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History of Tomato Cultivation in Chile: The Limachino Tomato Case*

Historia del cultivo del tomate en Chile: el caso del tomate Limachino

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Abstract

Landraces play an important role in agricultural sustainability, food security and the future crop improvement. Systematic information about agricultural evolution of crops is crucial for the implementation of effective conservation and utilization strategies. Unlike Europe and North America, historical data of crops is less complete in other parts of the world, especially for regions where high diversity of crop genetic resources, such as Chile. In order to contribute to the understanding of Chilean genetic resources dynamics and their conservation, we present the case of tomato landraces, particularly the *Limachino* tomato. Through an extensive literature review, an overview is presented regarding the tomato origin and diversification, *in situ* conservation status, the role of the genetic resource's units and the importance of the integration of the small-scale commercially-oriented tomato farmers in the modern Chile to advance towards a more effective and sustainable landraces conservation.

Keywords *Solanum lycopersicum*, landraces, Limache, *in situ* conservation, Chile.

Resumen

Las variedades locales juegan un papel importante en la sostenibilidad agrícola, la seguridad alimentaria y la futura mejora de los cultivos. La información sistemática sobre la evolución agrícola de los cultivos es crucial para la implementación de estrategias efectivas de conservación y utilización. A diferencia de Europa y América del Norte, los datos históricos de cultivos son menos completos en otras partes del mundo, especialmente en regiones donde existe una gran diversidad de recursos genéticos de cultivos, como Chile. Con el fin de contribuir a la comprensión de la dinámica de los recursos genéticos chilenos y su conservación, se presenta el caso de las razas de tomate, en particular del tomate Limachino. A través de una extensa revisión bibliográfica, se presenta un panorama sobre el origen y la diversificación del tomate, el estado de conservación in situ, el papel de las unidades del recurso genético y la importancia de la integración de los pequeños productores de tomate con orientación comercial en el Chile moderno para avanzar hacia una conservación más eficaz y sostenible de las variedades locales.

Palabras clave: *Solanum lycopersicum*, variedades locales, Limache, conservación *in situ*, Chile.

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Background

The tomato (*Solanum lycopersicum var. lycopersicum*) is the most cultivated vegetable worldwide. The anthropogenic cultivation of tomatoes has proven an increment in its productivity and a reduction of its genetic diversity. A combination of natural self-pollination, small natural population size, natural selection, and early breeding, have generated multiple bottlenecks during the centuries of tomato cultivation (Rick, 1958; Rodríguez *et al*., 2011). In tomatoes, as in several cultivated species, genetically uniform varieties developed by breeding programs were adopted at the beginning of the XX Century, replacing the farmer's varieties, often called landraces. The adoption of these varieties allowed the maximization of yield when associated with irrigation, fertilization, pest control, and mechanization, gathering the high-quality standards required by the markets. In several crops, the process of development of new varieties has been based on a limited number of breeding lines with good performance as parental lines, named elite lines (Fischer *et al*., 2014). Although this strategy allowed substantial genetic gains in terms of yield, this rate of growth will decline if the gene pool is not broadened. In general, the improvement of new varieties is originated by the introduction of foreign plant material, corresponding to a wild relative or a landrace. In the case of tomato, the use of the wild relative *Solanum pennellii* to lift the yield barrier of tomatoes achieved an increment of more than 50% (Gur and Zamir, 2004).

The local varieties or landraces are a product of social process of adaption of cultigens to local territories agroecological conditions done by farmers (Casañas *et al.,* 2017). Traditional agriculture generated and continues to generate a wide range of local varieties with specific adaptions to certain environments, with distinctive morphological, organoleptic, nutritional and nutraceutical characteristics. Landraces of all the crop species have been estimated up to hundreds of thousands. The replacement of traditional varieties with more genetically uniform, modern varieties with better yields has caused the genetic erosion of crops cultivars around the world. The loss of genetic diversity reduces the potential for modern crops to adapt to, or be bred for, changing conditions—and so directly threatens long-term food security and climate change adaptability. But also reduces the possibility of small farmers to compete and subsist under a high-input agricultural model.

Agricultural evolution of Europe and North America is fairly well described, and it has been crucial for the implementation of comprehensive conservation methods. Unfortunately, historical data for agricultural evolution are less complete for other parts of the world, especially for regions with high diversity of crop genetic resources are found, such as Chile.

In Chile, tomatoes are the most important vegetable for the family market basket, ranking second in land cultivated with vegetables. The central valley of the country concentrates 69% of the surface for fresh tomato, comprehending the geographic area between the regions of Valparaíso and Maule (ODEPA, 2015). Among national territories the valley of Limache located in the Valparaíso region was historically known for its local *Limachino* tomato, which now is almost extinct. In several cases, the rescue of landraces is promoted after recovering part of the history and culture of the territories. This has been reported in tomato landraces such as San Marzano of the Sarno valley, Tomàtiga de Ramellet and Tomàtiga de Penjar from the Balearic Islands, as in other horticultural crops, or like the case of *gourgane* in the Sanguenay – Lac-Saint-Jean region (Gade, 1994). Culture that in the last half-century, have been left behind by modernity.

The case of Limache can be an important step forward in the recognition and consolidation of the Chilean agricultural culture, as an integration example of territories tradition in nowadays Chilean markets. In order to contribute to the understanding of Chilean genetic resources dynamics and to their conservation, we present the case of evolution and maintenance of tomato landraces by Chilean farmers, particularly the *Limachino* tomato. We reconstruct the historical origin of the *Limachino* tomato, as part of the history of transcontinental dissemination of food plants in the pre-Columbian and post-Columbian periods. Emphasizing in the empirical basis provided by molecular techniques in the dissemination history of cultivated tomatoes. For this, under a critical heuristic system available historical background is reviewed, and an argument for an origin is formulated. Finally, our work appreciates the social role that farmers and social agencies have in the landrace's conservation.

Domestication syndrome and diversification

Domestication of plants and animals at the dawn of civilization is the source of nowadays alimentation. The process of domestication was developed independently in nine geographic areas worldwide: Mesopotamia, China, Mesoamerica, Andes-Amazonia, East of the United States, Sahel, East Africa, Ethiopia, and Nueva Guinea. In the Andes being domesticated the quinoa, large lima bean, peanut, potato, and pumpkin. Plus, this region has also been postulated as the origin of the tomato. Even though is not clear if the domestication took place in Mexico or the Andes. Evidence of botanical, linguistic and historical aspects exist for both hypotheses. But the archaeological evidence is unclear to support either one (Rodríguez *et al.*, 2011). The most probable wild ancestor is *Solanum pimpinellifolium*, being the cherry tomato (*Solanum lycopersicum* var. *cerasiforme*) a mid-form from *Solanum lycopersicum* var. *esculentum* varieties and *S. pimpinellifolium* (Nesbitt and Tanksley, 2002), with the domestication process later derived in the current tomato (*Solanum lycopersicum* var. *lycopersicum*). All these species are registered in the Andes region, adding to the evidence of an Andean origin. But the isolation from the Andes to Central America has been postulated as part of the domestication process.

Domestication is a man-driven process that is a type of species diversification, sometimes referred to as the improvement phase. The traits that the domesticated plants possess different from their ancestors are commonly called the domestication syndrome. Domestication is associated with multiple morphological and physiological characteristics changes in the plant. These modifications in a great number of cultivated plants are controlled by a rather small number of genes. Similar characters in tomato, red pepper, and eggplant, are controlled by shared loci, showing that a few genes are responsible for drastic changes in the phenotype.

The tomato most important characters of the domestication syndrome are the weight and shape of fruits and seeds. The shape and weight of the tomato seed, even though is not the main edible part, have seen an increment associated with a need for uniform germination and seedling vigor. In terms of fruit, the wild ancestor had a red fruit of just a couple of centimeters diameter, round and with two locules. The increase in the fruit size and weight has been proposed as a process that involves two sets of loci. A first group would explain the size increase between *Solanum pimpinellifolium* and *Solanum lycopersicum* var. *cerasiforme*, and a second group the increase between *S. lycopersicum* var. *cerasiforme* and *S. lycopersicum* var. *lycopersicum*. In the second group, *fw*2.2 gene is the main component, repressing the process of cellular division during fruit development. A change in the promoter sequence of this gene has been associated with a reduction in the expression during fruit cellular division and expansion process, making it one of the principals responsible for the increased weight and volume of the current tomato fruit (Nesbitt and Tanksley 2002). The fruit shape and the number of locules are quantitative characters, mainly controlled by four loci: *sun*, *ovate*, *fasciated* (*fas*), and *locule number* (*lc*) (Figure 1). The expression of *sun* is a positive regulatory protein of the fruit growth, generating an elongated fruit. While *ovate* is a negative regulator of the growth, conditioning the fruit elongation, associated with the pear, heart, and ellipsoid shapes. The loci *fas* express a YABBY transcription factor, and when these loci got less expression a greater number of fruits loculi are generated. And last, *lc* express a WUSCHEL protein, which is responsible for the cellular destination. Most of the round tomatoes and the wild species have not modified alleles of the four loci. The *sun* loci, unlike *fas*, *ovate* y *lc* is not presented in any of the subspecies *cerasiforme* o any of the Latin American varieties. Its origin has been associated with an event outside of this region. The loci *ovate,* on the other hand, would have had an independent origin. A pear shape tomato was not described in Europe until Dunal in 1813, being the first tomatoes described in the XVI century probably bearers of the *fas* and *lc* mutations (Rodríguez *et al.*, 2011).

History of the tomato growing

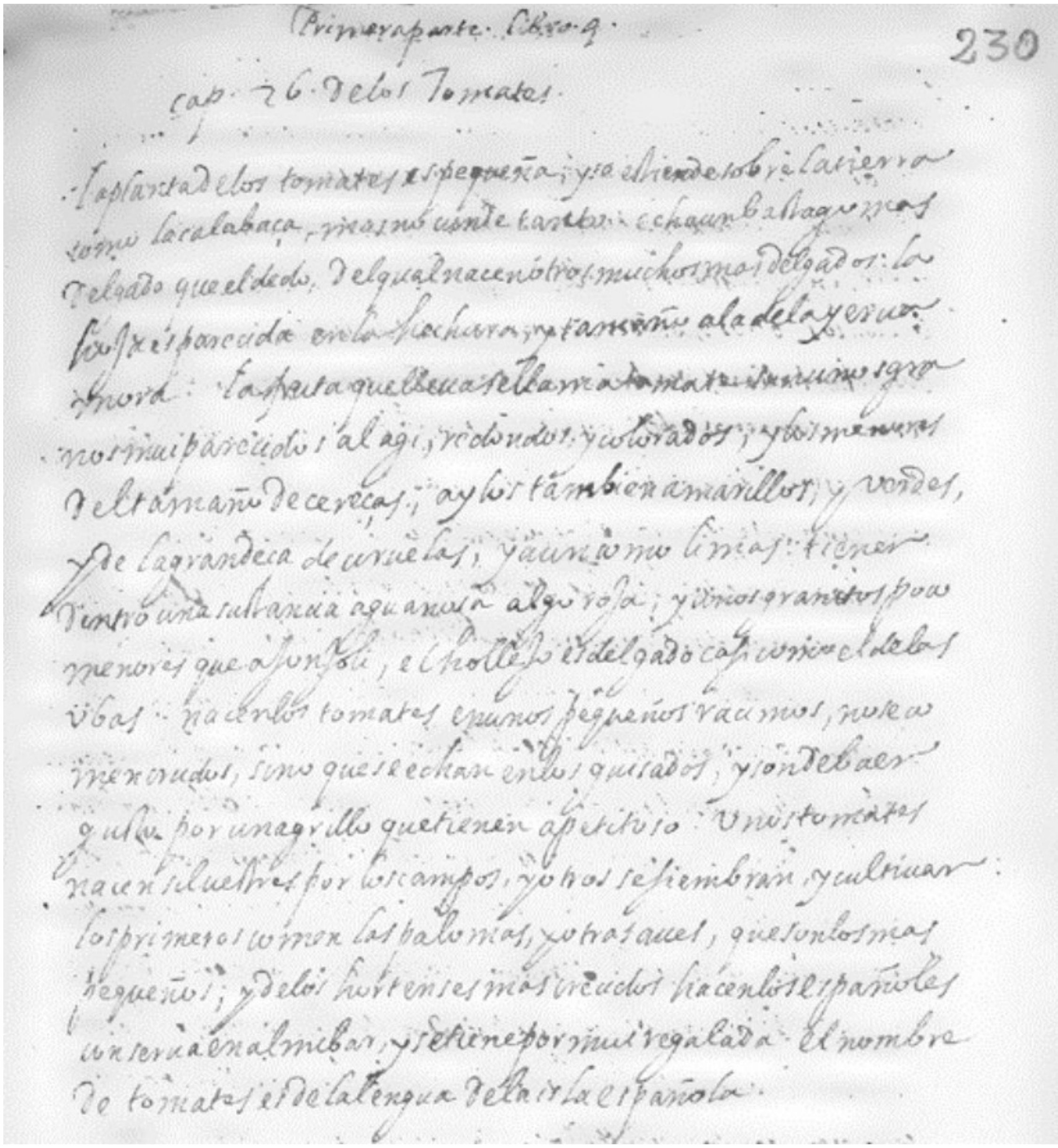
Introduced at the beginning of the XVI century in Europe, the tomato was not consumed until the XVII century, because the fright to the presence of alkaloids. The first botanical descriptions made in Europe were made by in 1543 by Oellinger and in 1544 by Matthiolus, who describe it as a flat and segmented fruit. Spanish and Italian cuisine early introduced the tomato. In 1803 Brillat-Savarin, a French food historian wrote that the tomato was unknown in Paris 15 years before (1780). But to 1778, the seeds were already sold on the French catalogue of "Maison grainère Andrieux Vilmorin". The commercial cultivation of the tomato in France only started in 1860, after the phylloxera vineyard disaster. As the French wine growers could not afford to replant resistant varieties, they started the extensive tomato growing, enhanced by the development of the irrigation networks, the railroad's trains in France and the technologies of pasteurization and canning. It was mainly consumed as a fresh vegetable and as sauce. The tomato was reintroduced into America (United States) from Italy in the XVIII century. Already to 1766 there are reports of tomatoes being grown as food in the United States, and by 1784 David Landreth Seed Co. started the seed commercialization. The United States, along with Spain and Italy, became a secondary center of diversification, becoming the round and smooth tomato the standard, with the other morphotypes relegated as *Heirlooms* or landraces. While in Europe the ribbed and flat varieties, plus the heart, pear and elongated ones were preferred (Rodríguez *et al.*, 2011). Thus, in the United States, Peter Henderson & Co. introduced to the market in 1891 the "Henderson's Ponderosa" a big, ribbed, and pink tomato, of the "Beefsteak tomato" type and Livingston Seed Co. released in 1889 the "Livingston Stone" variety, a round and smooth tomato, which was breed from local seeds collected in 1885 from Columbus, Ohio. Livingston crossed later the Ponderosa and Stone varieties, obtaining the Globe variety released in 1905. This latter variety was crossed with the Marvel variety, a ribbed tomato of French ancestors. Creating in 1925 the Marglobe, a red and round tomato, one of the most used varieties since 1930's in Chile and worldwide during the XX century (USDA, 1933; CORFO, 1967). To the end of the XIX multiple cultivars of different colors and shapes were available worldwide, being nowadays considered as landraces produced by the early breeding (Casañas *et al.*, 2017), while in Chile there is a record to 1931 of the availability of varieties from Europe and United States (Lagarde, 1931).

History of tomato cultivation in Chile

In Chile, as reported by Gay (1865), the cultivated pre-Columbian crops were potatoes, quinoa, and large lima beans. Although, their cultivated surface had already decreased to 1865, remaining only the potato as an important crop in Chile. The tomato growing was described in that period as a crop originated in Mexico, being a widely cultivated crop with a high consumption in Chile. But there is a prior report of tomato growing in Western South America. Cobo (1653) after living since 1596 in the Viceroyalty of Peru, described botanically the cultivated crops of Peru. Between the plants described by Cobo, many of them are nowadays ornamental and no longer considered as crops. The tomato was described as a widespread cultivated crop and as a wild plant (Figure 1). The wild ones were described as bearers of smaller fruits and were left to be eaten by birds. Botanically, the tomato was described as similar in terms of leaves shape and size to yerba mora, referring most probably to *Solanum nigrum* L. and what would be considered nowadays as a modification in the leaf. The fruit diversity described was wide, being the smaller ones of the size of a cherry and the biggest ones the size of a prune or a lime. Red and rounds were the most common ones, but there were also yellow and green. There have been other reports from the cultivation and consumption in America, from the XVI and XVII centuries. In Argentina, Colombia and Bolivia, the cultivation of tomatoes has been presumed as a common crop in pre-Columbian times (Patiño 2002). These historical descriptions of the tomato growing must be seen in modern terms when it comes to define the territories. The description of Claudio Gay (1865) in Chile, was made before the Pacific war, after which territories from Peru and Bolivia passed to Chile. Even more, what Bernabe Cobo (1653) described might be an image of the Viceroyalty of Peru, and not from Peru only. The Viceroyalty of Peru comprehended the territories of the current Peru, Argentina, Uruguay, Paraguay, Bolivia, Colombia, Chile, Panamá, and Ecuador. The title of Cobo's work, *Historia del Nuevo Mundo* (History of the New World), indicate that he might be describing many territories of America, the new world.

Figure 1. Extracted text of Cobo (1653), tomato chapter describing the cultivated tomato in the Viceroyalty of Peru

Figura 1. Extracto del texto de Cobo (1653), capítulo del tomate describiendo el tomate cultivado en el Virreinato del Perú


Primera parte. Libro 9 230
cap. 26. De los Tomates.
La planta de los tomates es pequeña, y se estiende sobre la tierra
como la calabaça, mas no crece tanto; echa un bastago menos
delgado que el dedo, del qual nacen otros muchos mas delgados: la
hoja es parecida en la hechura, y tamaño a la de la yerva
mora: la fruta que lleva se llama tomate; son unos gra-
nos mui parecidos al agi, redondos y colorados; y los menores
del tamaño de cereças; ay los tambien amarillos, y verdes,
de la grandeça de ciruelas, y aun como limas: tienen
dentro una sustancia aguanosa algo roja; y unos granitos
menores que ajonjoli, el hollejo es delgado casi como el de las
uvas. nacen los tomates en unos pequeños racimos, no se co-
men crudos, sino que se echan en los guisados, y son de buen
gusto por un agrillo que tienen apetitoso. Unos tomates
nacen silvestres por los campos, y otros se siembran, y cultivan:
los primeros comen las palomas, y otras aves, que son los mas
pequeños; y de los hortenses mas crecidos hacen los españoles
conserva en almibar, y se tiene por mui regalada. El nombre
de tomates es de la lengua de la isla española.

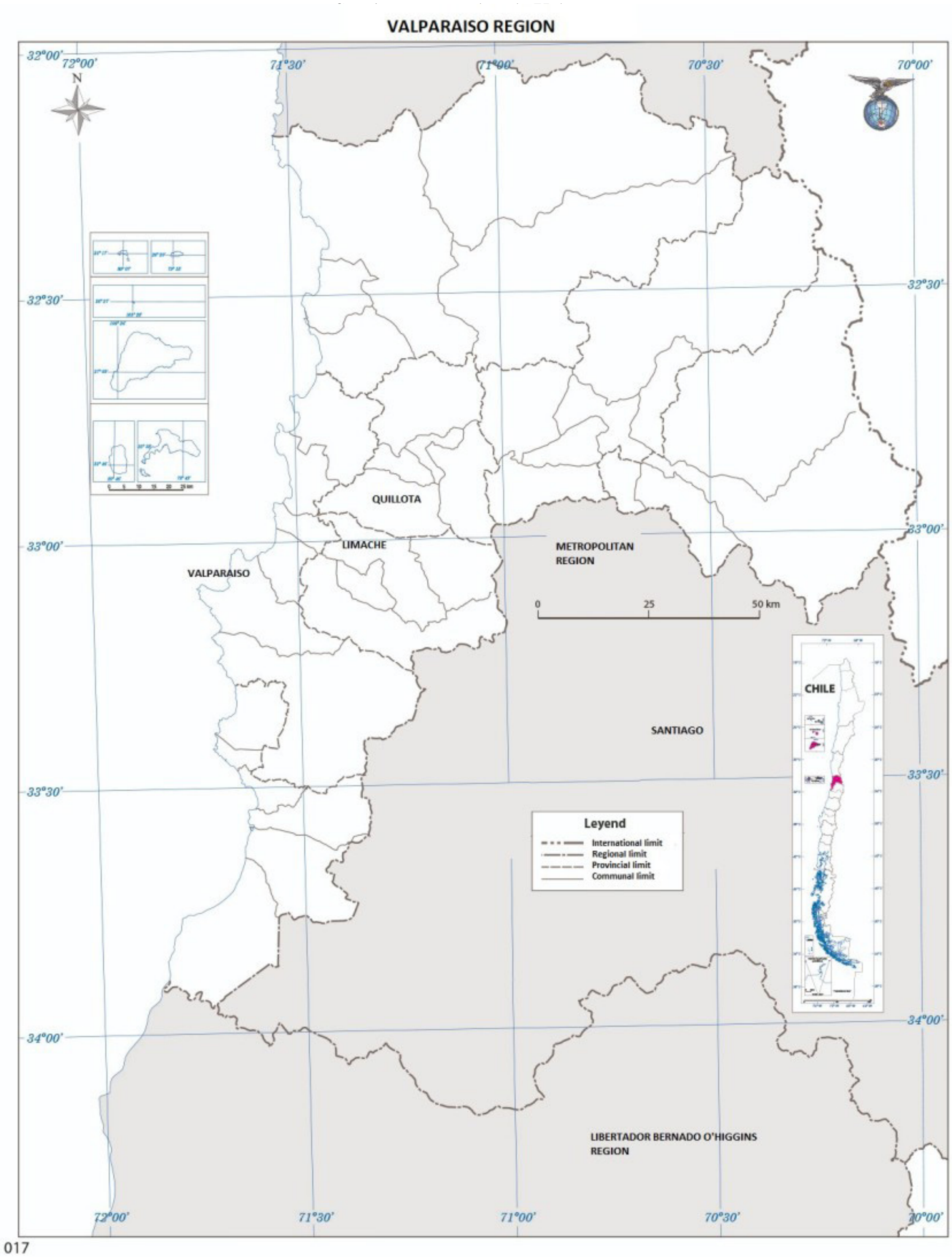
Source/fuente: Cobo, 1653.

On the other hand, the modified leaf mentioned by Cobo (1653) is possible referring to the *Lanceolate* (*La*) mutation, and not to the *potato leaf* (*c*). Lanceolate leaf is characterized as a simple, entire, elongated leaf, much smaller than potato and entire leaf. When the Lanceolate leaf type cultivars undergo the initiation of the setting and ripening of fruits, leaves with a bigger terminal leaflet and fewer secondary leaflets appear. This leaf type has been referred to as discovered in a primitive tomato cultivar in Peru. Rick (1958) already pointed out that: "Races of cultivated tomatoes *(Lycopersicum esculentum Mill.)* from the main area of distribution of the genus—Ecuador, Peru and Chile—have attracted remarkably little attention", showing higher rates of cross-pollination with hybridization with *S. pimpinellifolium* L. But the hybridization with the other species of the *Lycopersicum* clade may not be discarded, because of the enormous variation in the cultivated tomatoes of Ecuador, Peru, and Chile to 1958 reported by Rick. The emergence of the tomato landraces in the Western South America, was hypothesize by Rick (1958) as an introduction from a Marmande-type and San Marzano, with natural occurring introgressions with the local material, probably taking place in post-Columbian times. Tomato collection in Chile date back to 1938. Unpublished morphological and molecular data shows in old Chilean tomato landraces, a difference towards old varieties from United States, France, and Italy, being old Limache landraces highly diverse in phenotype and genotype. Stehberg and Sotomayor (2012) have recently brought new historical insight to the Inca settlement in the Mapocho valley, providing empirical evidence of the existence before the Spanish founding of Santiago a well develop agriculture with irrigation systems, silver, and gold mining. Where the center of Santiago, Chile would have been part of the Andes complex agriculture in the pre-Columbian period.

The historical progress of the Chilean census is difficult to analyze due to the constant change of geopolitical divisions inside the country. Efforts to create a Chilean National Agricultural Census started between 1919 and 1928. But was not until the II National Agricultural Census (1930), that a systematic census was made, following the guidelines of the International Institute of Agriculture from Rome. The Chilean territory was organized into a small number of Provinces, but the territory associated with each Province changed many times, being created more divisions continuously. During 1974 thirteen Regions were established to cluster the Provinces, in 2007 and 2017 two and one more Regions were created, respectively. Nowadays fifty-five Provinces exist but must not be confused with the ones from the early XX century. A more stable geopolitical division in Chile is the communes, which are the smallest territory subdivisions. To compare the census of different years more comprehensively the Provinces must be grouped as the nowadays Regions. In 1930 the tomato growing was concentrated from the central valley to the northern frontier, comprehending 884 ha (Table 1) mainly to the north of Santiago. The varieties recommended in 1931 to be used in the central valley of Chile for early harvest were Reina temprana, Rey de los tempranos, Chemín, Favourite, Frisé hatif de París, Rey Humberto (Cocogallo), and Tomate Crespo chico. For regular harvest, Perfección, Trophy, Duke of York, Beauty, Ponderosa and Merveilles des Marché, among others. And for late harvest Marglobe, El Mikado grande, Enormous, Ponderosa, Champion, Mikado Amarillo, New King from Chicago, Mervelosa, and others. These varieties were purchased from English, French, German, Belgian, and American catalogs. (Lagarde, 1931). In 1955 Coquimbo Region along with Valparaíso and Metropolitana Region, had an important increase in the land dedicated to tomato growing. In the case of the Coquimbo Region, the communes of Vicuña (168 ha.), Monte Patria (103 ha.) and Combarbalá (79 ha.) started to make a significant contribution, displacing Coquimbo commune which in 1930 was the main tomato growing commune in that region. In Valparaiso was Quillota the main tomato producer commune. Limache (Figure 2) only registered 34 ha with tomatoes in 1933, which meant less than 4% of the total national tomato cultivated surface. Between 1955 and 1965, Limache established itself as a main tomato-growing territory, reaching in 1965 a total of 11% of the surface dedicated to tomato cultivation (589 ha), being the main tomato growing commune in the country (INE, 1933, 1955, 1969). Meanwhile, inside the Metropolitana Region to 1965, Quilicura was its main tomato growing-commune.

Figure 2. Limache commune is valley 80 km to the northwest of the Santiago Metropolitan Region and 40 km from Valparaíso

Figura 2. La comuna de Limache es un valle ubicado a 80 km al noroeste de la Región Metropolitana de y



Source: modified from IGM, 2018. Fuente: modificado de IGM, 2018.

In 1965 the tomato was still grown only north of Santiago with 5,224 ha (INE, 1933; INE, 1969). In 1967 the Production Development Corporation (CORFO, in its Spanish acronym) published *Adaptabilidad de variedades de tomates conserveros*, a study developed by the Agricultural Research Institute (INIA, in its Spanish acronym) and the Chilean Universities. Based on this work a tomato industry for preserves and concentrates was installed in Malloa commune located in the southern Libertador Bernardo O'Higgins Region. Growers started using canning tomato varieties evaluated by CORFO, open-pollinated varieties, and other varieties with good behavior in California. With the evaluation of the industrial tomato carried out by CORFO, new localities of Libertador Bernardo O'Higgins Region were incorporated, establishing the communes of Rengo and Rancagua as the areas with the most potential for industrial tomato cultivation due to the higher yield in soluble solids. Later, other communes of Central Chile, like Maipu, Hijuelas and Quillota were also prospected as communes adequate for the tomato concentrate industry (CORFO, 1967), explaining the actual tomato cultivation area to the year 2007 (Table 1).

Until the mid of 1970 decade, in Valparaiso Region, the Limachino tomato (Figure 3) was a historically grown tomato for fresh consumption, cultivated as an option to Marglobe and Rutgers, because it was a very early variety. For the industry Roma, Napoli and San Marzano were historically used in Chile. Early standard varieties, for fresh market, as Packmor, Earlypack 7, Petoearly were named, while Calace (Cal-Ace) and Ace 55VF were available as standard varieties since the end of 1960. The hybrids used were Duke, Count and Baron, plus GS-12, an early variety that could be used for the industry or fresh consumption. Marmande was the standard tomato variety used on greenhouses, along with the hybrids Carmelo, Robin, 6718, 7718, Camilo, Tito, and Dona. Commercial varieties available to 1986 were divided between the standard varieties and the hybrids, with many varieties named to the end of 1960 still in use. Among the tomato varieties reported for the industry in 1986 were Petoearly, UC82B and Petomech II, plus the hybrids GS-12, Peto 9889 and Nema 1400. The cherry tomatoes were also grown commercially in the country, using the varieties Small Fry, Red Cherry and Sweet 100 (CORFO, 1986).

Table 1. Historical tomato surface cultivated in Chile by territory (INE, 1933, 1955, 1969, 2007)

Table 1. Superficie histórica de tomates cultivados en Chile por territorio (INE, 1933, 1955, 1969, 2007)

Territory Región	Comuna	Cultivated land (ha.)			
		1930	1955	1965	2007
Región de Tarapacá (Provincia de Tarapacá)		**84**	**107**	**228**	**840**
	Arica	*3*	*87*	*222*	*840*
	Pisagua	*81*	*11*	*2*	*-*
Región de Antofagasta (Provincia de Antofagasta)		**0**	**0**	**11**	**0**
Región de Atacama (Provincia de Atacama)		**2**	**75**	**437**	**212**
	Copiapó	*1*	*18*	*57*	*175*
	Vallenar	*1*	*18*	*366*	*23*
Región de Coquimbo (Provincia de Coquimbo)		**77**	**506**	**829**	**358**
	Ovalle	*2*	*25*	*36*	*139*
	Vicuña	*7*	*168*	*219*	*24*
	Monte Patria	*11*	*103*	*189*	*69*
	Combarbalá	*1*	*79*	*220*	*0*
	Coquimbo	*40*	*59*	*38*	*14*
Región de Valparaíso (Provincias de Aconcagua y Valparaíso)		**382**	**1.221**	**1.719**	**1.179**
	San Felipe	*36*	*88*	*82*	*92*
	Quillota	*247*	*202*	*326*	*360*
	Nogales	*31*	*69*	*182*	*37*
	Limache	*34*	*290*	*589*	*432*
Región Metropolitana (Provincia de Santiago)		**159**	**959**	**1.504**	**1.079**
	Conchalí	*60*	*48*	*107*	*-*
	Barrancas	*23*	*58*	*211*	*-*
	Quilicura	*21*	*190*	*186*	*2*
Región de O'Higgins (Provincia de O'Higgins y Colchagua)		**21**	**86**	**174**	**1.061**
	Rancagua	*1*	*4*	*13*	*-*
	Rengo	*1*	*24*	*56*	*106*
	Requinoa	*14*	*9*	*-*	*30*
Región del Maule (Provincias de Talca y Maule)		**100**	**176**	**226**	**938**
	Talca	*18*	*82*	*102*	*31*
	Linares	*51*	*8*	*-*	*84*
	Longaví	*-*	*1*	*-*	*105*
Región del Bio Bío (Provincias de Ñuble, Concepción y Bio Bío)		**41**	**168**	**87**	**466**
	Los Ángeles	*1*	*21*	*3*	*12*
	Bulnes	*-*	*1*	*3*	*208*
Total		884	3.352	5.230	6.308

Source: own elaboration. Fuente: elaboración propia.

Figure 3. Limachino tomato fruit photographed in Limache in 2015, as part of the rescue of the local genetic resource's initiative

Figure 3. Tomate Limachino fogorafiado en Limache en 2015, como parte de la iniciativa del recate local de recursos genéticos

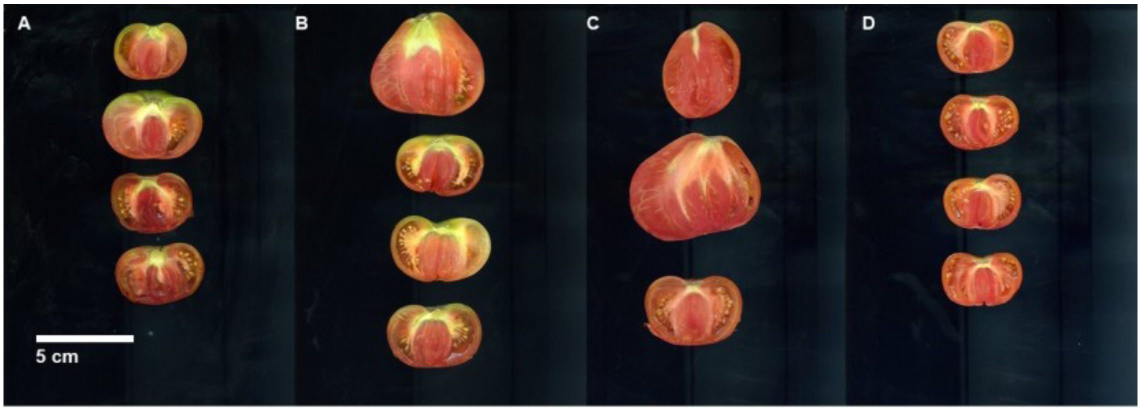
Source: photography by the author. Fuente: fotografía del autor.

History of Limache as a commune of tomato growers

The earliest records of Limache take place as a mining site, being still to 1877 known for its mines of copper, silver, gold, marble, magnets, iron, rock crystal, and other minerals; some of them being part of the estates of the commune. Limache is taken as the first native name, but to 1630 was changed to Santa Cruz. It was 29 November 1691, the population was attracted by the gold established in the territory and was officially founded under the church of San Pedro de Limache, taking this name the estate right next to the church. Most of the population was indigenous during the XVIII century. In 1776 José Sanchez-Dueñas divided the Hacienda San Pedro de Limache, onto two different estates the Hacienda San Pedro and the Hacienda Limache. It was not until 1854 that Francisco Cerda Dueñas, grandson of José Sanchez-Dueñas, founded the village of San Francisco de Limache, a twin village to San Pedro de Limache, with only the latest having a well developed irrigation system. It was Hacienda Limache, which surrounded the village San Francisco de Limache, that develop the most advanced agriculture to the time in Chile, with European vineyards, dairy, plantations and the first plantation in Chile of *Eucalyptus globulus*. After the death of the owners, José Tomas Urmeneta a Chilean senator, industrial, entrepreneur, and lawyer, acquired part of the land, subdividing it, and investing in an irrigation system for Hacienda Limache. The irrigation allowed the establishment of a vineyard of 115,000 plants, yielding 500,000 bottles of red and white wine. This generated a cluster of wineries in Limache. Hacienda Limache dairy was based on 500 half-breed cows and has a production of 1,000 walnut trees. Crops grown in the Hacienda Limache were the common ones for the region: hard wheat, legumes, and potatoes. Being the commune was considered the biggest legumes grower in Chile to 1877 (Vicuña, 1877). In the XX century, tomato cultivation began in Valparaiso Region, with Quillota and Limache recognized as historical communes in tomato production (Table 1). Quillota, with 247 hectares, was the main tomato producer in 1930, surpassing Santiago Province. During the first half of the XX century, the *Limachino* tomato, a local tomato, was the main variety cultivated in Limache, characterizing it as a tomato-growing territory. Because of its precocity, Limachino tomato arrived first in the Santiago market, competing with the tomatoes from the northern city of La Serena, which has a warmer climate. Limache with a surface of 29,380 hectares represented a greater number of growers in 1955 than Quillota (30,200 ha), with 163 growers against 63, with a smaller area per grower in respect to other tomato grower communes, making Limache a commune of multiple small-holder tomato growers. Making the origin of the Limachino tomato a social process bounded by numerous tomato growers from Limache. Nowadays Limache is the third tomato-growing commune (Table 1) (INE 1933, 1955, 1969, 2007; ODEPA, 2015).

A report from 1957 regarding the tomato growers of Limache mentioned that the cultivated land for early tomatoes was 250 hectares with a yield of 5,000 boxes per hectare (a box is nowadays of about 18 kg), being grown without any frame. The Department of National Agriculture Research of that time evaluated 50 varieties from United States, to be grown without frame. The recommended varieties in earliness order were: Early Hybrid, Early Market, Perón (from Argentina), Earliana, Scarlet Domn, Sumray, Marglobe (late for industry), Stockerdale; Limachino was the eight in the earliness order; followed by Victor, Early Chatham, Red Richard, Red Jacket y Siux, all of them from the United States, except Perón and Limachino. The creation of tomato growers' cooperatives was being implemented at the time, to avoid market weaknesses, as the brokers paid $12 Chilean pesos to the growers on field. While in Santiago, 80 km far away and historically the main market for vegetables, the early tomato price was $100 Chilean pesos (Torres, 1957). The Limachino tomato cultivation was slowly replaced since 1960, mainly for its short shelf-life and the short harvest period, associated to the summer, which affected the commercialization of the variety (Merino, 1968), until near disappearance. In 2015, a collection expedition in the Marga-Marga valley (which included Limache commune, among others), revealed that only 4 small-scale old growers maintained some seed reservoirs of this and other traditional varieties (Figure 4).

Figure 4. Tomato landraces representing the four accessions collected in 2015 at Limache commune. A. Limachino tomato (La Platina genebank ID LP2014); B. Limachino tomato (LP2015); C. Limachino italiano tomato (LP2016), and D. Limachino tomato (LP2017)
Figura 4. Tipos de tomate representando las cuatro accessiones recolectadas en 2015 en la comunda de Limache. A. Tomato Limachino (banco de genes La Platina ID LP2014); B. Tomate Limachino (LP2015); C. Tomate Limachino italiano (LP2016) y D. Tomate Limachino (LP2017)



Source: photography by the author. Fuente: fotografía del autor.

The role of the genebanks

In the absence of formal breeding, the historical events that led to the development of a landrace are the product of a social process lead by farmers within their territory (Casañas *et al.*, 2017). Moreover, landraces play a key role for the small farmers, providing security against the ever-changing climate conditions, pests, and diseases, and at the same time allowing farmers to exploit the multiple agroecosystems present in a region. It is the diversity found in landraces and wild relatives the one that has been the focus of collection and conservation via public-funded genebanks (Fischer *et al.*, 2014).

The *ex-situ* and *in-situ* conservation are the two main strategies to maintain the genetic diversity of crops. Until recently, crop genetic resource conservation has emphasized *ex-situ* methods over *in-situ* ones. Some reasons for this were the fear at the beginning of the XX century that genetic erosion was so generalized and rapid that the collection and conservation of them in genebanks should be primary, but also due to the importance given by breeding programs to *ex-situ* conservation as a genetic resource. Nowadays, the importance of complementing both conservation strategies has been established, allowing both the continuity of the population evolution and covering most of its genetic diversity (Casañas *et al.*, 2017). Nowadays, questioning related to the concentration of the stored genetic resources with minimal use and the lack of recognition of the contribution made by farmers to the conservation of these genetic resources has made relevant the need for a complementary system. The conservation and census of the wild genetic resources have been well established by a great number of countries, as well as the genetic diversity of the cultivars is sheltered by the seed companies and germplasm banks. But relegated the information gathering of the local varieties that are being and had been cultivated. Upon being the landraces one of the main elements of a crop genetic resources, understanding the *in situ* crop history and dynamics is crucial for developing effective conservation strategies and policies to guarantee agricultural sustainability, food security, and future crop improvement.

Germplasm banks as *ex-situ* historical conservation units create a background that allows examining the persistence of landraces in a territory through the 20^{th} century to nowadays. In relation to the Limachino tomato, it was the repatriation of Chilean tomato germplasm preserved at international genebanks along some old samples stored by INIA's crops vegetables program that allowed to study the persistence in the territory. Using molecular and phenotyping techniques (unpublished data), empirical information was gathered to reconstruct the history and support the distinctiveness and the permanency of this landrace in the territory.

Taking as a model the San Marzano tomato PDO for the Limache valley triggered the rescue of the last genetic resources available to 2015 in the territory by an initiative of the Instituto Nacional de Investigaciones Agropecuarias (INIA) with public funding for genetic resources rescue from the Fundación para la Innovación Agraria (FIA). The loss of the *Limachino* tomato due to the agricultural modernization displacement that had occurred during the second half of the XX century left only four types available in the territory. As landraces were develop as a social process, in several countries the conservation of the cultural ties of landraces to farmers' communities has proven successful as social development. The incorporation of this approach plus the innovation in commercialization and marketing methods is allowing the recovery of Limachino tomato in its historical production area (Martínez *et al*., 2021).

Modern-day *in-situ* conservation can be transformed to an *in-situ* landrace growing to minimize the impact on local culture, employing participatory plant breeding (PPB) along farmer to potentiate their agricultural needs in a climate change scenario. Casañas *et al*. (2017) points out the need for support the process of PPB, by public association with private partners. The relevance of Genetic Resources units in working with local farmers communities in the creation of a new generation of landraces, comes from the knowledge of management of the landrace heterogeneous nature, the virus accumulation issues associated to landraces and the high-throughput phenotypic and agronomic characterization. Being genebanks an important part of the process, securing the different improvement states of the landraces in time and as repositories of local farmers communities. The use of the genetic resources, should undertake a thorough review to protect but at the same time promote agriculture growth, allowing the use of genetic resources by growers in an innovative way, but at the same time in a conservative way (Martínez *et al*., 2021).

Conclusions

Similar to other cultigens, tomato's agricultural transfer had a two-stage diffusion. One pre-Columbian in America as a primary center of diversity, where it developed with an unknown origin in either Andes or Mexico with a subsequent introduction to Europe before 1540s. A second stage in the post-Columbian period, where reintroduction of a narrow genetic base of tomato occurred in America in the late XVIII century from Europe. In Ecuador, Perú, and Chile as part of the Western Andes, during this second stage a hybridization of European introduced tomato types and some local tomatoes would be the origin of novel cultigens, among which the *Limachino* tomato could be a case.

Tomato was an important vegetable crop in the northern Chile in the pre-Columbian period. In early 1900's, the tomato production was displaced to the central Chile as Santiago centralized the population. Due to advantageous agroecological conditions for an early production, numerous farmers that became tomato growers to 1955 and closeness to the big markets of Santiago, Limache became a symbolic territory for tomato growing in Chile. Later, the Chilean agriculture modernization, based on the importation of improved varieties, and the adoption of entire packages of improved technologies by local farmers plus the lack of conservation strategies allowed the displacement of tomato landraces in the Valparaiso region. Maintaining nowadays the distinctive *Limachino* tomato of unknown origin needs additional efforts to reconstruction of landraces history. The landraces *ex-situ* conservation needs further review towards the market-driven *in situ* landrace growing. Studies on the genetic composition of tomato genetic resources to identify the natural qualities that make certain seeds or varieties better adapted to climate change, more resistant to pests and diseases, and of higher yield potential, along with participatory plant breeding implementation in national conservation systems will give new perspectives to a new generation of landraces, by allowing local farmers communities to maintain cultural ties with landraces, but also making these varieties a real economic alternative ensuring their permanence in the future. Genetic resources units' involvement in the process of landrace growing under a new landrace definition may generate a viable *in situ* conservation, inserted in nowadays market.

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