# Tomatoes: domestication and diversity

*Published 18 April 2022, with Jose Blanca*

Plants of the weedy wild relatives of the tomato all look pretty much like one another, but under the surface they're a seething mass of genetic diversity. That diversity — along with the discovery of truly wild tomatoes in Mexico — has allowed researchers to finally tell a story of tomato domestication that fits all the available evidence.

You don't actually need to know much about DNA and genetics to understand the story. Wild tomatoes are found in Peru and Ecuador, and the old story was that they were domesticated there. Then they spread up to Mexico, and it was in Mexico that people selected plants with much larger fruits, which found their way to Europe.

**Jose Blanca**: We were completely confused. The original idea was we have wild tomatoes in Ecuador and cultivated tomatoes in Ecuador, so for sure, the tomatoes from Ecuador come from Ecuador, from the wild tomatoes from Ecuador, and that is not the case. There always have been genetic evidence that something didn't fit the original theory. Now with a new hypothesis, everything fits.

I am Jose Blanca and I am a geneticist working in Valencia, Spain.

**Jeremy**: Jose Blanca and his colleagues are responsible for the evidence and for the new theory of tomato domestication that it fits so well. The key discovery is that there are true wild tomatoes in Mexico, and they were there long before people.

**Jose**: We have discovered that there are even wild tomatoes in Mexico. There are wild tomatoes in Peru and Ecuador clearly, and they are wild. They do not come from the cultivated tomato. In Mexico, there were doubts about that for a long time, but we think they are truly wild.

**Jeremy**: How does the discovery of these Mexican wild tomatoes, how does that change the story?

**Jose**: Quite a bit, because we always thought that there was a possibility of the tomato being domesticated in Mexico. We have found out that it looks like that is not the case. It looks like there were wild tomatoes in Mexico when people arrived there for the first time, and those look like the origin of the cultivated tomato. That's quite surprising, because the cultivated tomato, it looked like it was developed in the region between Peru and Ecuador, but the materials that they used as the base to domesticate the tomato that came from Mexico.

We thought that from Ecuador for sure, it came from Ecuador, but no, that is not the case. The tomatoes used as the base of the domestication came from Mexico.

That is quite surprising. The sequences of the Mexican tomato are very different from the sequences from the Peruvian and Ecuadorian tomatoes. That means that it has passed a long time. Those Mexican tomatoes are not recent. They are quite, quite differentiated genetically. The tomatoes in, let's call it the Amazonian region of Peru and Ecuador, they are almost like Mexican tomatoes. They come from Mexico.

**Jeremy**: The wild tomatoes in Mexico are very different from the wild tomatoes in Ecuador and Peru, which means they've been there a long time, but the cultivated tomatoes of Ecuador are very like the Mexican wild tomatoes, which means they only emerged relatively recently. How did they get back from Mexico to Ecuador? Did people bring them?

**Jose**: We don't know how they came back, but we know it was a fast come back. They migrated north, and that was a slow migration. There was time to create lots of new mutations, but when they came back to Peru and Ecuador it was quite fast. The genomes are very, very similar to the genomes in Mexico. There has been no time to gain new mutations. First, they went north quite slowly, likely before humans arriving there. Then they went back south very fast, so likely with some human interventions. Maybe they came back because humans brought them there. We don't know. But it's also possible that they came, I'd say, with maize or some other crop brought from Mexico to Peru and Ecuador. That is something that we don't know.

**Jeremy**: You've got this picture of enormous diversity in the Ecuadorian and the Peruvian tomatoes. When you look at tomatoes

in Europe, there seems to be huge diversity among the tomatoes in Europe. I mean, even if I go down to the greengrocer down here in Rome, I can get tiny little ones, I can get longer ones, I can get San Marzano types. I can get what they call Costoluto which are the very ribbed ones. It looks like there's a huge amount of diversity in Europe. Is that also the case when you look at the genetics?

**Jose**: No. The genetic diversity, it's very low. You have to take into account that the tomatoes were brought to Europe and we guess not many of them. So when they established the tomato in Italy and in Spain, mainly, that crop in Italy and Spain maybe started with few plants, and the diversity is very, very low in general, along the genome, although we have found out that there are islands of high diversity along the genome, but very few places. These few places are related with morphology. There are places like, for instance, genes related with colour, fruit colour or fruit size; those places are highly diverse, but otherwise the genome has a very low diversity. That is typical of cultivated species.

What the growers in Spain and Italy did is to mix the remaining diversity in order to create new varieties. For instance, red varieties that were big, red varieties that were small. Varieties ribbed and small with different colours, with pink or red, and so they mix and match the remaining diversity. That is quite standard when you domesticate a species, or when you create new diversity. You take what is left and you mix the genes, the remaining diversity.

This process of the diversification of tomato in Italy and Spain, we are talking about before, it's 17th and 18th century. In the 19th century, tomato already became popular, because before it was not popular at all. When it became popular in the 19th century, then the history becomes much more tangled and complex, because there are people developing new varieties in England. These new varieties are exported to Spain to create an industry to export back to England, but with tomatoes produced in Spain or in the Canary Islands, in order to be exported to England, but the seed it was England['s] tomatoes. The 19th century is much more complex, but before that, it was clear that there was a diversification in Italy and Spain.

**Jeremy**: What is a very typical Spanish variety?

Jose: In the Mediterranean region of Spain, you have, for instance, tomatoes that last for a long time. They have a mutation, and you

collect them and they can last for months. These are called tomato de penjar. These are very typical and very old.

**Jeremy**: They have those in Sicily here as well, I think.

**Jose**: Yes, yes, yes, but they are independent. They were created independently we think.

**Jeremy**: That's interesting that farmers in two different places selected these tomatoes that would last over the winter.

**Jose**: Oh yes, but because they are useful. Yes.

**Jeremy**: [chuckles] Because they're useful is a very interesting answer, because what do you think drives the development of new varieties, especially before you have scientific breeding and everything. You say that the farmers had all this diversity in the genes that were affecting; the morphology, the shape. So what kinds of things were they looking for?

**Jose**: I think farmers have always looked for — at least, what we see in the genes — is that they have always looked for diversity, small tomatoes, big tomatoes, ribbed tomatoes, tomatoes without ribs, all kind of tomatoes really. Colours also. I think that they have always enjoyed diversity. This is what they selected mainly without knowing what they were doing, but they were selecting for new mutants, for instance, like in the case of these tomatoes that last for months.

And also, because sometimes the tomato crosses the different plants or different varieties. If you grow them together, they cross, and they create new varieties that are selected. Then, in the end of the 18th century and in the 19th century, this got professionalised and systematised, and then you get many, many more varieties.

**Jeremy**: It seems what you're saying is that farmers just like diversity, which is the exact opposite of what scientific breeding, modern kind of production-oriented breeding is all about. Is there a danger that we are losing this diversity in tomatoes?

**Jose**: The diversity within species is very low. [chuckles] Is quite confusing, because morphologically, it looks like you have many kinds of tomatoes, but if you look at the genes, you have really few genes. You could have, well, maybe 99% of the genetic diversity of the traditional tomato, just by having 50 varieties.

I don't think we can say that we have lost genetic diversity. Maybe what we have lost is some of the old varieties that are not cultivated anymore. It should be an objective to recover some of the lost diversity and incorporate this diversity in the modern commercial breeds, and this has been done in 20th century. Many genes from the wild species have been introgressed in the commercial varieties. The commercial varieties that are produced nowadays have higher genetic diversity than the old ones.

**Jeremy**: When you looked at the genetics of all these — well, you looked at 1200, more than 1200 different varieties — there was some that were labeled traditional but when you looked at the genetics, you discovered that they were modern, I don't quite understand how that worked out.

**Jose**: Yes, that's because what you call traditional — you have to define a border — because what is traditional? Something that has not been bred by a professional. What we call traditional in the paper is anything that does not have the modern integrations. Lots of genes were introgressed from the wild varieties, especially genes related with resistance to diseases, and those genes improve the production of the tomato a lot. They are not supposed to be in the traditional tomatoes, for sure because these genes were introducing the commercial varieties.

Our surprise, up to a point, was that 25% of the traditional tomatoes — traditional in this case, it's somebody went to a traditional grower and said, "Do you have seeds?" He said, "Yes, these seeds are traditional, these are not modern tomatoes bought from a commercial seed company." What's in the genome, you can find this while integrations related with resistant genes and that's normal, because these genes are very, very useful.

Again, if you have tomatoes, they will cross and it's quite likely that even the traditional growers will grow the best varieties, the ones that behave the best. I am a geneticist, for me, crossing and mixing, it's ideal, because the more you cross, the best you can choose from, you have more diversity to choose from.

**Jeremy**: How do you feel about this fashion for heritage, heirloom traditional tomatoes? You find people who say, "Oh, these are always better than modern tomatoes." Do you agree?

**Jose**: That they are better? No, not at all. I think it varies with what people prefer, and that's very related with culture and with what people expect to find. I think it's great that some people are devoted to culture, the history of the tomato and to keep it alive. I think that it's great but to think that that is superior, in some sense, I do not agree with that, not at all.

I think what the breeders, the most professional breeders are doing, it's very important. They are creating new varieties adapted for the new needs and for the new market. And that should live with the old ones. It's great that we have the old ones and people, they are devoted to them. I don't think it's right to say that — for me, it's like a little bit snobbish [chuckles] — really to say that the modern ones are all bad.