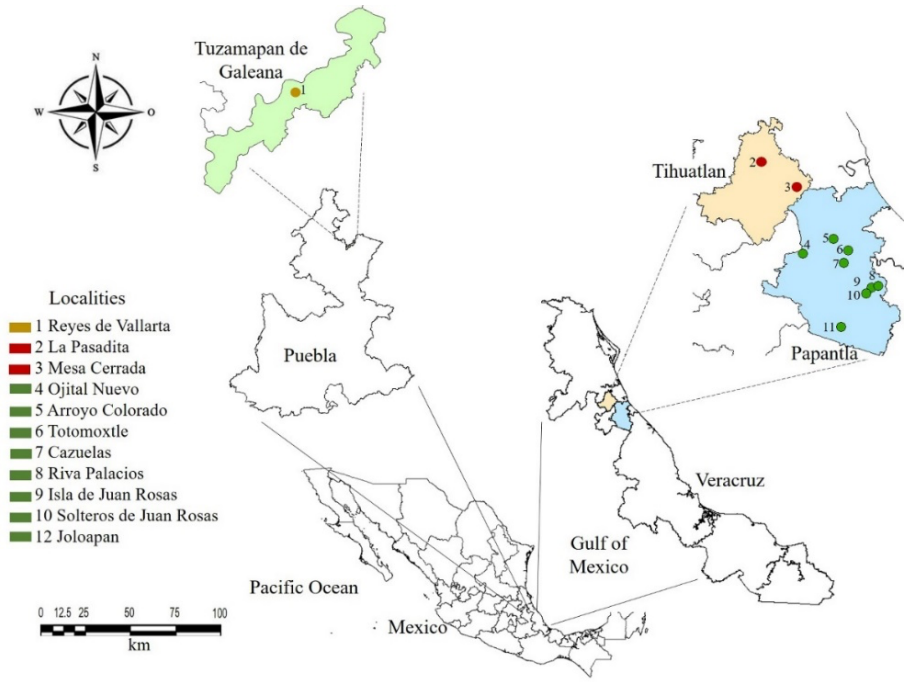

Figure 1. Geographic location of the localities where interviews were held.

Study design and data collection

This study was framed in a qualitative descriptive approach with the objective of deeply understanding the description and interpretation that people assign to their lived experience in the management of *V. pompona*. People from some localities in Puebla and Veracruz, Mexico (Figure 1) were interviewed using a semi-structured interview guide (Trindade 2016).

The interview guide was designed to capture information on socio-cultural and economic aspects of the management and use of *V. pompona*. Its structure was defined based on i) theoretical and field experience of the research team, ii) orchid reproductive biology (Soto-Arenas & Solano-Gómez 2007), and iii) methodological frameworks of previous studies on vanilla (Espinoza-Pérez *et al*. 2018; Hernández & Lubinsky 2011). The five thematic sections of the guide are detailed in Table 1.

Table 1. Structure and thematic sections of the semi-structured interview guide.

Section of the interview	Specific objective
1. General information	Collect basic sociodemographic variables of the informant.
2. Origin and knowledge of vanilla	Document ethnobotanical history and knowledge on *V. pompona*.
3. Management	Document the management of *V. pompona*
3. Use	Identify current and potential uses of the species.
4. Economic dimension	Evaluate the perception of value and commercial dynamics.
5. Knowledge transmission	Register the mechanisms of preservation of traditional knowledge.

The main inclusion criterion was that the participants cultivated or had specimens of *V. pompona* in their farm plots or production units. Given that *V. pompona* is a wild species with no established formal market, the population with access to the plant is small and difficult to contact. To overcome this methodological challenge, we established collaboration with the Veracruz Vanilla Council in Papantla, Veracruz, an organization that groups approximately 300 vanilla growers. Through this alliance, we requested the Council president to facilitate contact with growers that met the study criterion.

We interviewed 17 people, 13 of whom were from the localities of Papantla, Veracruz, Mexico: Cazuelas, Arroyo Colorado, Isla de Juan Rosas, Solteros de Juan Rosas, Riva Palacios, Totomoxtle, Ojital Nuevo, and Joloapan. Localities belonging to the municipality of Tihuatlán, such as La Pasadita and Mesa Cerrada, in the state of Veracruz. The interviews were programmed to coincide with the orchid's initial flowering period (May-June 2021), so that the people could precisely describe their management and cultural practices associated with the species in this phenological phase. In addition, in December 2021 (harvest period), contact was established with some people through a recommendation from a professor at the Intercultural University of the State of Puebla, Huehuetla, Puebla, who works in vanilla cultivation. Therefore, we expanded the sample to include and interview four people from the Sierra Norte region of Puebla, specifically from Reyes de Vallarta, Tuzamapan de Galeana, Puebla.

In accordance with the code of ethics of the Latin American Society of Ethnobiology, before each interview, before each interview, we requested informed consent, both verbal and written to record and to take photographs the people who collaborated in the interviews. All the collaborators interviewed readily agreed.

Data analysis

Information from the interviews was processed using descriptive statistics. Frequencies, percentages, ranges, medians and modes were calculated to code and synthesize systematically the traditional knowledge reported on *V. pompona*. All the analyses were carried out using the statistical software SPSS (version 15.0; SPSS Inc., 2008).

Results and Discussion

Sociodemographic characterization and production systems

Of the 17 people who collaborated in the interviews from different localities of the municipalities of Papantla and Tihuatlán, Veracruz, and Tuzamapan de Galeana, Puebla, 88% were men and 12% women, the latter had notable knowledge on the species. The age range of the key informants was 17 to 72 years, with an average of 52 years and residence in their localities oscillating between 10 and 71 years.

Ethnobotanical knowledge and *V. pompona* management

All the collaborators stated that they know about *V. pompona*, and 82% identify it by its scientific name, which is used by most people, because its morphological characteristics differentiate it from *V. planifolia*. The remaining 18% know it by the

common names “platanillo” or “Xanath” (Nahuatl term meaning ‘black flower’). This onomastic knowledge reflects the co-existence of scientific knowledge and traditional knowledge. Coincidently, in the Totonacapan region, Espinoza-Pérez *et al*. (2024) report that this species is known as “sumixanat” in the Totonaca language.

Knowledge on the distribution of *V. pompona*

Knowledge on *V. pompona* is predominantly transmitted within the family nucleus, parents, grandparents or parents-in-law being the main sources of information, having an average of 25 years with this knowledge. Despite this, 58% of the interviewees consider that the species is not well-known, and only 12% believe that it is well-known. Of the interviewees, 82% mention that it is mostly the adults that identify *V. pompona*. More than half of the interviewees (53%) know of other localities where the species is present, such as Cerro del Carbón, Arroyo Blanco, Isla de Juan Rosas and Totomoxtle in Papantla, Veracruz. The pattern of knowledge transmission, based on observation and accumulation of empirical experience that is passed on orally and practically, has been documented previously for other Vanilla species (Mora-Delgado, 2008; Burrola-Aguilar *et al*. 2012).

Presence and management of *Vanilla pompona*

The analysis of the production systems reveals a marked difference in the management between *V. planifolia* and *V. pompona*. Generally, *V. planifolia* is found under formal cultivation systems, mainly in shade houses and acahual [secondary vegetation], frequently in association with other crops, such as **coffee** (*Coffea Arabica* L.), **lime** (*Citrus x limon* (L.) Osbeck) and **orange** (*Citrus x sinensis* L.) Osbeck) (Borbolla-Pérez *et al*. 2017). While *Vanilla pompona* has been reported as native in coffee plantations in the Totonacapan region in Puebla (Espinoza-Pérez *et al*. 2024). Moreover, production of *V. pompona* is not identified as a consolidated production system in the area. Except for one case dedicated to commercial production and processing. The vast majority (94%) of interviewees reported having and observing *V. pompona* in their homegardens. This suggests that management is limited or nil; people mainly tolerate and conserve the plant, thereby initiating a process of generation of knowledge. Similar situations of incipient management, where plants are tolerated and conserved, have been reported for *V. planifolia* in Totonacapan (Espinoza-Pérez *et al*. 2018) and in the Potosí Huasteca, where a gradient of management is described, going from gathering in the woods to low-scale cultivation (Lima-Morales *et al*. 2018).

The practice of “tolerance” consists of the active conservation of plants that grow spontaneously within or on the edges of the milpa systems or family homegardens. The producers attribute value to these plants because of their adaptability to local conditions and the ecosystem services and direct uses they provide, including retention of soil moisture, erosion prevention, pollinator attraction, and food or medicinal uses, distinguishing them from weeds (Casanova-Pérez *et al*. 2022).

This phenomenon is not exclusive to *V. pompona*; parallels are found with other orchids in Mexico. For example, in the community of El Salto, in the state of Morelos, Mexico, *Lalelia autumnalis* is used by people and has economic and cultural value (Beltrán-Rodríguez *et al*., 2012). Likewise, in the communities of Tenanacingo and Malinalco, State of Mexico, *L*. autumnalis (Lex.) Lindl. is valued as an ornamental in ritual and traditional decorations, as well as for its medicinal and food uses (Emeterio-Lara *et al*. 2016). Similarly, studies in Apaseo el Alto, Guanajuato, and Tuxpan, Veracruz, report that *L. autumnalis* and *Oncidium sphacelatum* Lindl. are managed in homegardens; their flowers and pseudobulbs are used to make religious ornaments (crosses) and traditional candies, respectively, constituting both cultural symbolism and a source of complementary income (Morales *et al*. 2020). Therefore, species like *L. autumnalis*, *O. sphacelatum* and *V. pompona* can be categorized as tolerated species, whose socioeconomic and cultural value make them part of the biocultural heritage of rural communities and foment their *in situ* conservation.

Finally, some of the farmers that previously managed *V. pompona* at a small scale abandoned its production to produce other crops, suggesting that permanence of these traditional management systems is vulnerable and underlines the need to evaluate the socio-economic factors that drive this transition.

Origin of cultivated material

Most of the plants (59%) present in the interviewees’ communities come from localities of Papantla, Veracruz (e.g., Arroyo Blanco). Others were obtained from municipalities such as Coyutla, Tecolutla, and Xalapa in Veracruz, as well as Tuzamapan de Galeana and Hueytamalco in Puebla (Table 2). This indicates exchange of this genetic resource in municipalities of Veracruz and Puebla. Almost all (94%) do not know whether genetic material has been transported from their localities to others, although movement of plants to Gutiérrez Zamora, Veracruz, has been reported. This local exchange is consistent with vanilla’s sociocultural importance as well as its importance as a source of income for small producers of the region (Andrade-Andrade *et al*. 2018), suggesting that there is a flow of both *V. pompona* and *V. planifolia* material.

Table 2. Geographic origin (localities and municipalities) from which Vanilla pompona plants have been obtained in the states of Veracruz and Puebla, Mexico.

State	Municipality	Locality
Veracruz	Papantla	Arroyo Blanco
		El Aguacate
		Arroyo Colorado
		Isla de Juan Rosas
		Solteros de Juan Rosas
		Riva Palacios
		Totomoxtle
		Ojital Nuevo
		Joloapan
	Tecolutla	Boca de Lima
	Tihuatlán	La Pasadita
		Mesa redonda
	Xalapa	
	Coyutla	
Puebla	Tuzamapan	El Tuti
		Huitziltepec
		Reyes de Vallarta
	Hueytamalco	San Antonio

Homegarden cultivation and agronomic management

Of the interviewees, 88% cultivate *V. pompona* in their homegardens, with a median of 12 plants per unit. For 59%, cultivation is recent (10 years or less). However, 12% stated that they stopped conserving plants because of the lack of a stable market to commercialize the fruits, a situation that contrasts with the cultivation of *V. planifolia*, which is part of the region's identity and a source of economic income (Andrade-Andrade *et al*. 2018).

Cultivation of *V. pompona* is like that of *V. planifolia*. The process involves selecting cuttings of approximately 1.50 m long (from the tip or middle part). Two to three leaves are removed from the cut end, and the cuttings are left in the shade to allow the tip to dry for three days. The cuttings are planted with the scar tissue below and tied to a tutor, then covered with leaf litter to promote growth. Live tutors, such as white **cedar** (*Cedrela odorata* L.), **orange** (*Citrus sinensis* (L.) Osbeck), **grapefruit** (*Citrus paradisi* Macfad.), **coral tree** (*Erythrina sp.* L.) and white **milkwood** (*Tabernaemontana alba* Mill.) (Figure 2), are used. For *V. planifolia*, it has been estimated that the production system under orange can generate up to 1.2 t ha-1 (Barrera-Rodríguez *et al*. 2009). This information is lacking for *V. pompona*.

Planting is done from February to June and from September to November. Planting in December is avoided because excess moisture causes rot. It has been reported that the families of mycorrhiza Tulasnellaceae and Ceratobasidiaceae are dominant in the roots of both species (Wong *et al*. 2024). The interviewees have observed that *V. pompona* cuttings have a superior regenerative capacity to that of *V. planifolia*, an aspect that deserves study. While propagation of *V. planifolia* with pre-calluses (Gätjens-Boniche *et al*. 2024) and use of cytokinins such as BAP to induce adventitious shoots is documented (Lozano-Rodríguez *et al*. 2015), and even the use of biostimulants with *V. tahitensis* (Rivas *et al*. 2021), these studies are incipient or non-existent for *V. pompona*.

Once established, the *V. pompona* cuttings do not receive much management, which is limited to tying them to a tutor to prevent their contact with the ground. This lack of investment in management is directly associated with the perception of absence of a profitable market. This differs from the practices reported for *V. planifolia* in other regions where up to five management stages have been identified and associated with environmental and socio-cultural conditions (Lima-Morales *et al*., 2018) and four profiles of growers, according to their practices (Espinoza-Pérez *et al*. 2018).

Figure 2. Systems of *Vanilla pompona* cultivation in homegardens using live tutors: a) **grapefruit** (*Citrus paradisi* Macfad.) and b) **white cedar** (*Cedrela odorata* L.).

Local knowledge of phenology and flowering

Regarding flowering, most (82%) of the people who collaborated in the interviews report an annual flowering stage between March and May. Nevertheless, 12% have observed three stages: early (March-May), late (June-August), and continuous (March-October). The literature for Mexico (Veracruz, Chiapas, Oaxaca) documents flowering between April and July (Soto-Arenas & Dressler 2010), with some variation. In other countries, such as Brazil (Ferreira *et al*. 2017), Costa Rica and Peru (Pansarin 2023), and for the subspecies *V. pompona* subsp. *grandiflora* in Peru (Householder *et al*. 2010), the flowering period varies. The existence of plants with different flowering phenology in Mexico (Viveros-Antonio *et al*. 2023) and in other countries, as mentioned previously, is an interesting characteristic, since this species may exhibit phenological asynchrony throughout its distribution area. However, that requires more study to determine its adaptative or productive advantages.

Pollination

All the people who collaborated in the interviews know about the process of pollination, which can be manual or natural. Manual pollination is done by 56%; they point out that the *V. pompona* pollen and flowers are more rigid than those of *V. planifolia* (Figure 3). The remaining 44% depend on pollinating insects, mainly **bumblebees** (*Bombus sp*.). Studies in Brazil have identified male *Eulaema bombiformis* Packard, *Eulaema cingulate* Fabricius and *Eulaema meriana* Olivier (Pansarin 2023) as specific pollinating insects, while *E. cingulata* (Watteyn *et al*. 2021) has been reported in Costa Rica and Perú. In Mexico, the information on natural pollinators of *V. pompona* is scarce and not documented. Because the flowers are ephemeral (lasting one day), opportunities for pollination are limited (Soto-Arenas & Dressler 2010). Ecological studies in wild habitats are required to identify pollinators, confirm specific relationships, and study floral phenology to optimize strategies of conservation and sustainable management.

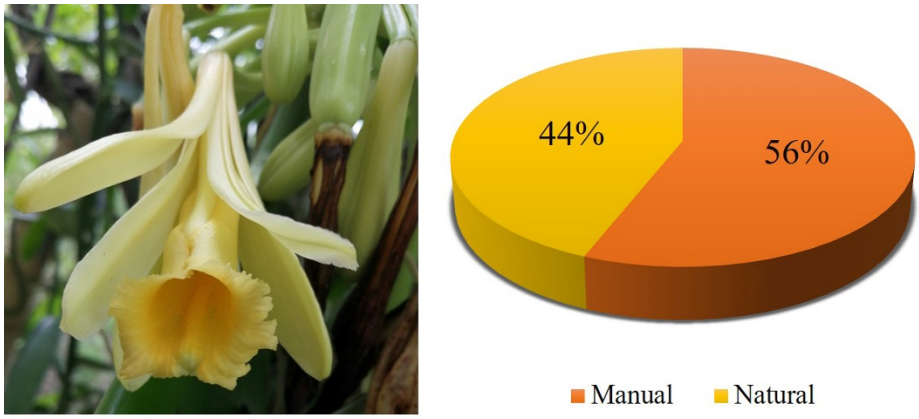

Figure 3. Methods of pollination reported for *Vanilla pompona*: manual or natural (by insects).

Fruit harvest and characteristics

Harvest criteria vary. Of the people who collaborated in the interviews, 29% pick the fruits at 8 months and another 24% at 9 months after pollination, although only 29% keep a formal record of times. To determine ripeness, 47% are guided by the yellow color at the base of the fruit, 40% by the aroma and from the tip, and 13% by a combination of color and length (Figure 4). In some cases, the fruits are left to ripen completely on the plant. Determining optimal maturity is crucial since in *V. planifolia*, maturation at nine months is a key quality factor, together with climate, geographic origin, and curing process (Dunphy & Bala 2011).

V. pompona harvested fruits measure on average 18 cm long and a range of 7 to 35 cm. Most of the people who collaborated in the interviews (86%) indicated that the size is similar in all their plants, while 14% report variation (large and small fruits on different plants). This local knowledge on the variation of fruit size is valuable to identify diverse germplasm, which would facilitate the creation of hybrids with *V. planifolia*. Interspecific hybridization is a promising approach for incorporating new genes into the relatively narrow genetic base of *V. planifolia* (Chambers *et al*. 2021; Hu *et al*. 2019).

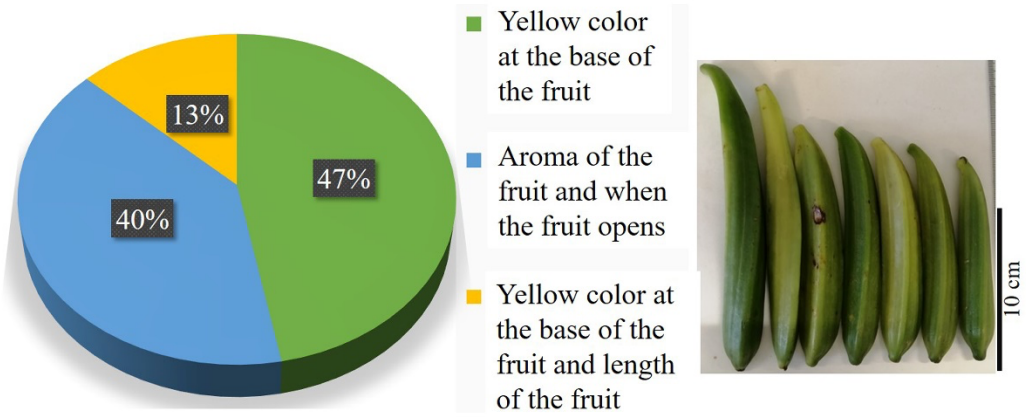

Figure 4. Criteria used by growers to determine the optimal time for harvesting *Vanilla pompona* fruits.

Uses of *Vanilla pompona*

There is insufficient information on the use of *V. pompona*. However, it has been reported that processed *V. pompona* fruits can be used in making products such as fragrances, cosmetics, extract for flavoring, salt with vanilla, sugar with vanilla, and pepper with vanilla (Crymes *et al*. 2020). The results show that people of the municipalities of Papantla and Tihuatlán, Veracruz, and Tuzamapan de Galeana, Puebla, Mexico, use the leaves, stems, flowers and fruits of *V. pompona*. The results of our study document a diversity of uses for *V. pompona*. These are categorized and presented in Figure 5. These uses include applications in food, medicine, ornaments, handcrafts and commerce, reflecting its socio-cultural value and economic potential in the communities studied.

Use as food and flavoring

Of the interviewees, 12% reported the use of processed *V. pompona* fruits as flavoring in maize atole [sweet thickened hot drink], valuing its pleasing taste. An equal percentage (12%) mentioned its use in aromatization of alcoholic beverages. This use as a flavoring finds similarity to those reported for *V. planifolia*, whose fruits are used in traditional beverages, such as café de olla [coffee boiled in a pot with raw cane sugar and, in this case, vanilla] and atole in festive occasions and during farm work (Andrade-Andrade *et al*. 2018), as well as to aromatize chocolate (Caso & Aliphat 2006). Moreover, Espinoza-Pérez *et al*. (2024) document the use of *V. pompona* fruits as a spice in the region of Totonacapan in Puebla, although they do not specify the dishes. This finding points to an emerging potential of *V. pompona* in the local gastronomy.

Medicinal use

Vanilla pompona is recognized for its application in traditional medicine. Twenty-four percent of the people who collaborated in the interviews reported the historical use of infusions prepared with leaves and flowers to treat female infertility and infusions of fruits to alleviate menstrual problems. This traditional knowledge has parallels in other medicinal orchids, such as *Prosthechea karwinskii* (Mart.) J.M.H (Garcia *et al*. 2014) and in uses reported for *V. planifolia*, whose flowers and fruits are used against colic and abdominal pain and its leaves for headaches and to accelerate childbirth (Rodríguez-

López & Martínez-Castillo 2019). Preliminary scientific research sustains this potential: in *V. planifolia* extracts antioxidant (Dong *et al*. 2014; Shyamala *et al*. 2007) and anticancer (Akagi *et al*. 1995; Lirdprapamongkol *et al*. 2005) properties, as well as antimicrobial activity have been identified in leaves and stems (Shanmugavalli *et al*. 2009). Recently, phenolic glucosides isolated from extracts of *V. pompona* leaves and stems have been shown to promote the synthesis of collagen, hyaluronic acid and elastin in dermal fibroblasts, suggesting applications to combat cutaneous senescence (Wang *et al*. 2023). This convergence between ethnobotanical knowledge and scientific evidence underlines the need to delve more deeply into phytochemical and pharmacological research on *V. pompona*.

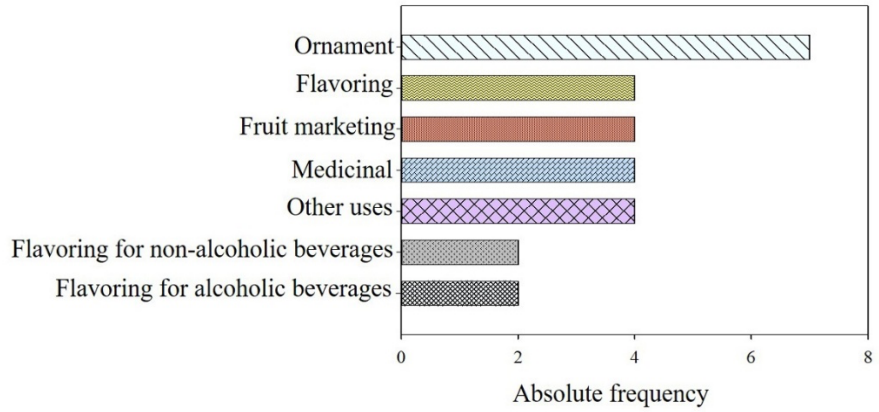

Figure 5. Frequency of uses given to *Vanilla pompona* in localities of Puebla and Veracruz, Mexico.

Commercialization

Globally, the vanilla market is dominated by *V. planifolia*, whose prices fluctuate due to its susceptibility to environmental perturbations (Barrales-Cureño & Herrera-Cabrera 2023). Although *V. pompona* is considered the third most important species of the genus commercially in Mexico (Ranadive *et al*. 2011; Soto-Arenas 1999), the people who collaborated in the interviews consider that its market still incipient because people in the region cannot easily sell their produce. Only a fourth of the people (24%) reported commercializing green or processed fruits, indicating that its value chain and knowledge on post-harvest management are still basic.

Use as a perfume

The aromatic profile of *V. pompona*, determined by its complex chemical composition, supports its use as a fragrance. Analyses of its processed fruits have identified 123 volatile compounds, including hydrocarbons, phenols, alcohols, esters, heterocyclic compounds, aldehydes, ketones, ethers and acids (Galeas *et al*. 2015). The major compounds, anisyl alcohol, anisic acid, and p. anisaldehyde, are those mainly responsible for its sweet floral aroma (Ehlers & Pfister 1997; Galeas *et al*. 2016), which has driven its use in perfumes and aromatherapy, especially in South America (Havkin-Frenkel & Belanger 2018). Consistent with this, 24% of the people who collaborated in the interviews use ripe fruits to freshen indoor environments. The aroma is described as having sweet and floral notes, attributed to a larger proportion of minor compounds (vanillic acid, hydroxybenzoic acid, p-hydroxybenzaldehyde) and a low content of vanillin (Delgado-Alvarado *et al*. 2014).

Ornamental and cultural use

Almost half of the people who collaborated in the interviews (48%) highlight the ornamental and cultural use they assign to *V. pompona*. The plant itself, as well as the ripe fruits, are used as ornaments. Cuttings, whose thick, leathery texture delays dehydration, are especially used to adorn Day of the Dead altars, giving it significant cultural value. Also, many growers conserve them in their vanilla groves considering them “queen of the vanilla grove” for their rapid, exuberant and vigorous growth. This aesthetic appreciation and value as cultural heritage has also been documented for *V. planifolia* in Totonacapan and the Hidalgo Huasteca (Andrade-Andrade *et al*. 2018).

Other uses

A fourth (24%) of the informants reported using *V. pompona* fruits in handcrafts, specifically bracelets, although they pointed out that its fragility limits its use for other handcrafts. This artisan use is similar to that documented for *V. planifolia* (Andrade-Andrade *et al*. 2018).

Historically (1940s to 1960s), it was common to manually extract oil from processed *V. pompona* fruits to apply on handcrafts and *V. planifolia* fruits, to make them shiny and aromatic and supposedly to prevent fungus development. The informants perceive variability in the content of oil that they associate with the geographic origin of the material; fruits from more humid zones have a higher content than those from Papantla (Veracruz). They also mention topical use of a mixture of ground *V. pompona* fruits and commercial oil (Mennen) as a treatment to promote hair growth. The documented presence of secondary metabolites such as saponins, triterpenes, flavonoids and phenolic compounds in the fruits of this species (Viveros-Antonio *et al*. 2019a) suggests that one of these groups of compounds could be associated with the biological activity reported; future research on this traditional application is merited.

***Vanilla pompona* fruit curing**

The curing process is crucial for developing the flavor and aroma characteristic to vanilla fruits. For *Vanilla planifolia*, growers process the fruits in four steps: matado (killing), sudado (sweating), secado (drying) and acondicionado (conditioning) (Havkin-Frenkel *et al*. 2004; Xochipa-Morante *et al*. 2016). In contrast, information on curing *V. pompona* is limited. Most of the studies that analyze the chemical compounds of its cured beans do not describe the curing method used. One study that did evaluate the effect of the type of "killing" reported that "killing" in the sun resulted in a higher content of total phenolic compounds, total flavonoids, total triterpenes, and total saponins when compared with other methods (Viveros-Antonio *et al*. 2019b).

The results of our study reveal that only 25% of the people who collaborated in the interviews carry out the traditional curing of *V. pompona* fruits, while the rest do not know the traditional process. The process described by these producers is similar to that used for *V. planifolia*; they recognize that it requires considerable time and experience (Borbolla-Pérez *et al*. 2017). The complexity of quality control resides in the fact that each step of the process depends on multiple factors, such as the ripeness index of each fruit, climatic conditions, the volume of fruits to be processed and the availability of labor (Xochipa-Morante *et al*. 2016).

According to the interviewees, the traditional curing process of *V. pompona* generally involves four steps. 1) Killing: carried out mainly in the sun, although in some cases hot water is used for a few seconds; it should be mentioned that some producers omit this step. 2) Sweating: the fruits are covered with blankets. 3) Drying: natural drying is recommended, 20 to 30 suns (days of exposure to the sun). 4) Conditioning: at this stage, the pods are left to rest in boxes to let the flavors mature and stabilize, which takes one to two months. The complete traditional curing process takes approximately 3 to 5 months, which is longer than that for *V. planifolia*.

The scarce documented information on processing practices for *V. pompona* underlines a knowledge vacuum. Viveros-Antonio *et al*. (2019b) described the effect of applying the traditional *V. planifolia* protocol to process *V. pompona*, observing the four stages (killing/wilting, sweating, drying and conditioning). Their work highlighted that the phytochemical content varied significantly with the method of killing/wilting used (sun or hot water). These findings suggest that the protocol for *V. planifolia* may not be optimal for *V. pompona*, indicating the need to study and standardize processing methods specific for this species to maximize the quality of its processed fruits.

Economic dimension of vanilla

Of the interviewees, 47% believe that growing *V. pompona* is potentially profitable in their localities since, they argue, both green and processed fruits have begun to sell on the market at a price comparable to that of *V. planifolia*. The interviewees highlighted the thickness of *V. pompona* fruits as an advantage, as a kilogram can be reached with fewer pods. Previous reports indicate that the green fruits of this species are 7.3 to 28 cm long and weigh between 7 and 39 g (Reyes-López *et al.* 2014; Soto & Dressler 2010), coinciding with the range of 7 to 30 cm reported by the growers.

Nevertheless, only 29% of the interviewees have obtained concrete profits from the sale of green fruits (2 to 10 kg), which were paid at the same price as *V. planifolia*. In the case of processed fruits, only one person reported sale at an equivalent price. Besides direct sale of the fruits, other associated economic activities include handcrafts, whose profitability is considered similar to that of *V. planifolia*, and guiding tourists to exhibit the plants.

In general, the interviewees identified two main vias to increase the crop's profitability: increase the planted area and acquire more knowledge on its management. However, they emphasized that the development of a broader market with a larger number of buyers is fundamental to assure its commercialization and profitability. There was consensus that they would

cultivate *V. pompona* if a stable, just sale price could be guaranteed, preferably comparable to that of *V. planifolia*. This underlines the need to establish fair reference prices for green and processed *V. pompona* fruits for small producers.

These findings reflect that economic and cultural valuation of vanilla is crucial for growers to receive remuneration for conserving their genetic resources (Herrera-Cabrera *et al*. 2012). Conservation of biodiversity should be accompanied by just, equitable distribution of the benefits. In the case of *V. pompona*, it is evident that equitable benefits do not exist for the farmer, who cannot—and should not—solely assume the costs of in situ conservation since this effort benefits the society as a whole and not necessarily the individual. If genetic diversity possesses real value for the future of humanity, some entity or institution must be willing to cover the costs of its maintenance (Smith 2000).

Transmission of traditional know-how

Traditional knowledge associated with *Vanilla planifolia* has been abundantly documented, covering aspects of agronomic management, pollination, harvest and processing of the fruit, as well as its socioeconomic relevance for small producers (Espinoza-Pérez *et al*. 2018; Lima-Morales *et al*. 2018). In contrast, for *V. pompona*, this knowledge is incipient and is transmitted predominantly within families.

The results of this study indicate that knowledge on the uses of *V. pompona* is acquired through direct teaching, mainly by parents, grandparents, parents-in-laws, and brothers and sister's in-law (Table 3). This is reflected in the fact that most of the interviewees (14 of 17) use some structure of the plant, especially the fruits—in their natural state or after traditional curing, and only one informant mentioned receiving or transmitting knowledge about *V. pompona* cultivation. This dynamic of intrafamily transmission coincides with reports on *V. planifolia* in the regions of Totonacapan and the Hidalgo Huasteca, where conservation of the plant is frequently linked to family inheritance (Andrade-Andrade *et al*. 2018). A similar pattern is observed with other orchids of cultural value, such as *Laelia anceps* subsp. *dawsonii* f. *chilapensis*, where knowledge on its management and use is also transmitted from generation to generation within the family (Herrera-Cabrera *et al*. 2018). These findings underline the fundamental role of the family in preserving and using phytogenetic resources.

Table 3. Frequency of ways of transmission of knowledge on *V. pompona.*

	Absolute frequency	
	Yes	No
Use of *V. pompona* structures	14	3
People who teach or know about *V. pompona*	17	0
In the community there are people who have greater knowledge of vanilla	17	0
In the community knowledge about vanilla is being lost	15	2
People outside the community have taught people in the community about vanilla cultivation	1	16
People of the community have taught people from other communities about *V. pompona* cultivation	1	16

All interviewees know the conservation and management methods for *V. pompona*, which were learned from family members and strengthens the central role of intergenerational transmission, also reported for *V. planifolia* (Andrade-Andrade *et al*. 2018; Espinoza-Pérez *et al*. 2018). There is consensus among the people who collaborated in the interviews that older adults are the main carriers of knowledge on *V. pompona*. Nevertheless, most (15 of 17) perceive that this knowledge is eroding (Table 4), attributing the erosion to the lack of interest on the part of the younger generations in learning how to manage and cultivate the crop in the absence of a consolidated market for the fruits. This concern for the loss of traditional knowledge coincides with Rodríguez-López and Martínez-Castillo (2019) for *V. planifolia* in Yucatán and Quintana Roo, where knowledge of the medicinal use associated with vanilla maintained by midwives is being lost since it is not transmitted to young people, who show little interest in traditions.

It is worth noting that two interviewees believe that this knowledge is not being lost, arguing that interest in the market for *V. pompona* fruits is growing. Finally, horizontal transference of knowledge between communities is limited. Only one people

who collaborated in the interviews reported having received instruction on processing the fruit from someone external to the community and mentioned having taught people of other localities the technique of manual pollination.

Conclusion

This study provides evidence that *Vanilla pompona* is a valuable component of the biocultural heritage of Totonacapan, and that it is conserved mainly through traditional practices of tolerance in acahual and homegarden systems. Its management, based on traditional knowledge of phenology and cultural practices, such as pollination and harvest, is intimately linked to specific cultural and domestic uses that give value to the species beyond its immediate commercial potential. The main threat to the persistence of this system of traditional knowledge and conservation of the species is the perception of low economic viability, due to difficulty in selling the fruits, leading to an alarming intergenerational loss of knowledge. The lack of a structured market and just remuneration for the fruits disincentivizes its cultivation and puts conservation of this genetic resource at risk. Therefore, conservation of *V. pompona* and associated knowledge requires an approach that integrates the environmental dimension with the socioeconomic development dimension. It is imperative to:

1. Socially and economically revalue the resource, highlighting its phytosanitary advantages and its potential for market niches (gastronomic, cosmetic, artisan crafts).
2. Strengthen local markets and value chains to generate direct economic incentives that motivate the newer generations.
3. Design and implement public policies and initiatives for payment for environmental services that justly and equitably compensate the farmers for their crucial role in in situ conservation of agrobiodiversity in recognition that it benefits the entire society.

Integration of *V. pompona* in strategies for sustainable development could make it a pillar of diversification of incomes and biocultural resilience in the Totonacapan region and ensure the preservation of this important phytogenetic resource for future generations.

Declarations

List of abbreviations: IUCN - International Union for Conservation of Nature; SPSS - Statistical Package for Social Sciences; TK - Traditional knowledge.

Ethics approval and consent to participate: Informed consent was obtained from all participants.

Consent for publication: Participants consented to publication of data.

Availability of data and materials: The datasets generated by the research through interviews and analyzed during the present study are available in the Harvard Dataverse repository: https://doi.org/10.7910/DVN/UX19B1

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