# Horticultural Potential of Andean Fruit Crops Exploring their Centre of Origin

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**Abstract**

**Southern Ecuador is generally acknowledged to be located in a biodiversity hot spot. Several species of agricultural and horticultural crops can be found there with a huge genetic diversity and can be found in wild or in semi-cultivated status as backyard crops. Cherimoya (*Annona cherimola* Mill.) and several species of highland papayas (*Vasconcella* spp.) have their centre of origin in southern Ecuador and are cultivated as minor fruit crops in several subtropical zones worldwide. Little research work has been carried out so far in exploring the crops' centre of origin. Germplasm collection and characterisation can give valuable information to local and international crop breeding programmes whereas a detailed study of the ecology of wild stands, may provide useful information on climate and soil preferences of the crop and can -combined with a GIS analyses- be used to locate suitable cropping areas.**

**Collection and characterisation of 137 wild and semi-cultivated cherimoya accessions was carried out in southern Ecuador between January 1996 and March 1998. A tremendous variability of pomological characteristics was encountered, typical situation of a main centre of biodiversity. The best accessions collected during these trips can easily withstand preliminary comparison with commercial cherimoya cultivars ('Fino de Jete', 'Bays', 'White', 'Bronceada' and 'Concha Lisa'). The collection of *Vasconcella* germplasm was carried out between August 1997 and April 2000. A total of 211 accessions of the common species *Vasconcella cundinamarcensis* (Solms-Laub.) Badillo, *V. stipulata* (Badillo) Badillo and *V.* × *heilbornii* (Badillo) Badillo were collected together with some accessions of the rarer species *V. candicans* (A. Gray) A.DC., *V. microcarpa* (Jacq.) A.DC., *V. monoica* (Desf.) A.DC., *V. palandensis* (Badillo et al.) Badillo, *V. parviflora* A.DC. and *V. weberbaueri* (Harms) Badillo. These accessions showed great variability and raised several questions about their exact taxonomic position. Preliminary studies of the papain content of some of these accessions showed papain activities up to 20 times higher than those of papaya (*Carica papaya* L.). Edapho-climatological conditions in the collection areas indicated the preferences of cherimoya and highland papayas in their natural environment, and were used, combined with GIS studies, to determine the potential cultivation zones.**

## INTRODUCTION

The Andean region with its striking eco-geographical contrasts is generally acknowledged as an important centre of biodiversity and is described as one of the eight centres of plant diversity as defined by Vavilov (Vavilov and Chester, 1950). Ecuador alone accounts for 16,087 plants species (Jørgensen and León-Yánez, 1999), being the highest plant diversity of the world per area unit. Within this rich plant biodiversity, several species are known as agricultural or horticultural crops. A lot of these crops however are considered as under-utilised (Izquierdo and Roca, 1998), due to "botanical colonialism" and have often been replaced by crops from Asia, Mexico and Europe

(National Research Council, 1989). Fruit species account for an important part of this under-utilised potential. Despite the immense potentials of some fruit species for exploitation at the (inter)national level, few studies have been carried out so far on such economic possibilities , especially in their centre of origin, where countries have often little research capabilities.

The aim of the current study was to evaluate the existing potential of native fruit species in southern Ecuador. Cherimoya (*Annona cherimola* Mill.) and highland papayas (*Vasconcella* spp.) are common and can be found in wild or in semi-cultivated status as backyard crops. They are however not being cultivated at commercial level.

Cherimoya is a delicious syncarpous fruit, belonging to the Annonaceae family, and is often considered as the "queen of subtropical fruits" (National Research Council, 1989). It is native to the dry inter-Andean valleys of southern Ecuador and northern Peru, at elevations ranging 1,500 – 2,600 m a.s.l. (Farré Massip and Hermoso González, 1987). Worldwide, Spain is the largest producer of this crop with a total area of 3,266 ha in 1999 (Guirardo Sánchez et al., 2001) followed by Chile (Gardiazabal and Rosenberg, 1993) and Peru (Franciosi Tijero, 1992), all possessing over 1,000 ha of cherimoya plantations. Other less important cherimoya growing countries include USA, Australia, New Zealand, Mexico, Portugal and Brazil.

Highland papayas is a general term used for species belonging to the *Vasconcella* genus, Caricaceae family, that occur at elevations above 1,500 m a.s.l., from Colombia to Chile. The genus *Vasconcella* was recently rehabilitated from a section of the *Carica* genus to the generic level (Badillo, 2000), leaving *Carica papaya* as the only *Carica* representative. Compared to their well-known tropical cousin, the papaya (*Carica papaya* L.), highland papayas tend to be smaller, less succulent, and quite different, but often very pleasant, in taste. Ecuador alone accounts for 15 of the 21 described *Vasconcella* species (Badillo, 1983, 1997; Badillo et al., 2000) and must be considered as a hot spot for *Vasconcella* research. In southern Ecuador, *Vasconcella cundinamarcensis*, *V. stipulata* and the natural hybrid between these species *V.* × *heilbornii* are common and can be found in wild and in backyard gardens. Other less common highland papayas include *V. candicans*, *V. microcarpa*, *V. monoica*, *V. palandensis*, *V. parviflora* and *V. weberbaueri.* Consumption of highland papayas is common in the Andes where fruits are eaten fresh, roasted, in juices, in marmalades or in preserves (Van den Eynden et al., 1999). Only babaco, *V.* × *heilbornii* 'Babaco', is already commercially developed. It was introduced as a new crop in New Zealand in 1973 (Harman, 1983) from where it spread in the eighties to Australia (Cossio, 1988), Italy (Ferrara et al., 1993), Spain (Merino Merino, 1989), France (CTIFL, 1992), South Africa (Wiid, 1994) and even Switzerland (Evéquoz, 1990) and Canada (Kempler et al., 1996) where greenhouse trials are being currently pursued.

This study aimed at showing the potential of these native fruit crops. A study of the existing pomological variability in a centre of biodiversity gives valuable information to select potential accessions for future cultivation and/or breeding programmes. An edapho-climatological study of the targeted fruit species in their natural habitat has provided in fact valuable information on their soil and climate preferences which can - combined with GIS- be used to establish potential cultivation zones. A study of the papain content of highland papayas shows an even broader perspectives for the exploitation of *Vasconcella* species.

## RESULTS AND DISCUSSION

A collection and characterisation of 137 wild and semi-cultivated cherimoya accessions was carried out in southern Ecuador between January 1996 and March 1998. A large variability of pomological characteristics was encountered, typical for a centre of biodiversity (Scheldeman and Van Damme, 1999). A selection of the best accessions, based on low seed content showed that local accessions easily withstand preliminary comparison with commercial cultivars from Spain ('Fino de Jete'), United States ('Bays' and 'White') and Chile ('Bronceada' and 'Concha Lisa') (Scheldeman et al., 1999). Locally selected cherimoya accessions clearly show higher fruit weight and lower seed

index (number of seeds/100 g fruit) than the commercial cultivars as tested in germplasm characterisation trials realised at the Experimental Station "La Mayora" in Malaga, Spain (Morales, 1993) (Fig. 1 & 2). A collection and characterisation of 211 *Vasconcella* accessions was carried out in southern Ecuador between August 1997 and April 2000. Besides an enormous variability (Scheldeman et al., 2001) the germplasm collection revealed big problems in identifying some collected *Vasconcella* accessions with the existing identification tables. A new *Vasconcella* species was described (Badillo et al., 2000), while some accessions as yet remain undetermined and could be new species as well. Genetic characterisation of the different accessions was carried out using AFLPs. Preliminary results confirm the presence of a very large intraspecific genetic diversity, showing considerable introgression, and confirming furthermore the presence of a newly undescribed species among the material collected (Van Droogenbroeck et al., 2001).

A study of edapho-climatological conditions of wild cherimoya stands at 20 sites, and of wild and semi-domesticated *Vasconcella* species (*V. cundinamarcensis*, *V. stipulata* and *V.* × *heilbornii*) at 24 sites indicates the climate and soil preferences of cherimoya and highland papayas in their natural environment. Using highest frequencies, optimal soil and climate conditions were determined (Table 1). An adaptation of FAO's "Simple Limitation Method" (Sys et al., 1991), combined with a GIS analyses, can be used to determine potential cultivation zones (Bydekerke et al., 1999).

Highland papayas are generally acknowledged to have high papain activities (National Research Council, 1989), although concrete data are scarce. A preliminary papain analysis of some Ecuadorian *Vasconcella* species indeed revealed a very high proteolytic activity (Table 2), especially when compared to *Carica papaya*, currently used for papain extraction. Particularly, some varieties of *V.* × *heilbornii* and *V. stipulata* show promising papain activity levels. Nevertheless, caution is warranted, as no results about exact enzymatic composition nor actual yields are currently available.

## CONCLUSIONS

Despite numerous studies on subtropical fruits, including cherimoya, little research has focused so far on the fruits' centre of origin. This centre of origin is often located in remote areas of underdeveloped countries, complicating considerably the research work. Long term investigation on minor Andean fruit crops in southern Ecuador, shows that there exists a big potential of unknown fruit varieties or even new species. Local cherimoya accessions prove to easily withstand a preliminary comparison with commercial cultivars while it is clear that the potential of *Vasconcella* species have not fully been exploited yet. A crop's centre of origin also offers the unique possibility of assessing both climate and soil conditions using edapho-climatological data obtained from wild or semi-domesticated stands, which can be used to select the best cultivation zones at national and even at international level.

In spite of the wide array of economic potentials offered by these species, the present problem of the Andean fruits studied in one of the hot spots of diversity is one of increasing threat. As human population increases, so does pressure on land, resulting in deforestation and loss of wild stands. The shift of cultivation systems towards cash and food crops results in a neglect particularly of native fruit crops, which do not show immediate large economic returns. Considering the existing unexploited potentials it is clear that there is an urgent need for intensified research for promoting these species combined with serious conservation measures.

More information on this study, including photographs of varieties and species can be found at http://allserv.rug.ac.be/~xschelde/start.htm.

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**Literature Cited**

Badillo, V.M. 1983. Caricaceae. In: Harling G. and Sparre B. (Eds.). Flora of Ecuador No. 20. Göteborg University, Göteborg, Sweden. 48 pp.

Badillo, V.M. 1997. Neotipificación de *Carica pubescens* Lenné et Koch y de *Carica quercifolia* (St. Hil.) Hieron y nuevos regitros de la familia para Ecuador. Ernstia 6:201-205.

Badillo, V.M. 2000. *Carica* L. vs. *Vasconcella* St.-Hil. (Caricaceae) con la Rehabilitación de este ultimo. Ernstia, 10: 74-79.

Badillo, V.M., Van den Eynden, V. and Van Damme, P. 2000. *Carica palandesis* (Caricaceae), a New Species from Ecuador. Novon 10: 4-6.

Bydekerke, L., Scheldeman, X., Van Ranst, E. and Van Damme, P. 1999. Edaphoclimatological Study of Cherimoya (*Annona cherimola* Mill.) in Loja Province, Southern Ecuador. Acta Hort. 497, 71 - 80.

Cossio, F. 1988. Il Babaco. Edizioni Calderini Edagricole, Bologna, Italy. 60 pp.

CTIFL. 1992. Nuevas Especies Frutales. Ediciones Mundi-Prensa. Madrid. Spain. 164 pp.

Evéquoz, N. 1990. Premiers Résultats d'un Essai de Culture de Babaco. Revue Suisse Vitic. Arboric. Hortic. 22 (2): 137-141.

Farré Massip, J.M. and Hermoso González, J.M. 1987. Informe del viaje de exploración sobre la chirimoya realizado a Ecuador y Peru entre el 1 de abril y el 15 de mayo de 1987. Estación Experimental "La Mayora". Malaga, Spain, 16 pp.

Ferrara, E., Barone, F., Calabrese, F., D'Ascanio, R., De Michele, A., Giorgio, V., Martelli, S., Monastra, F. and Nieddu, G. 1993. Babaco (*Carica pentagona* Heilb.). L'Informatore Agrario XLIX (1): 41-47.

Franciosi Tijero, R.F. 1992. El cultivo del chirimoyo en el Perú. Ediciones Fundeagro. Lima, Perú. 108 p.

Gardiazabal, F. and Rosenberg, G. 1993. El cultivo del Chirimoyo. Universidad Católica de Valparaíso. Facultad de Agronomía. Valparaíso, Chile. 145 pp.

Guirardo Sánchez, E., Hermoso González, J.M., Pérez de Oteyza, M.A, García-Tapia Bello, J. and Farré Massip, J.M. 2001. Polinización del Cherimoyo. Consejería de Agricultura y Pesca. Spain. 45 p.

Harman, J.E. 1983. Preliminary Studies on the Postharvest Physiology and Storage of Babaco Fruit (*C.* × *heilbornii* Badillo nm. *pentagona* (Heilborn) Badillo). New Zealand Journal of Agricultural Research 26: 237-243.

Izquierdo, J. and Roca, W. 1998. Under-utilized Andean Food Crops: Status and Prospects of Plant Biotechnology for the Conservations and Sustainable Agricultural Use of Genetic Resources. Acta Hort. 475: 157-172.

Jørgensen, P.M. and León-Yánez, S. 1999. Catalogue of the Vascular Plants of Ecuador. Missouri Botanical Garden Press, St. Louis. 1181 p.

Kempler, C. and Kabaluk, T., 1996. Babaco (*Carica pentagona* Heilb.): A Possible Crop for the Greenhouse. Hortscience 31(5): 785-788.

Merino Merino, D. 1989. El Cultivo del Babaco. Ediciones Mundi-Prensa, Madrid, Spain. 87 pp.

Morales, L.M. 1993. Descripción pomológica y análisis de componentes del fruto en una colección de cultivares de chirimoya. Escuela Universitaria de Ingeniería Agrícola Sevilla. Tesis. Sevilla, Spain, 233 pp.

National Research Council, 1989. Lost Crops of the Incas. Little-Known Plants of the Andes with Promise for Worldwide Cultivation. National Academy Press. Washington D.C., USA. 415 pp.

Sanewski, G. 1991. Custard apples, cultivation and crop protection. Queensland Department of Primary Industries. Brisbane, Australia, 103 pp.
Scheldeman, X., Ureña, V. and Van Damme, P. 1999. Collection and characterization of cherimoya (*Annona cherimola* Mill.) in Loja province, Southern Ecuador. Acta Hort. 497: 153-161.
Scheldeman, X. and Van Damme, P. 1999. Promising cherimoya (*Annona cherimola* Mill.) accessions in Loja province, Southern Ecuador. Acta Hort. 497: 173-180.
Scheldeman, X., Romero, J. and Van Damme, P. 2001. Highland papayas in Southern Ecuador: need for conservation actions. Acta Hort. In Press.
Sys, C., Van Ranst, E. and Debaveye, J. 1991. Land evaluation. Principles in land evaluation and crop production calculations. Agricultural Publications n° 7. Brussels, Belgium, 274 pp.
Van den Eynden, V., Cueva, E. and Cabrera, O. 1999. Plantas Silvestres Comestibles del Sur del Ecuador – Wild Edible Plants of Southern Ecuador. Ediciones Abya-Yala. Quito, Ecuador. 221 pp.
Van Droogenbroeck, B., Breyne, P., Goetghebeur, P., Romeijn-Peeters, L. Kyndt, T. and Gheysen, G. 2001. AFLP Analysis of Genetic Relationships among Papaya and its Wild Relatives (Caricaceae) from Ecuador. Theor. Appl. Genet. Submitted.
Vavilov, N.I. and Chester, K.S. 1950. The origin, variation, immunity and breeding of cultivated plants. Chronica Botanica. New Series of Plant Science Books 13. Chronica Botanica Co. Waltham, Massachusetts, USA. 364 p.
Wiid, M., 1994. Aanpasbaarheid van Babako in Subtropiese Gebiede. Instituut vir Tropiese en Subtropiese Gewasse Inligtingbulletin 15(12), 17-19.

## Tables

Table 1. Most frequent edaphoclimatological conditions at wild and semi-domesticated stands of *Annona cherimola* and some *Vasconcella* species in southern Ecuador.

| | Avg. Mean Temp. (°C) | Avg. Ann. Prec. (mm) | Soil Texture* | Soil pH | Org. Matter. (%) |
|---|---|---|---|---|---|
| *A. cherimola* | 16 – 20 | 800 – 1,200 | SaL, L, SaCL | 5 – 6.5 | 1 – 5 |
| *V. cundinamarcensis* | 12 – 14 | 900 –1,000 | SaL, SaCL | 4.5 – 6 | 3 – 6 |
| *V. stipulata* | 14 – 18 | 1,000 – 1,300 | CL, C | 4 – 7 | 4 – 8 |
| *V. × heilbornii* | 12 - 18 | 700 – 1,200 | SaL, L, CL, C | 3 - 7 | 5 – 7 |

* USDA Classification : SaL : Sandy Loam; L : Loam; SaCL: Sandy Clay Loam; C : Clay; CL : Clay Loam

Table 2. Papain activity in Ecuadorian *Vasconcella* species.

| Species | Papain Activity (mU BAPA/mg dried latex) |
|---|---|
| *Carica papaya* (reference) | 10.4 |
| *Vasconcella* × *heilbornii* 'Babaco' | 38.1 |
| *V.* × *heilbornii* var. *chrysopetala* | 127.6 |
| *V. stipulata* | 129.4 |
| *V. cundinamarcensis* | 57.0 |
| *V. monoica* | 55.1 |

## Figures

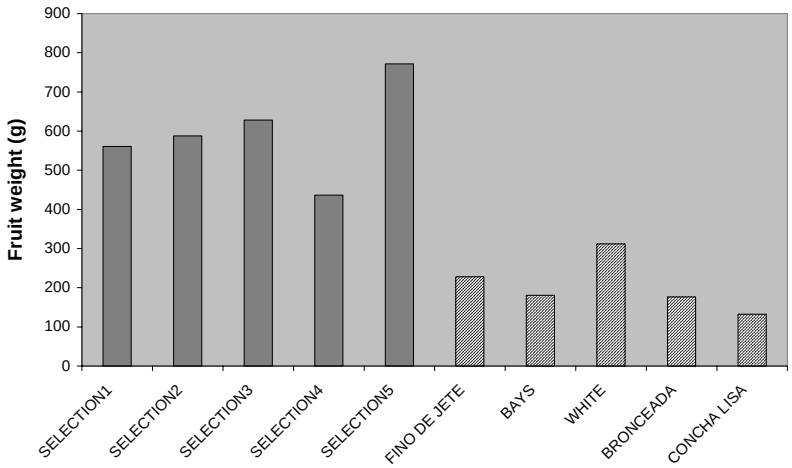


Fig. 1. Comparison of fruit weight between local selected accessions and commercial cultivars.

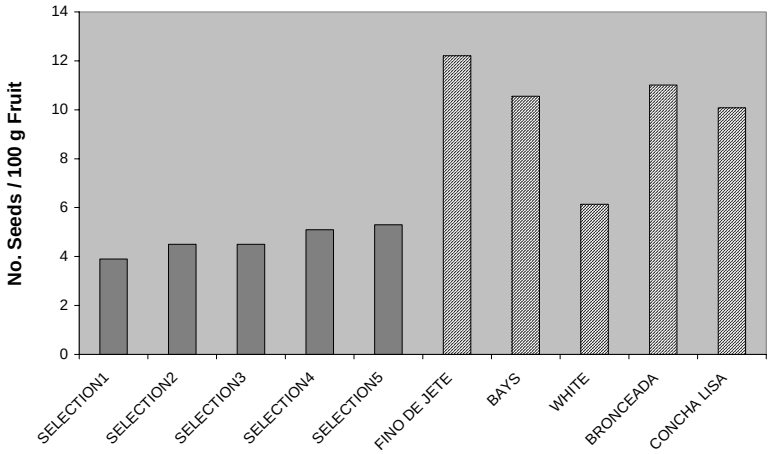


Fig. 2. Comparison of seed index between local selected accessions and commercial cultivars.