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Following the traces of fermentation

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Yeasts are everywhere. This little bubbly-like single-cell fungus is a superstar of human food culture. Bread, beer, yogurt, cheese, wine and even coffee and cacao require yeast for their preparation. Thanks to Louis Pasteur we know that yeasts are responsible for the process of fermentation - the biochemical conversion of sugars into alcohol, gas or acids. But humans were using fermentation long before they actually knew what exactly it is.

Over 9,000 years ago humans began producing wine. Through years and years we were selecting favorable fermentation products and thus creating specialized yeast strains of *Saccharomyces cerevisiae* whose fermented products gave us likable flavors. The knowledge and tools of wine making spread around the world together with specialized wine yeast strains. And today wine fermentation is typically carried out by clonal populations of yeasts common to all cultivating areas in the world. This is confirmed by genetic population analysis of *S. cerevisiae* strains residing in modern vineyards.

But it is less known that fermentation is also extremely important for coffee and cacao production. For us to have our warm and balmy morning drink, the outer pulps of cacao and coffee beans have to be first digested by yeasts. This step crucially affects the flavor of the final drink. That's why just after the collection of the fruits, they are left outside for a few days in special tanks. Microorganisms on the fruit's surface trigger biochemical changes that impart flavor and color to the yet unroasted beans.

Like wine, the production of coffee and cacao is spread across the entire world. However, the plants for cacao and coffee, *Theobroma cacao* and *Coffea*, originally grew in the Amazon/Orinoco and modern Ethiopia regions, respectively[1],[2]. But today both are spread anywhere where conditions are warm and humid enough. Most of these countries are located within the tropics. But what about their yeasts? Are the yeasts of coffee and cacao similar to those of wine? Do they represent the same accordance and uniformity of their genetic material? The authors of this paper took these questions as the challenge to study genetic diversity of our bubbly friends.

One of the ways of looking at how related or unrelated different groups of organisms are, is to look into their genetic sequence and identify very small variations among different groups. These variations are called *single nucleotide polymorphism (SNPs)*. By comparing the amounts and variants of SNPs (so called *alleles*) between different strains of same species, we can have a hint on how closely these strains related to each other and how they were evolving.

Authors of the paper took DNA samples of cacao- and coffee- associated yeasts from various countries and continents to compare them with yeasts from wine and yeast. It turned out that if all wine yeast strains are brothers to each other, the cacao and coffee yeasts are cousins. When authors looked closer at the set of SNPs in different yeasts strains, they realized a huge difference between cacao, coffee, and wine. Whereas wine represents a single ancestry strain, the former two appear to be a diverse group of different strains that are clearly defined by the geographical origin of the cacao and

coffee samples. This geographical variation is so clear that authors of the paper could pinpoint with 86% chance the origin of blindly chosen cacao or coffee beans just by analyzing SNPs from yeast samples from these beans.

The analysis of SNPs also allowed authors to look into the more ancient history of cacao and coffee yeasts. Yeasts appeared on the planet long before people start to use them. It is thought that yeasts took their origin on territory of modern China [3]. After that they've spread to all the continents, forming a number of populations. These populations are referred by the name of the location and place they've been originally described (North America/Oak, Asia/ Palm, Israel/Soil etc. - 12 populations in total).

What authors saw is that coffee and cacao yeasts appear as the result of mixing events between major populations that were geographically vicinal to each other. For example, the two South American populations (SA coffee and SA cacao) share alleles with the North American oak (NA oak) population. And the genetic profiles of both African groups (coffee and cacao) show mixtures of European and Asian alleles. But at the same time, it seems like human activities also have fostered the establishment of cacao and coffee hybrid groups. For example, the combinations of alleles present in cacao/coffee groups coincide with known paths of transportation, organized cultivation, and fermentation of the crops.

This research tells us how related are our little bubbly friends that help us so much to produce so different and so tasty products. Who knows, maybe with the help of scientists in the future we are going to acquire coffee and cacao drinks of a superior taste that would be very different from what we drink now.