

Aided by genomic technologies, the patent pillage of Andean tomato diversity continues

by Edward Hammond

In November 2011, Third World Network reported on how new genomic technologies and Northern government research subsidies had spurred many new patent claims on valuable tomato genes originating in South America.¹ Now, over three years later, the wave of new claims on tomatoes is continuing to grow while there is still no sign of significant benefits being shared with the countries of origin of these valuable genes.

In this update to the 2011 report, information and analysis of new intellectual property claims on tomato genes and their use is provided.

Tomatoes are among the most profitable fruit/vegetable² crops in many parts of the world, but the genetic resources that confer the key traits of many new commercial varieties mainly come from only two countries – Peru and Ecuador – that sit at the centre of diversity for the tomato genus. Tomatoes from these countries, including species unique to Ecuador's famed Galapagos Islands, have recently been the subject of new patent claims on genes for disease resistance, drought and salt tolerance, as well as increased fruit sweetness.

And in an interesting twist on biopiracy of farmers' varieties, researchers at the University of Florida in the United States have sifted through "heirloom" varieties of tomato, many developed by farmers and indigenous peoples, to find out why these tomatoes frequently taste better than intensively bred industrial varieties. Aromatic and flavourful compounds (called "volatiles") in these tomatoes can be used in a variety of ways. The University of Florida has filed for patents on their use as a food additive which, when used in combination with sugar or artificial sweeteners, makes foods taste sweeter. It has also claimed tomato varieties and plant breeding methods designed to increase sweetness by increasing production of taste compounds identified in heirloom tomatoes.

With the recent publicly funded sequencing and publication of the full genome of *Solanum pennellii*,³ an Andean tomato wild relative, patent claims will likely continue to accelerate. Genes from *S. pennellii* and other wild relatives can be introduced (by genetic engineering or marker-assisted methods) into cultivated tomatoes with beneficial results. Companies and others continue to claim such insertions as

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“inventions”, without benefit sharing with the countries of origin or their local communities.

1. Firmness trait from Peruvian wild tomatoes (WO2013153237)

Syngenta (Switzerland)

Switzerland’s Syngenta has filed for patent⁴ on harder (firmer) tomatoes, a trait useful to prevent damage to fruit in industrial tomato production, in which tomatoes are often roughly handled in trucks and by machines. The patent application boldly claims any tomato of a specified hardness – four times as hard as typical tomatoes – when it incorporates a “genetic element” (quantitative trait locus – QTL) that was identified in *Solanum pennellii*, a tomato wild relative that is a native of Peru.

The trait Syngenta seeks to patent was identified through the use of introgression lines⁵ that crossed a cultivated tomato with LA0716, an *S. pennellii* plant collected near the town of Atico on the southern coast of Peru’s Arequipa State. LA0716 is part of the collection of the Rick Tomato Genetic Resources Center at the University of California at Davis.⁶

Information on the trait was published⁷ in 2012, shortly after the patent application was filed, by Syngenta researchers working with scientists from British and Australian universities and INRA, the French agricultural research agency. The work leading to the patent application on the Andean genetic resource was funded by Syngenta, the UK Biotechnology and Biological Sciences Research Council, and the European Union.

In addition to Syngenta scientists, the patent application names two British public sector researchers, Graham Seymour and Natalie Chapman, as “inventors” of the Peruvian trait. In addition to the international patent publication, in October 2014 a European patent application appeared (EP2013728382) and, in March 2015, a US patent application was published. It is likely that the patent application will also be published in other jurisdictions.

2. New claims on Ecuadorian Galapagos tomatoes (WO2014153032)

Evolutionary Genomics (US)

Also using genomic techniques, the American company Evolutionary Genomics has laid claim to two genes identified in an Ecuadorian wild tomato species endemic to the Galapagos Islands. One is related to salt and drought tolerance, while the other is related to sweetness. The hope is that the genes could be used to create more environmentally hardy tomato varieties and/or types with sweeter fruit. The United States government provided initial funding for the research.⁸

Galapagos tomatoes (*Solanum cheesmaniae*) have previously yielded processing and disease resistance traits used in the industrial tomato industry. The Ecuadorian species are especially interesting to Evolutionary Genomics because the company’s approach focuses on identifying valuable genes by comparing the genetics of related plants and identifying genes that are positively selected over time, a potential indication of their usefulness. The company is further interested in – and has sought patent protection on – genomic research techniques to identify useful genes by assessing the effects of historical genetic “bottlenecks” – cases when a population of a species becomes isolated or severely reduced.

Because of the Galapagos Islands’ famed biological isolation, Galapagos tomatoes are especially suitable for analysis with the company’s methods, and are a promising source of interesting genetic information and traits for Evolutionary Genomics.

Evolutionary Genomics is a small company with large ambitions of international interest. With funding from the Bill and Melinda Gates Foundation it has worked on cassava disease and wheat rust, and it has out-licensed rice yield genes for hybrid rice varieties sold in the Americas.⁹ The company has a clear interest in international agricultural development, but its motives should not be mistaken as being philanthropic. Evolutionary Genomics is an aggressive user of intellectual property, filing many patent claims on both its research technique and results.

Evolutionary Genomics' claims on the Ecuadorian genes have so far been published in an international patent publication (WO2014153032), and a US patent application has been filed. Applications in other countries are likely to follow. The company has not claimed use of the genes in conventional breeding (Galapagos tomatoes can be crossed with cultivated tomatoes), but has claimed genetic constructs with the Ecuadorian genes, their use to make genetically modified (GM) tomato plants, the resulting GM plants themselves, their use in breeding, and their cultivation.

Walter Messier, the company's leader and lead scientist, did not respond to a query about Evolutionary Genomics' perspective and plans on access and benefit sharing.

3. Virus resistance from Peruvian wild tomato relatives (WO2014045206)

Government of Israel

Israeli government researchers have filed for patent on a tomato gene that encodes resistance to tomato yellow leaf curl virus (TYLCV), a major disease of cultivated tomatoes in much of the world. Transmitted by whiteflies, the virus can cause complete crop failure despite heavy applications of pesticides to control its insect vector.¹⁰

The gene was isolated following a cross between a standard cultivated tomato and four wild relatives. Three are types of *Solanum peruvianum*: PI 126926 was collected in 1936 in Pacasmayo, a town on the Peruvian coast north of Trujillo; PI 126930, or *tomate de culebra* ("serpent's tomato"), was collected by the same American researcher in 1937 in Chancay, north of the capital Lima; and PI 390681, or *lomas de Camaná* ("Camaná ridge"), was collected by Peruvian scientists in 1974 in the district of the same name along Peru's southern coast. The fourth accession belongs to a different tomato wild relative species, *Solanum arcanum*. LA0441, or *Cerro Campana* ("Bell Hills"), was collected in 1956 north of the city of Trujillo.

The TYLCV-resistant cross between four Peruvian tomatoes and the standard cultivated tomato was made in the 1990s, but it was not until later that Israeli scientists identified the

exact genetic source of the virus-stopping trait and filed for patent.

The international patent application, published in March 2014, claims the DNA sequence of the resistance gene, variations on it, identifying resistant plants with the gene (or variants) and using them in breeding, and using the gene to create transgenic cultivated tomatoes or other plants. A US patent application has been filed, and it and others will likely be published in the coming months.

4. Farmers' varieties of tomato mined for flavour compounds and genes (WO2013163272)

University of Florida (US)

The tomato has been called an "iconic symbol of the declining quality of fresh fruits and vegetables," because the industrial varieties that dominate supermarket shelves in urban areas lack the flavour that tomatoes once typically had. This problem is believed to be due to a combination of factory farming methods and intense breeding that has emphasized plant traits other than flavour.¹¹

Tomato flavour is determined by a complex interplay of sugars, acids and a mix of aromatic compounds referred to as "volatiles". In many recently bred tomatoes, the palate-pleasing balance of these factors has clearly declined in comparison to many older varieties. Trying to recover lost ground, University of Florida scientists have been researching older varieties of tomato in order to better identify and understand the volatile compounds involved in tomato flavour.

The Florida research programme brings together molecular biologists and taste researchers. The lead biologist in the group is Harry Klee, who worked at Monsanto to genetically engineer tomatoes for a decade. Klee's work for the seed giant included a project to make GM tomatoes that did not naturally ripen and could thus be kept on the shelf longer.¹² Now in academia, Klee has discarded his previous identity as a genetic engineer pursuing unpalatable industrial traits and radically recast himself as a backer of traditional taste, breeding methods and small-scale tomato farming.¹³

Nevertheless, Monsanto has continued to fund Klee's research at the University of Florida.

With government funding – and a Monsanto grant – the Florida researchers bought seeds of dozens of farmers' varieties and other "heirloom" tomatoes from companies that produce and sell seeds of older tomato types. These open pollinated tomatoes are free from intellectual property claims and, in some cases, were bred well over 100 years ago. The seeds ranged from Zapotec and Cherokee, both varieties named for the Mexican and US indigenous peoples that originally bred them, to traditional Thai, Malaysian, Peruvian, Mexican, Lebanese, Italian, Moldovan, Russian and other tomatoes mostly created by farmers generations ago or, in other cases, freely released by public breeding programmes (most of which no longer exist or no longer release varieties without intellectual property claims).

The Florida researchers grew the heirloom tomato varieties and measured the (highly variable) levels of different volatiles in each. They then fed the heirloom tomatoes to research subjects, who rated the flavour. After measuring for several growing seasons, the researchers identified a set of volatiles most important for tomato taste and how they interact with sugars in the perception of sweet flavour.¹⁴

Florida has so far claimed two tomato varieties that emerged from the research, and it promises more. These presumably include genetic material from farmers' varieties that scored well in their tests; however, Florida's plant breeder's rights applications are still pending, so there is little information available about their genetic makeup. And because plant breeder's rights are often granted without the pedigree of varieties being well described, or even described at all, Florida may never have to divulge which farmers' varieties it has used and how. Klee is also developing hybrid tomato varieties that incorporate taste profiles he has lifted from the work of farmers and indigenous peoples.

Florida has also filed for patent on both conventional breeding methods to enhance the expression of volatiles in tomato fruit, and the use of a number of the volatile compounds, in conjunction with sugar and artificial sweeten-

ers, to enhance the sweet flavour of other foods. In one case, it has further identified a specific tomato gene responsible for production of an aromatic volatile, and has filed for patent on that gene and its regulation. The claims also include the form of the gene found in wild Peruvian *S. pennellii* accessions, and introducing the *S. pennellii* gene into cultivated tomatoes. With work ongoing to identify more of the genes that are linked to volatile flavour compounds, more patent applications can be expected.¹⁵

But good-tasting tomatoes are not new, and they definitely are not Florida's invention. By its own admission, Florida has mined the chemistry and genetic resources of traditional tomato varieties, whose flavours were developed by indigenous peoples, farmers and breeders – and not 21st-century American university scientists.

While there is nothing wrong per se with Florida turning to farmers' varieties of tomato to recover good taste stamped out by industrial breeding, claiming it as Florida's invention is wrong. It cannot be said that the manipulation of traditional varieties' aromatic compounds in breeding nor their use to enhance flavour was a discovery of university researchers. To the contrary, fundamentally, Florida has not invented anything at all. It has simply gone back to older varieties to take advantage of the selection and breeding skill of previous generations of farmers and others.

Florida researchers might be proud of the scientific accomplishment of the more chemically detailed understanding of tomato taste that they have developed, but they should be ashamed to have claimed the use and manipulation of tomato volatile flavours, both in breeding and in foods, as something they invented and own.

Florida's plant breeder's rights applications, for "Garden Gem" and "Garden Treasure", are pending at the US Plant Variety Protection Office and may be filed elsewhere.¹⁶ Florida's patent applications, one of which claims both breeding methods and use of volatiles to enhance sweet taste, with the other claiming a volatile-related gene and its use, were filed in the United States and international applications have recently been published.¹⁷ The University is presently seeking to sell licences to the tomato volatile

compounds that it identified in heirloom varieties, and for which it has filed patent claims.¹⁸

What rights and data Monsanto has obtained, as partial funder of the research, are not known and, due to lack of a disclosure-of-origin requirement in plant breeder's rights laws, may never be known.

Conclusion

Taken together with the claims highlighted in our 2011 report, one of which is now under challenge from non-governmental organizations in Europe,¹⁹ it is clear that a move to privatize the tomato genome is underway. This theft from Peru, Ecuador and surrounding countries has been propelled by public funding from US and European governments, who have subsidized the research that has indirectly and in some cases directly led to patent claims by corporations and universities.

Ex situ collections have been the main provider of tomatoes and tomato wild relatives that have fallen under patent claim. Many of the genes and traits claimed were found in genebank accessions collected before the entry into force of the Convention on Biological Diversity, but those genes and traits can be put to new uses and claimed in patents and patent applications. Newly styled patent claims, like Syngenta's grab for a tomato fruit hardness QTL, extend well beyond proprietary assertions over materials found in seed banks. They can extend, for example, to using any tomato plant with a claimed trait in breeding.²⁰

The irony of the University of Florida's patent claims on tomato taste compounds is inescapable. Not only do they reflect pillaging of traditional open pollinated, non-patented varieties for "new" "inventions" that are neither new nor inventions, they also reflect an admission that decades of proprietary breeding for processing traits have damaged key qualities for human enjoyment of a most important fruit species.

Unfortunately, tomatoes are likely a sign of what is to come in other fruit and vegetable crops if biopiracy is not countered. Since tomatoes are used as a model plant, and their genome was sequenced relatively early, the relative abun-

dance of knowledge about tomatoes and existence of significant *ex situ* collections of tomato wild relatives have stimulated research and, less positively, patents. As similar genetic tools (genomes, introgression lines, etc) and datasets (e.g., fingerprints of genebank accessions) become available for other fruits and vegetables and their wild relatives, a similar patent rush can be expected.

The patent rush on tomatoes draws attention to the need for national access and benefit-sharing laws to address agricultural crops not covered by the International Treaty on Plant Genetic Resources for Food and Agriculture (ITPGRFA). The ITPGRFA's multilateral system for access and benefit sharing only applies to crops listed in the Treaty's Annex 1. Crops not in Annex 1 fall under the terms of the Convention on Biological Diversity and, more particularly, its Nagoya Protocol on access and benefit sharing (for ratifying countries).

Although talks are underway that could lead to the expansion of the Treaty's Annex, it is unclear if they will be successful or if a resulting agreement would be advantageous to developing countries to join.²¹ Even optimistic financial projections for benefit sharing under the Treaty, if its Annex were expanded, indicate that benefit sharing for fruits and vegetables and other non-Annex crops like tomatoes would be quite modest. Developing countries would thus be prudent to place crops like tomatoes into strengthened access and benefit-sharing regimes in accordance with the Nagoya Protocol, particularly where a country is a significant source of natural or farmer-bred crop diversity or of wild relatives of cultivated crops. At present, if countries do not ensure that Nagoya-type access and benefit-sharing protections are extended to non-Annex 1 crop diversity, they will facilitate biopiracy of their agricultural biodiversity.

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Endnotes

- 1 Hammond E (2011). Marker-assisted Biopiracy. Third World Network. November. URL: http://www.twtn.my/title2/briefing_papers/No61.pdf
- 2 While a tomato is botanically a fruit, it is considered a vegetable for culinary purposes (as well as under US customs regulations).
- 3 Bolger A et al. (2014). The genome of the stress-tolerant wild tomato species *Solanum pennellii*. *Nature Genetics* 46(9):1034-1039 (September).
- 4 See PCT patent publication WO2013153237.
- 5 See Hammond (2011) for an introduction to tomato introgression lines. URL: http://www.twtn.my/title2/briefing_papers/No61.pdf
- 6 University of California at Davis (2014). TGRIC Entry for LA0716 (web page). URL: <http://tgric.ucdavis.edu/data/acc/AccDetail.aspx?AccessionNum=LA0716>
- 7 Chapman NH et al. (2012). High-Resolution Mapping of a Fruit Firmness-Related Quantitative Trait Locus in Tomato Reveals Epistatic Interactions Associated with a Complex Combinatorial Locus. *Plant Physiology* 159(4):1644-1657 (August). URL: <http://www.plantphysiol.org/content/159/4/1644.full>
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- 10 Polston JE and M Lapidot (2007). Management of Tomato Yellow Leaf Curl Virus: US and Israel Perspectives. p. 251. Chapter in Czosnek H (ed.). *Tomato Yellow Leaf Curl Virus Disease*. Springer.
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- 12 See international patent publication WO1992012249, Control of fruit ripening and senescence in plants.
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- 14 Tieman D et al. (2012). The chemical interactions underlying tomato flavor preferences. *Current Biology* 22(11):1035-1039.
- 15 See, for example, *J Exp Bot.* Feb 2014; 65(2):419-428 and *Mol Plant.* Oct 29 2014; pii: ssu124 [Epub].
- 16 See: Garden Gem: URL: <http://www.ars-grin.gov/cgi-bin/npgs/acc/display.pl?1914756> and Garden Treasure: URL: <http://www.ars-grin.gov/cgi-bin/npgs/acc/display.pl?1914757>
- 17 See international patent publications WO2013163272, Compositions and Methods for Modifying Perception of Sweet Taste, and WO2013043666, Tomato catechol O-methyltransferase sequences and methods of use (published 28 March 2013).
- 18 University of Florida Technology Licensing Office (2014). Natural Compounds that Enhance the Perception of Sweetness (web page). URL: http://technologylicensing.research.ufl.edu/technologies/14111_natural-compounds-that-enhance-the-perception-of-sweetness
- 19 No Patents on Seeds (2014). Opposition against European Patent on tomatoes (news release). 30 May. URL: <http://www.no-patents-on-seeds.org/en/information/news/opposition-against-european-patent-tomatoes>
- 20 See Hammond (2011) for more extensive discussion of marker-assisted breeding and genomic technologies and how they are creating broad patent claims over tomatoes.
- 21 If talks at the Food and Agriculture Organization result in a proposal to expand the ITPGRFA's Annex 1, doing so will require a new round of ratifications by member states of the Treaty. For more information on these talks, please see: Hammond E (2015). A report of the 2nd meeting of the Ad Hoc Technical Committee on Sustainable Use of Plant Genetic Resources for Food and Agriculture. Third World Network. 5 January. URL: <http://www.twtn.my/title2/biotk/2015/btk150101.htm>