Ethnobotany of fruit species native to paramos and cloud forests of Northern Peru

Fidel A. Torres-Guevara, Mayar L. Ganoza-Yupanqui, Elena Mantilla-Rodriguez, Luz A. Suárez-Rebaza and Rainer W. Bussmann

Correspondence

Fidel A. Torres-Guevara[1]*, Mayar L. Ganoza-Yupanqui[2], Elena Mantilla-Rodriguez[3], Luz A. Suárez-Rebaza[2] and Rainer W. Bussmann[4,5]

[1]Asociación para la Ciencia e Innovación Agraria de la Red Norte - AgroRed Norte, Piura 20009, Perú.
[2]Grupo de Control de Calidad de Plantas Medicinales, Facultad de Farmacia y Bioquímica, Universidad Nacional de Trujillo, Trujillo 13011, Perú.
[3]Departamento de Farmacología, Facultad de Farmacia y Bioquímica, Universidad Nacional de Trujillo, Trujillo 13011, Perú.
[4]Department of Ethnobotany, Institute of Botany, Ilia State University, 0105 Tbilisi, Georgia.
[5]Department of Botany, State Museum of Natural History Karlsruhe, 76133 Karlsruhe, Germany.

*Corresponding Author: fidel.torres@agrorednorte.org.pe

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Review

Abstract

Background: This study was carried out in the paramos and cloud forests of the Andes of the department of Piura of Northern Peru and aimed to document the native fruit species known and culturally used by the communities around these ecosystems.

Methods: The Use Value and Importance indices were applied. An intercultural communication approach was used to achieve the consensus of participation of community organizations in the registration of interviews and field collections based on the timing established by the communities to collect the species.

Results: For a total of 49 fruit species ecological zone, phenology, nutritional and ethnomedicinal use were described. Of these 39 (80%) were not traditionally commercialized in the markets and only used by the communities in their nutrition and/or treatment of diseases. Overall, 27 species (55%) had nutritional and medicinal use; and among the 39 non-traditional species, 22 had dual use.

Conclusions: The traditional knowledge of the communities around the paramos and cloud forests indicated the presence of 39 fruit species not known in the market, but with traditional consumption, which makes them promising native species for science, innovation, and ecologically sustainable profitable reforestation.

Keywords: Ethnobotany, Andean fruit trees, paramos, cloud forests, reforestation, functional foods, nutraceuticals.

Background

The incomplete scientific about fruit species of the paramos and cloud forests reduces the economic use of their biodiversity, and consequently their conservation as strategic resource in areas with a function of water control and as important carbon sinks (Torres-Guevara *et al.* 2020). The existence of important traditional knowledge about the great diversity of wild fruit species in these ecosystems represents an advantage for their valorization that is endemic, given that they are found especially the Huancabamba Depression of the Andes of Northern Peru (Mutke *et al.* 2014). The growing demand from biotrade and public health especially for high-quality organic and functional fruits (Bueno *et al.* 2021, Carrillo-Perdomo *et al.* 2015), generates a possibility that can allow sustainable use, and is an opportunity for profitable reforestation as an adaptive strategy to climate change (Gonzáles Castillo *et al.* 2005, Llatas-Quiroz & López-Mesones 2005).

The permanent supply and demand throughout the year of tropical fruits is constantly increased due to the growing verification of species in trade and the demand for the nutritional and therapeutic properties of the secondary metabolites they contain (Gutiérrez Ravelo & Estévez Braun 2009, Pérez Sierra *et al.* 2016). The Andean-Amazonian countries harbor many underexploited native fruits of great potential as a source of diversification of the supply of products in the Andean and Amazonian family farming economy. These fruits, because they contain bioactive compounds, may prevent, reduce, and even eliminate the symptoms of various diseases (Reyes-Munguía *et al.* 2016).

Recent epidemiological studies indicate that frequent consumption of fruits is associated with a low risk of chronic diseases. The combination of vitamins, minerals, secondary antioxidant metabolites, and fiber seems to be responsible for these effects. Despite this, there is very limited information on bioactive compounds and the nutritional value of tropical fruits, especially the most exotic species (Contreras-Calderón 2012). On the other hand, even for more common species, scientific data for their adequate cultivation and the understanding of their ecophysiology to adapt them optimally is lacking. The development of Andean fruit crops in particular is seen as a possible essential and healthy contribution to global food consumption (Fischer & Miranda 2021).

The Andean-Amazonian area is an important center of genetic resources (Brack Egg 2003, Bussmann & Sharon 2007, 2016), and revaluing native fruit species, little known or still unknown outside their habitats of origin, can lead to potential nutraceutical resources with great benefits for public health and biotrade. This is an effort that requires regional research-innovation ventures. In some of these macro-regions a variety of interesting species have already been documented (Northern Peru, 45 species (Mostacero León 2017) and 44 species in the Andes of Piura (Valladolid Catpo 2011)).

The paramos and cloud forests pf Northern Peru are in the biogeographic region of the Huancabamba Depression between Ecuador and Peru, currently referred to as the Amotape-Huancabamba Zone (AHZ) with the lowest altitude of the central Andes of South America (2500 masl) around 5° and 8° S. The complex relief influences the pattern of wind direction, and because it located at the same latitude as the meeting point of the El Niño and Humboldt Ocean currents, it contributes to the climatic complexity of this territory, which is expressed in an outstanding floristic diversity rich in endemic species, but incipiently known (Emck *et al.* 2006, Hocquenghem 1998, Tejedor & Calatayud 2022).

Ethnobotanical studies carried out on fruit species in the Andes of Piura did so far not refer to species of the paramos and cloud forests of the provinces of Ayabaca and Huancabamba, which have a recognized tradition of knowledge of medicinal plants. The objective of this study was to document the native fruit species of the paramos and cloud forests in the provinces of Ayabaca and Huancabamba of the department of Piura, known and culturally used by the communities around these ecosystems.

Materials and Methods

Study area

Ethnobotanical records and species collection were carried out in paramos and cloud forests of the Andes of Northern Peru, between 4°43'48" to 5°30'00" S and 79°28'00" to 79°20'00" W, along the altitudinal range of 1300 to 3700 masl, covering a total area of 1200 km^2 (Ministerio del Ambiente 2015, 2016), comprising the districts of Pacaipampa (province of Ayabaca) and Carmen de la Frontera (province of Huancabamba), both in the department of Piura (Figure 1).

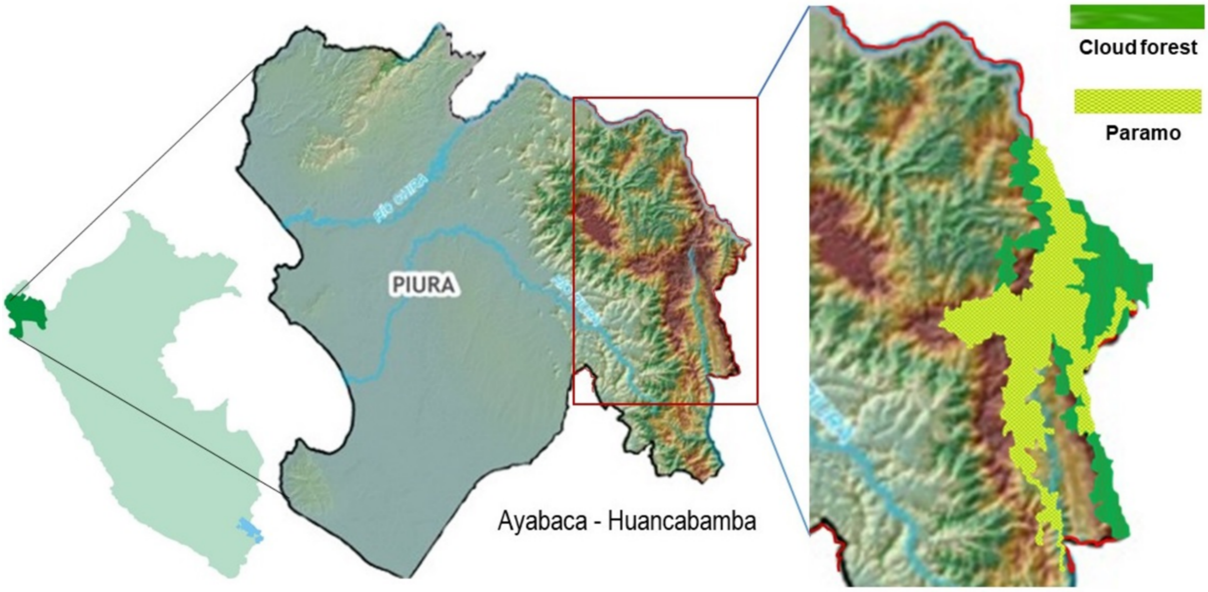

Figure 1. Paramos and cloud forests in the basins of the department of Piura.

Ethnobotanical data collection

Ethnobotanical interviews were conducted with the members of community organizations after obtaining their prior informed consent. This process followed with the convenience selection criteria (Otzen & Manterola 2017, Paniagua-Zambrana *et al.* 2010).

The local ethnobotanical knowledge was documented including information about their ecosystem requirements, abundance, phenology, flowering season, fruit production, the possibility of domestication, medicinal and nutritional use as well. Species were collected with community experts. For each specimen, 4 to 5 vouchers were collected for taxonomic determination in the Herbarium "Isidoro Sánchez" (CPUN), of the National University of Cajamarca, where all samples were deposited.

Results and Discussion

Due to the participatory nature of the research, a fundamental component was the consensus agreement with the communal organizations of the paramos and cloud forests on the purposes and methods of the research, as well as their form of participation. This intercultural approach represents the reciprocal willingness to establish commitments allowing the expectations of the use of the results to be met, by the communities using them as potential innovation initiatives (Bermúdez *et al.* 2005).

The ethnobotanical knowledge about 49 native fruit species consumed as food and in many cases also at the same time for medicinal purposes, was recorded. In each group, a distinction was made between those species traditionally consumed and sold in the markets and those that were known and consumed by the communities but not marketed. Twenty-seven types of nutritional and medicinal use were recorded. Five species were collected in the ecosystem paramo (3000-3700 masl) (Table 1); and 22 species in the cloud forest, with 12 species from 2000-2900 masl (Table 2) and 10 species from 1000-1900 masl (Table 3). Of the species consumed exclusively for nutritional purposes, only one was recorded in the paramo and 21 species in the cloud forest: 9 species between 2000-2900 masl and 12 species between 1000-1900 masl (Table 4).

The greatest diversity of fruit species was concentrated in the cloud forest between 1000-2900 masl; and the lowest in the paramos, between 3000-3700 masl (Figure 2). Of the 49 species recorded, in addition to be used as food, were also used as medicines (Figure 3). The drastic reduction of species diversity in the paramo is explained by low temperatures, high wind speed, higher UV radiation and great soil acidity (Torres Guevara 2019), which favor the exclusive selection of many species, but also favor physiological reactions of synthesis of secondary metabolites with therapeutic activities for humans, as a chemical adaptation to environmental conditions (Bueno *et al.* 2021, Chirinos *et al.* 2013, Espinoza-Tellez *et al.* 2021, Passos *et al.* 2022, Rodríguez-Hernández 2019). The main therapeutic uses of all 27 species were antibiotic, stomach, expectorant, and to a lesser extent as depurative, antidiabetic, soothing, anti-inflammatory, and expectorant (Figure 3).

Table 1. Traditional and non-traditional native fruit trees with functional properties (paramo: 3000-3700 masl).

Local name of the fruit tree	Scientific name	Commercial fruit	Plant type	Fruit production	Harvest months	Farming in farms	Amount used	Way of preparation	Preparation time	Way of use	Functional property
Cutijiro	*Deprea orinocensis* (Kunth) Raf. (Solanaceae)	Non-traditional	Tree	Scarce	February-April	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Five fresh leaves	Poultice	Instantly	Direct application	Control skin infections
Ushpa de oso	*Gaultheria bracteata* G. Don (Ericaceae)	Non-traditional	Shrub	Abundant	March-July	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Variable	Slices of fruit in a liter of water	Instantly	Refreshment	Nutritional
							5 g of fruits	Decoction in a liter of water	Three minutes	½ cup every four hours	Decongest the bronchial tubes
Sachón	*Hesperomeles obtusifolia* (Pers.) Lindl. (Rosaceae)	Non-traditional	Shrub	Regular	February-May	Difficult	10 g of fruits	Decoction in half a liter of water	20 minutes	A cup every four hours	Control kidney inflammation and infection
Solapa	*Macleania salapa* (Benth.) Hook. f. ex Hoerold (Ericaceae)	Non-traditional	Shrub	Regular	January-August	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							10 g of fruits	Infusion in ¼ liter of water	Instantly	Time water	Control infections and diarrhea
Ushpa grande	*Vaccinium crenatum* (G. Don) Sleumer (Ericaceae)	Non-traditional	Shrub	Abundant	March-July	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Variable	Slices of fruit in a liter of water	Instantly	Refreshment	Nutritional
							5 g of fruits	Decoction in a liter of water	Three minutes	½ cup every four hours	Decongest the bronchial tubes
							30 g of fruits	Macerate in a liter of cane alcohol (cañazo)	30 days	1/8 cup three times a day	Control stomach spasms
Ushpa	*Vaccinium floribundum* Kunth (Ericaceae)	Non-traditional	Shrub	Abundant	February-May	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							20 g of fruits	Decoction in a liter of water	15 minutes	Time water	Regulate blood
							40 g of fruits	Macerate in a liter of cane alcohol (cañazo)	30 days	1/8 cup a day	Regulate blood

Table 2. Traditional and non-traditional native fruit trees with functional properties (cloud forest: 2000-2900 masl).

Local name of the fruit tree	Scientific name	Commercial fruit	Plant type	Fruit production	Harvest months	Farming in farms	Amount used	Way of preparation	Preparation time	Way of use	Functional property
Lanche chiquito	*Myrcianthes myrsinoides* (Kunth) Grifo (Myrtaceae)	Non-traditional	Tree	Scarce	February-April	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Variable	Milky maize pudding (mazamorra)	Variable	Dessert	Nutritional
							20 g of leaves	Infusion in a liter of water	Five minutes	A glass every four hours	Control respiratory infection
							40 g of leaves	Macerate in half a liter of cane alcohol (cañazo)	20 days	1/8 cup every 12 hours	Control respiratory infection
Lanche o lanche grande	*Myrcianthes myrsinoides* (Kunth) Grifo (Myrtaceae)	Non-traditional	Tree	Regular	May-July	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Variable	Milky maize pudding (mazamorra)	Variable	Dessert	Nutritional
							50 g of fruits	Decoction in a liter of water	Five minutes	A glass three times a day	Control stomach and respiratory infections
Lanche colorado	*Myrcianthes myrsinoides* (Kunth) Grifo (Myrtaceae)	Non-traditional	Tree	Scarce	January	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							40-50 g of fruits	Decoction in a liter of water	Five minutes	Time water	Control diarrhea and respiratory infections, digestive
Granadilla	*Passiflora ligularis* Juss. (Passifloraceae)	Traditional	Shrub	Regular	May	Seed	5 g of leaves	Poultice in cane alcohol (cañazo)	Instantly	Direct application	Control infections
Yuto	*Rapanea andina* Mez (Primulaceae)	Non-traditional	Shrub	Regular	June	Difficult	10 g of fruits	Smoothie in half a liter of water	15 minutes	Two glasses a day for 15 days	Control diabetes
Mora	*Rubus nubigenus* Kunth (Rosaceae)	Traditional	Herb	Regular	April	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							200 g of fruits	Jam in half a liter of water	25 minutes	Dessert	Nutritional
							100 g of fruits	Infusion in half a liter of water	Instantly	Every four hours	Reduce inflammation of the throat

Muyaca	*Rubus robustus* C. Presl (Rosaceae)	Non-traditional	Shrub	Regular	February-September	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Variable	Slices of fruit in a liter of water	Instantly	Refreshment	Nutritional
							Four to six young leaves	Infusion in a cup with water	15 minutes	A glass every six hours	Control diarrhea and flu
							10 tender fruits	Decoction in half a liter of water	10 minutes	A cup a day	Reduce inflammation
Zarzaparrilla	*Rubus acanthophyllos* Focke (Rosaceae)	Non-traditional	Shrub	Regular	May-September	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							30 g of fruits	Smoothie in a liter of warm water	Instantly	Time water	Decongest the bronchial tubes
Guañul	*Cavendishia bracteata* (Ruiz & Pav. ex J. St.-Hill.) Hoerold (Ericaceae)	Non-traditional	Shrub	Abundant	April-July	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							A root	Decoction	10 minutes	Two glasses a day	Control diarrhea and diabetes
Chimicuno	*Symplocos nuda* Bonpl. (Symplocaceae)	Non-traditional	Tree	Abundant	November-December	Difficult	30-40 g of fruits	First roasted, then decoction in a liter of water	10 minutes	A cup four times a day	Intestinal cleaning and laxative
Vara negra	*Ribes colandina* Weigend (Grossulariaceae)	Non-traditional	Herb	Abundant	May	Possible by seed	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Variable	Slices of fruit in a liter of water	Instantly	Refreshment	Nutritional
							20 g of fruits + 10 stems of 10 cm + half lemon	Decoction in half a liter of water	Five minutes	Time water	Relieve intestinal colic

Table 3. Traditional and non-traditional native fruit trees with functional properties (cloud forest: 1000-1900 masl).

Local name of the fruit tree	Scientific name	Commercial fruit	Plant type	Fruit production	Harvest months	Farming in farms	Amount used	Way of preparation	Preparation time	Way of use	Functional property
Chirimoya	*Annona cherimola* Mill. (Annonaceae)	Traditional	Tree	Scarce	May-July	Possible by seed	Variable	Raw	Not applied	Fresh fruit	Nutritional
							20 g of leaves	Decoction in a liter of water	10 minutes	Two glasses a day	Reduce inflammation of the throat
Higo	*Ficus carica* L. (Moraceae)	Traditional	Tree	Scarce	May	Difficult	5 g of leaves	Decoction in a liter of water	15 minutes	A cup every three hours	Control diarrhea
Chuco	*Miconia vaccinioides* (Bonpl.) Naudin (Melastomataceae)	Non-traditional	Shrub	Scarce	March-April	With difficulty by buds	Variable	Raw	Not applied	Fresh fruit	Nutritional
							20 g of fruits + a lemon	Decoction in a liter of water	10 minutes	A glass a day	Reduce inflammation of the throat
Maracuyá	*Passiflora edulis* Sims (Passifloraceae)	Traditional	Shrub	Abundant	May-July October-November	Possible by stakes	5 g of leaves	Infusion in a liter of water	15 minutes	Three to four cups a day	Nervous system relaxant
Granadilla de ratón	*Passiflora* sp. (Passifloraceae)	Non-traditional	Liana	Regular	February-April	Possible by seed	Variable	Raw	Not applied	Fresh fruit	Nutritional
							10 g of leaves	Infusion in a liter of water	15 minutes	A cup three times a day	Reduce fever
Tungay	*Physalis peruviana* L. (Solanaceae)	Traditional	Herb	Regular	March-June	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							5 g of fruits	Smoothie in half a liter of water	Instantly	A cup a day	Control diabetes
							40 g of fruits	Smoothie in a liter of water	Instantly	½ cup a day	Eliminate intestinal parasites
							50 g of fruits	Decoction in a liter of water	15 minutes	A cup every three hours	Control diarrhea
Lúcuma	*Pouteria lucuma* (Ruiz & Pav.) Kuntze (Sapotaceae)	Traditional	Tree	Abundant	October-December	Possible by seed	Variable	Raw	Not applied	Fresh fruit	Encourage the production of breast milk, prevent Alzheimer's

Naranjilla	*Solanum quitoense* Lam. (Solanaceae)	Traditional	Shrub	Abundant	January-August	Difficult	Four to five fruits	Slices of fruit in a liter of water	Instantly	Refreshment	Nutritional
							Two fruits	Decoction in ¼ liter of water	15 minutes	A glass four to five times a day	Control infection, diarrhea, and urinary inflammation
Toronche	*Vasconcellea parviflora* A. DC. (Caricaceae)	Non-traditional	Tree	Regular	March-August	Difficult	Variable	Raw	Not applied	Fresh fruit	Nutritional
							Variable	Slices of fruit in a liter of water	Instantly	Refreshment	Nutritional
							200 g of fruits	Jam in half a liter of water	25 minutes	Dessert	Nutritional
Chicope	*Vasconcellea pubescens* A. DC. (Caricaceae)	Non-traditional	Tree	Regular	April-October	Possible by seed	Four fruits	Smoothie in a liter of warm water	Instantly	Time water	Control infections
							200 g of fruits	Milky maize pudding (mazamorra) in half a liter of water	25 minutes	Dessert	Nutritional
							30 g of fruits	Decoction in a liter of water	10 minutes	Time water	Purgative

Table 4. Native fruit trees of paramos and cloud forests, traditional and non-traditional only for food consumption as fresh fruit.

Local name of the fruit tree	Scientific name	Ecosystem	Altitude (masl)	Commercial fruit	Plant type	Fruit production	Harvest months	Farming in farms
Chin chin	*Acnistus arborescens* (L.) Schltdl. (Solanaceae)	Cloud forest	2000-2900	Non-traditional	Tree	Abundant	January-March	By stakes
Piña de zorro	*Ananas* sp. (Bromeliaceae)	Cloud forest	1000-1900	Non-traditional	Shrub	Scarce	March-December	Difficult
Espina de culebra	*Berberis saxicola* Lechl. (Berberidaceae)	Cloud forest	2000-2900	Non-traditional	Shrub	Scarce	April-August	Difficult
Toronja	*Citrus paradisi* Macfad. (Rutaceae)	Cloud forest	1000-1900	Traditional	Tree	Regular	December-January	Difficult
Moyuyo	*Cordia lutea* Lam. (Boraginaceae)	Cloud forest	1000-1900	Non-traditional	Shrub	Scarce	Not reported	Difficult
Pitiquish	*Dioscorea* sp. (Dioscoreaceae)	Cloud forest	1000-1900	Non-traditional	Tree	Scarce	April	By seed
Arrayán	*Eugenia myrobalana* DC. (Myrtaceae)	Cloud forest	1000-1900	Non-traditional	Tree	Abundant	Not reported	By seed
Higo anaranjado	*Ficus* sp. (Moraceae)	Cloud forest	1000-1900	Non-traditional	Tree	Regular	May-July	Difficult
Huambillo	*Gaiadendron punctatum* (Ruiz & Pav.) G. Don (Loranthaceae)	Cloud forest	2000-2900	Non-traditional	Tree	Scarce	March-April	Difficult
Ushpa de venado	*Gaultheria reticulata* Kunth (Ericaceae)	Paramo	3000-3700	Non-traditional	Shrub	Abundant	February-March	Difficult
Nogal	*Juglans neotropica* Diels (Juglandaceae)	Cloud forest	1000-1900	Non-traditional	Tree	Abundant	May	Difficult
Lisho	*Miconia lutescens* subsp. *piurensis* Wurdack (Melastomataceae)	Cloud forest	2000-2900	Non-traditional	Shrub	Abundant	April	Difficult
Pisho	*Oryctanthus* sp. (Loranthaceae)	Cloud forest	1000-1900	Non-traditional	Tree	Scarce	Not reported	Difficult
Tumbo	*Passiflora mollissima* (Kunth) L.H. Bailey (Passifloraceae)	Cloud forest	1000-1900	Non-traditional	Tree	Scarce	Not reported	By stakes
Guayaba	*Psidium guajava* L. (Myrtaceae)	Cloud forest	1000-1900	Traditional	Shrub	Abundant	Mach-April	By seed
Mora	*Rubus adenothallus* Focke (Rosaceae)	Cloud forest	2000-2900	Non-traditional	Shrub	Regular	April	Difficult
Mora	*Rubus roseus* Poir. (Rosaceae)	Cloud forest	2000-2900	Non-traditional	Shrub	Regular	May-September	Difficult
Pepinito	*Solanum muricatum* Aiton (Solanaceae)	Cloud forest	2000-2900	Non-traditional	Herb	Regular	April-August	Difficult
Ushón	*Spondias mombin* L. (Anacardiaceae)	Cloud forest	1000-1900	Non-traditional	Tree	Abundant	December-February	By seed
Pomarrosa	*Syzygium jambos* (L.) Alston (Myrtaceae)	Cloud forest	1000-1900	Non-traditional	Tree	Abundant	Not reported	By seed
Mashupes	*Vasconcellea candicans* (A. Gray) A. DC. (Caricaceae)	Cloud forest	2000-2900	Non-traditional	Tree	Scarce	January	Difficult
Babaco	*Vasconcellea* sp. (Caricaceae)	Cloud forest	2000-2900	Non-traditional	Tree	Scarce	June-July	By seed

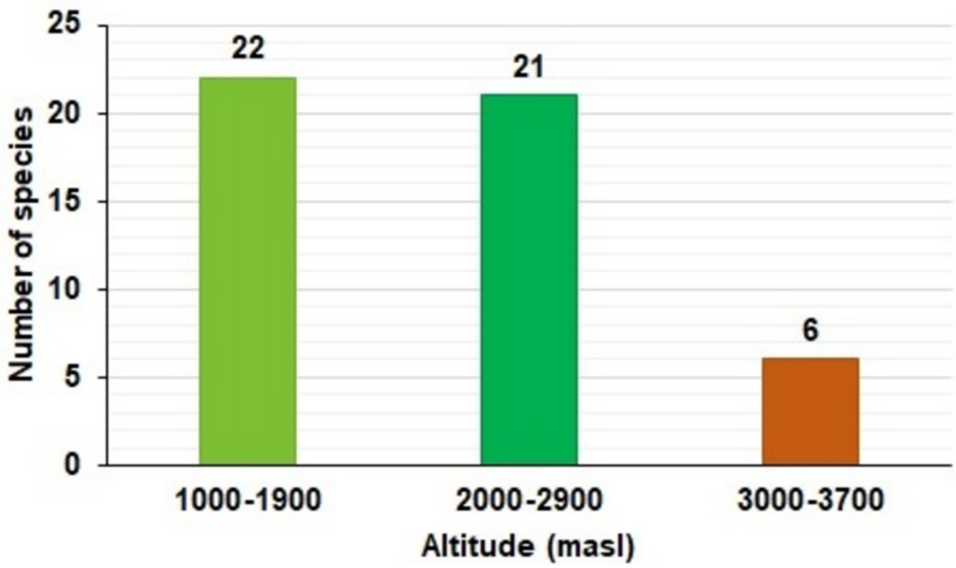

Figure 2. Number of fruit species according to ecological levels.

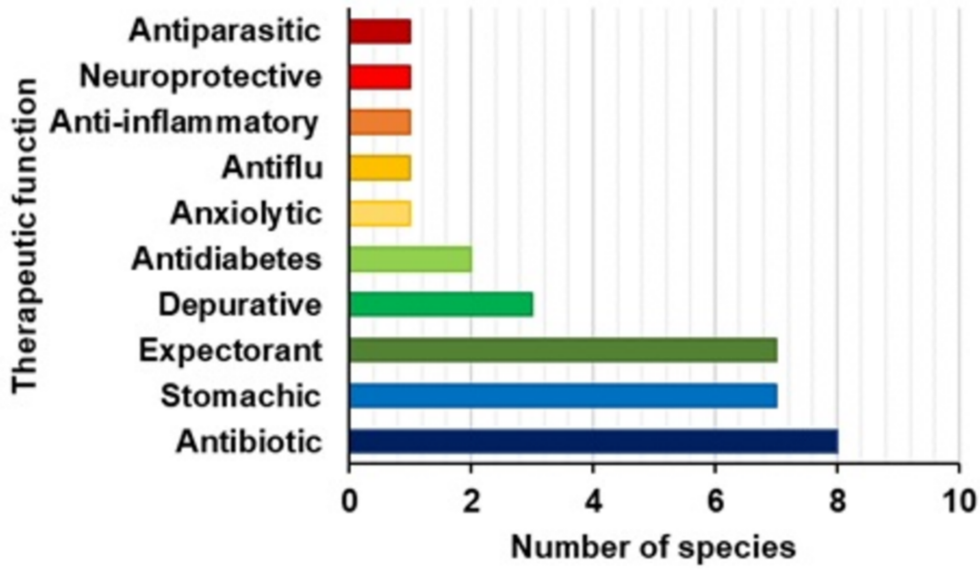

Figure 3. Therapeutic functions of functional fruit species of the paramos and cloud forests.

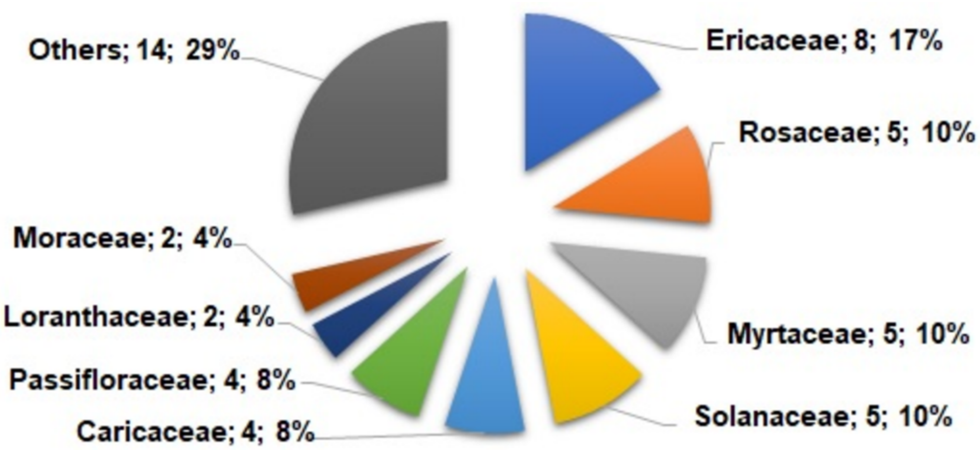

Figure 4. Main botanical families of fruit trees in paramos and cloud forests.

Therapeutic properties that other South American Andean societies also assign in the case of the same species or genera typical of the ecosystems of paramos or cloud forests (Benites *et al.* 2019, Carrillo-Perdomo *et al.* 2015, Ganoza-Yupanqui *et al.* 2021, Guevara *et al.* 2019). Of the various forms of preparation, the most used were infusion, decoction, and maceration, similar to other Andean species of Northern Peru (Llaure-Mora *et al.* 2021). Some species showed the advantage of concentrating their medicinal bioactive substances in shells and leaves (Stefănescu *et al.* 2019, Ganoza-Yupanqui *et al.* 2021).

The botanical families with the largest number of fruit species were Ericaceae (**ushpas**, **guañul**, **solapa**), Rosaceae (**moras, zarzamoras**, **muyacas**, **sachón**), Myrtaceae (**lanches**, **arrayán**, **pomarrosa**), Solanaceae (**naranjillas**, **pepinos**, **tungay**), Caricaceae (**toronche**, **chicope**) y Passifloraceae (**tumbo**, **granadilla**, **maracuyá**) (Figure 4). Shrubby species of Ericaceae and Rosaceae were mostly distributed in the paramo, especially *Vaccinium floribundum* Kunth, *Vaccinium crenatum* (G. Don) Sleumer, *Gaultheria bracteata* G. Don, *Gaultheria reticulata* Kunth, and *Hesperomeles obtusifolia* (DC.) Lindl. These species present high potential for production of edible fruits and leaves used for medicinal purposes (Stefănescu 2019, Pastor Cabanillas 2019). In the cloud forest the most important species belonged to the genera *Myrcianthes* and *Passiflora*, both with medicinal properties (Fischer & Miranda 2021, López *et al.* 2018, Ruiz Reyes *et al.* 2018). In contrast Rosaceae and Solanaceae were mostly shrubs (Llanos Ramos 2018, Sanjinés Asturizaga *et al.* 2006). The most important families were also documented as important in other studies (Alarcón-Barrera *et al.* 2018, Bueno *et al.* 2021, Karasawa & Mohan 2018, Samaniego *et al.* 2020, Van den Eynden *et al.* 2003).

To ensure consumer safety it is important that ethnobotanical studies guarantee the taxonomic identity of species in trade and are complemented by phytochemical studies (Ascate-Pasos *et al.* 2020, 2022, Organización Panamericana de la Salud 2019, Rodríguez-Silva *et al.* 2020).

The water catchment service provided by the paramos and cloud forests can be improved by using the diversity of fruit species of high economic value in reforestation initiatives and the protection of these ecosystems to turn them into economically profitable areas, especially considering that it is not a single species promising to encourage its propagation but a spectrum of 49 species of which 47% (23) are of trees and 45% (22) shrubs with great capacity to prevent soil degradation and improve moisture capture (Figure 5). Much emphasis has been placed on tree species for reforestation purposes, and little attention has been paid to shrubs which nevertheless have an important role both in the cover and fixation of soils and improvement of water permeability and retention due to their extensive root system (Gonzáles Castillo *et al.* 2005).

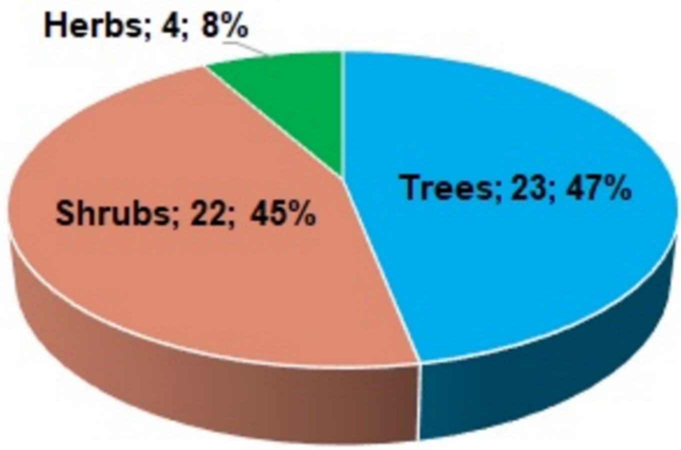

Figure 5. Dominant Fruit Plant Types.

Figure 6. Fruit trees of the paramos and cloud forests of Northern Peru: **Guaguña** (A), **Ushpa de oso** (B), **Sachón de páramo** (C), **Ushpa** (D), **Sachón** (E), **Tungay** (F), **Muyaca** (G), **Chicope** (H), **Mora** (I), **Chin chin** (J), **Vara negra** (K), **Chimicuno** (L), **Pepino** (M), **Lanche negro** (N), **Lisho** (O).

Conclusions

Our study underlined the importance of traditional knowledge of the communities of the area in which the paramos and cloud forests of the Andes of Northern Peru (department of Piura) are located, showing that currently only 20% of the existing potential of diversity of known fruit species of these ecosystems is consumed.

The communities in the research area knew and used 49 fruit species of which 39 (80%) were not traditionally marketed and 27 (55%) in addition to being food, had therapeutic functions of up to ten health conditions.
Over 88% of the culturally known fruit species and their greatest floristic richness, represented by six families (Rosaceae, Ericaceae, Myrtaceae, Passifloraceae, Solanaceae and Caricaceae) are concentrated in the cloud forest. This place is the intermediate ecosystem for the protection of the paramo and its water function, but at the same is the most affected by human occupation.

Because 47% and 45% of the recorded species are tree and shrub species respectively, they represent an advantageous option for reforestation and a climate change adaptation strategy by forest carbon management propagating native species with economic food and nutraceutical potential.

The species with nutritional and medicinal use are consumed as the fruit as well as by using the leaves, which means an advantage for their use in innovations by having their availability permanently throughout the year.

Declarations

Ethics approval and consent to participate: All participants gave their oral prior informed consent.
Consent to publication: Not applicable.
Availability of data and materials: Not applicable.
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Authors' contributions: FAT-G and MLG-Y conceived the work, FAT-G, MLG-Y and EM-R compiled the information and wrote the manuscript, LAS-R and RWB reviewed and improved the manuscript. All authors approved the final manuscript.

Literature Cited

Alarcón-Barrera KS, Armijos-Montesinos DS, García-Tenesaca M, Iturralde G, Jaramilo-Vivanco T, Granda-Albuja MG, Giampieri F, Alvarez-Suarez JM. 2018. Wild Andean blackberry (*Rubus glaucus* Benth) and Andean blueberry (*Vaccinium floribundum* Kunth) from the Highlands of Ecuador: Nutritional composition and protective effect on human dermal fibroblasts against cytotoxic oxidative damage. Journal of Berry Research 8:223-236.

Ascate-Pasos ME, Ganoza-Yupanqui ML, Suárez-Rebaza LA, Bussmann RW. 2020. *Valeriana pilosa* Ruiz & Pav.: a review of traditional uses, phytochemistry and pharmacology. Ethnobotany Research and Applications 20:19.

Ascate-Pasos ME, Ganoza-Yupanqui ML, Suárez-Rebaza LA, León-Vargas FR, Bussmann RW. 2022. Traditional use, chemical constituents, and pharmacological activity of *Maytenus laevis* Reissek. Ethnobotany Research and Applications 24:25.

Benites J, Ybañez-Julca RO, Ganoza-Yupanqui ML, Mantilla-Rodriguez E, Zavala E, Velasquez S, Gajardo S, Morales B, de Albuquerque RDDG, Rocha L, Martinez JL. 2019. Antioxidant effect and chemical composition of *Ananas comosus* (L.) Merr. peels from Peruvian Northern. Boletin Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 18(6):577-585.

Bermúdez A, Oliveira-Miranda MA, Velázquez D. 2005. La Investigación etnobotánica sobre plantas medicinales: Una revisión de sus objetivos y enfoques actuales. Interciencia 30(8):453-459.

Brack Egg A. 2003. Perú: Diez mil años de domesticación. Bruño, Lima, Perú.

Bueno S, Vallejos O, Schultz B, González L, Suazo, I, Catalán E. 2021. Alimentos e Inmunidad: Cocinando en tiempos de pandemia. Pontificia Universidad Católica de Chile, Santiago de Chile, Chile.

Bussmann RW, Sharon D. 2007. Plantas de los cuatro vientos, flora mágica y medicinal del Perú. Editorial Graficart, Trujillo, Perú.

Bussmann RW, Sharon D. 2016. Plantas medicinales de los Andes y la Amazonia, la flora mágica y medicinal del norte del Perú. Editorial Graficart, Trujillo, Perú.

Carrillo-Perdomo E, Aller A, Cruz-Quintana SM, Giampieri F, Alvarez-Suarez JM. 2015. Andean berries from Ecuador: a review on botany, agronomy, chemistry and health potential. Journal of Berry Research 5:49–69.

Chirinos R, Pedreschi R, Rogez H, Larondelle Y, Campos, D. 2013. Phenolic compound contents and antioxidant activity in plants with nutritional and/or medicinal properties from the Peruvian Andean region. Industrial Crops and Products 47:145–152.

Contreras-Calderón J. 2012. Capacidad antioxidante en frutas colombianas. Vitae 19(Supl. 2).

Emck P, Moreira-Muñoz A, Richter M. 2006. El clima y sus efectos en la vegetación. In: Moraes M, Øllgaard B, Kvist LP, Borchsenius F, Balslev H. (eds). Botánica Económica de los Andes Centrales. Universidad Mayor de San Andrés, La Paz, Bolivia. Pp. 11-36.

Espinoza-Tellez T, Bastías-Montes JM, Quevedo-León R, Valencia-Aguilar E, Díaz-Carrasco O, Solano-Cornejo MA, Mesa-Mesina F. 2021. La murta (*Ugni molinae*) y sus propiedades benéficas para la salud: Una revisión. Scientia Agropecuaria 12(1):121-131.

Fischer G, Miranda D. 2021. Review on the ecophysiology of important Andean fruits: *Passiflora* L. Revista Facultad Nacional de Agrononía Medellín 74(2):9471-9481.

Ganoza-Yupanqui ML, Muñoz-Acevedo A, Ybañez-Julca RO, Mantilla-Rodríguez E, Zavala E, Gajardo S, Ríos M, Benites J, Martínez JL. 2021. Potential antioxidant effect of fruit peels for human use from Northern Peru, compared by 5 different methods. Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 20(6):611-637.

Gonzáles Castillo J, Marcial Ramos R, Rojas Rojas J. 2005. Valoración económica de los recursos naturales en la cuenca binacional Catamayo Chira. Componente 1: auditoría/estudio del agua subcomponente 1: diagnóstico del servicio ambiental hídrico mayo 2005. Proyecto Binacional Catamayo Chira, Consorcio Universidad Nacional de Piura-Profesionales de Loja.

Guevara M, Tejera E, Granda-Albuja MG, Iturralde G, Chisaguano-Tonato M, Granda-Albuja S, Jaramillo-Vivanco T, Giampieri F, Battino M, Alvarez-Suarez JM. 2019. Chemical Composition and Antioxidant Activity of the Main Fruits Consumed in the Western Coastal Region of Ecuador as a Source of Health-Promoting Compounds. Antioxidants 8(9):387.

Gutiérrez Ravelo A, Estévez Braun A. 2009. Relevancia de los productos naturales en el descubrimiento de nuevos fármacos en el s. XXI. Revista de la Real Academia de Ciencias Exactas, Fisicas y Naturales (Espana) 103(2):409-419.

Hocquenghem AM. 1998. Para vencer a la muerte. Piura y Tumbes. Raíces en el bosque seco y en la selva alta - horizontes en el Pacífico y en la Amazonia. Centro Nacional de la Investigación Científica, Instituto Francés de Estudios Andinos, Instituto de la Naturaleza y el Conocimiento Ambiental Humano. Lluvia Editores, Lima, Perú.

Karasawa MMG, Mohan C. 2018. Fruits as Prospective Reserves of bioactive Compounds: A Review. Natural Products and Bioprospecting 8(5):335–346.

Llanos Ramos JR. 2018. Etnobotánica de la flora arbórea y arbustiva del Departamento de Cajamarca. Thesis, Universidad Nacional de Cajamarca.

Llatas-Quiroz S, López-Mesones M. 2005. Bosques montanos-relictos en Kañaris (Lambayeque, Perú). 2005. Revista Peruana de Biología 12(2):299-308.

Llaure-Mora AM, Ganoza-Yupanqui ML, Suárez-Rebaza LA, Bussmann RW. 2021. *Baccharis genistelloide*s (Lam.) Pers. "carqueja": a review of uses in traditional medicine, phytochemical composition and pharmacological studies. Ethnobotany Research and Applications 21:50.

López J, Vega-Gálvez A, Rodríguez A, Uribe E, Bilbao-Sainz C. 2018. Murta (*Ugni molinae* Turcz.): a review on chemical composition, functional components and biological activities of leaves and fruits. Chilean Journal of Agricultural and Animal Sciences 34(1):43-56.

Ministerio del Ambiente. 2015. Mapa nacional de cobertura vegetal - Memoria descriptiva. MINAM, Lima, Perú.

Ministerio del Ambiente. 2016. Mapa nacional de ecosistemas del Perú - Memoria descriptiva. MINAM, Lima, Perú.

Mostacero León J, Mejía Coico F, Gastañadui Rosas D, De La Cruz Castillo J. 2017. Inventario taxonómico, fitogeográfico y etnobotánico de frutales nativos del norte del Perú. Scientia Agropecuaria 8(3):215-224.

Mutke J, Jacobs R, Meyers K, Henning T, Weigend M. 2014. Diversity patterns of selected Andean plant groups correspond to topography and habitat dynamics, not orogeny. Frontiers in Genetics 5:351.

Organización Panamericana de la Salud. 2019. Situación de las plantas medicinales en Perú. Informe de reunión del grupo de expertos en plantas medicinales. (Lima, 19 de marzo del 2018). OPS, Lima, Perú.

Otzen T, Manterola C. 2017. Técnicas de muestreo sobre una población a estudio. International Journal of Morphology 35(1):227-232.

Paniagua-Zambrana N, Macía MJ, Cámara-Leret R. 2010. Toma de datos etnobotánicos de palmeras y variables socioeconómicas en comunidades rurales. Ecología en Bolivia 45(3):44-68.

Passos BG, de Albuquerque RDDG, Muñoz-Acevedo A, Echeverria J, Llaure-Mora AM, Ganoza-Yupanqui ML, Rocha L. 2022. Essential oils from *Ocotea* species: Chemical variety, biological activities and geographic availability. Fitoterapia 156:105065.

Pastor Cabanillas ME. 2019. Contenido de flavonoides totales de los frutos de *Gaultheria myrsinoides* Kunth "macha macha" y *Vaccinium floribundum* Kunth "mortillo". Thesis, Universidad San Pedro.

Pérez Sierra H, Ramírez Zegarra R, Cieza Zevallos J. 2016. Factores asociados a hiponatremia adquirida en la comunidad. Revista Médica Herediana 27(2):89-95.

Reyes-Munguía A, Carrillo-Inungaray ML, Carranza-Álvarez C, Pimentel-González DJ, Alvarado-Sánchez B. 2016. Antioxidant activity, antimicrobial and effects in the immune system of plants and fruits extracts. Frontiers in Life Science 9(2):90-98.

Rodríguez-Hernández D. 2019. Secondary metabolites as a survival strategy in plants of high mountain habitats. Boletín Latinoamericano y del Caribe de Plantas Medicinales y Aromáticas 18(5):444-458.

Rodríguez-Silva CN, Ramirez J-K, Velasquez-Arevalo S, Villarreal-La Torre VE. 2020. Agracejo - Many species, little ethnobotanical and ethnopharmacological information. Ethnobotany Research & Applications 19:17.

Ruiz Reyes SG, Venegas Casanova EA, Valdiviezo Campos JE, Plasencia Cuba JL. 2018. Contenido de fenoles totales y capacidad antioxidante *in vitro* del zumo de "pur pur" *Passiflora tripartita* var. *mollissima* (Passifloraceae). Arnaldoa 25(3):1003-1014.

Samaniego I, Brito B, Viera W, Cabrera A, Llerena W, Kannangara T, Vilcacundo R, Angós I, Carrillo W. 2020. influence of the maturity stage on the phytochemical composition and the antioxidant activity of four Andean blackberry cultivars (*Rubus glaucus* Benth) from Ecuador. Plants 9(8):1027.

Sanjinés Asturizaga A, Øllgaard B, Balslev H. 2006. Frutos comestibles. In: Moraes M, Øllgaard B, Kvist LP, Borchsenius F, Balslev H. (eds). Botánica Económica de los Andes Centrales. Universidad Mayor de San Andrés, La Paz, Bolivia. Pp. 329-346.

Stefănescu BE, Szabo K, Mocan A, Crişan. 2019. Phenolic compounds from five Ericaceae species leaves and their related bioavailability and health benefits. Molecules 24(11):2046.

Tejedor A, Calatayud G. 2022. Tree ferns from northern Peru: confirmation of the Amotape-Huancabamba Zone as a unique biotic hotspot in the tropical Andes. Brittonia 74(1):1-17.

Torres Guevara FA. 2019. Etnobotánica y biomoléculas de especies de páramos y bosques nublados de Piura; con potencial aplicación en medicina complementaria y biocomercio. Thesis, Universidad Nacional de Trujillo.

Torres-Guevara FA, Ganoza Yupanqui ML, Suárez-Rebaza LA. 2020. Sustancias bioactivas y actividad antioxidante de frutales nativos de páramos y bosques de neblina del norte peruano. Revista Peruana de Medicina Integrativa 5(4):129-134.

Valladolid Catpo B. 2011. La fruticultura en la provincia de Ayabaca: Problemas y potencialidades. Central Peruana de Servicios, Piura, Perú.

Van den Eynden V, Cueva E, Cabrera O. 2003. Wild foods from Southern Ecuador. Economic Botany 57(4):576-603.