Modern European genes may favor vegetarianism

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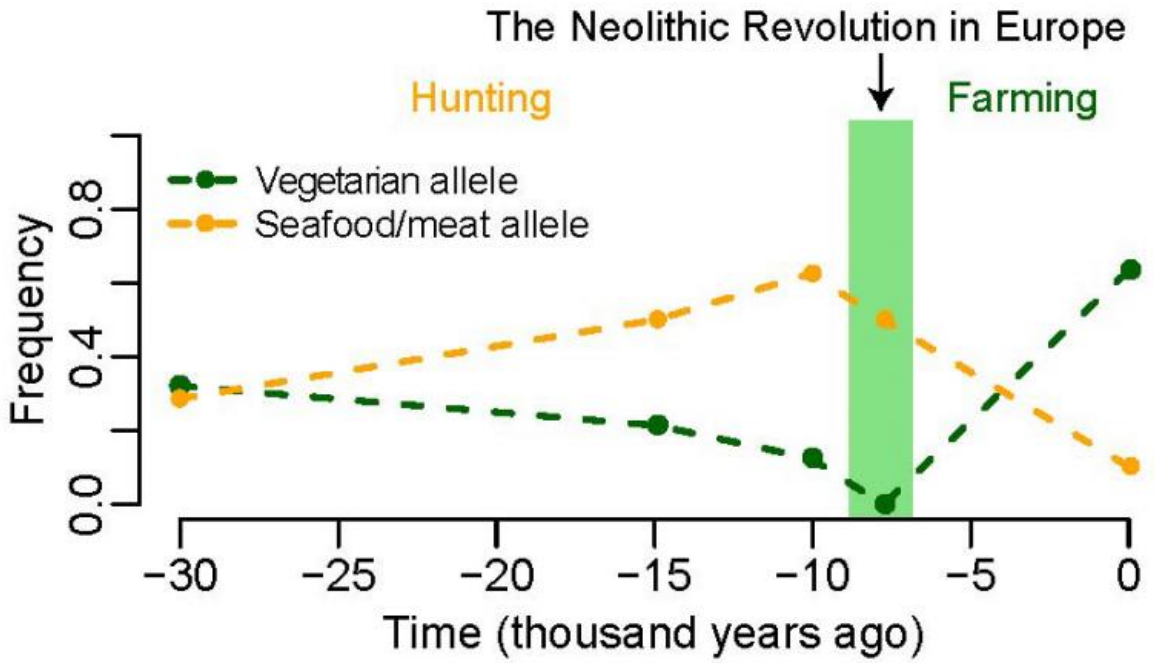

This graphic shows the frequency of a vegetarian allele and a seafood/meat allele, two versions of the same gene, over the past 30,000 years in European populations. The trends were opposite for the two alleles and both took a turn after the Neolithic revolution. Credit: Kaixiong Ye/Provided

A Cornell study, published May 26 in the journal *Nature Ecology and Evolution*, describes how shifts in diets in Europeans after the introduction of farming 10,000 years ago led to genetic adaptations that

favored the dietary trends of the time.

Before the Neolithic revolution that began around 10,000 years ago, European populations were hunter-gatherers who ate animal-based diets and some seafood. But after the advent of farming in southern Europe around 8,000 years ago, which spread northward thereafter, European farmers switched to primarily plant-heavy diets.

The study – the first to separate and compare adaptations that occurred before and after the Neolithic revolution – reveals that these dietary practices are reflected in the genes of Europeans. Researchers collected data from more than 25 other studies that examined ancient DNA from fossils and archaeological remains (dating back to 30,000 years ago until about 2,000 years ago), and DNA from contemporary populations.

The study found that adaptations occurred in an important genomic region that includes three fatty acid desaturase (FADS) genes. Different versions of the same FADS1 gene, called alleles, corresponded to the types of diets that were adopted.

"The study shows what a striking role diet has played in the evolution of human populations," said Alon Keinan, associate professor of computational and population genomics and the paper's senior author. Kaixiong Ye, a postdoctoral researcher in Keinan's lab, is the paper's lead author.

"Changing diets instantaneously switched which alleles are advantageous, a result of marked natural selection for the level that a crucial gene is expressed," Keinan said.

The study has implications for the growing field of nutritional genomics, called nutrigenomics. Based on one's ancestry, clinicians may one day tailor each person's diet to her or his genome to improve health and

prevent disease.

The study shows that vegetarian diets of European farmers led to an increased frequency of an allele that encodes cells to produce enzymes that helped farmers metabolize plants. Frequency increased as a result of natural selection, where vegetarian farmers with this allele had health advantages that allowed them to have more children, passing down this genetic variant to their offspring.

The FADS1 gene found in these vegetarian farmers produces enzymes that play a vital role in the biosynthesis of omega-3 and omega-6 long-chain polyunsaturated fatty acids (LCPUFA). These LCPUFAs are crucial for proper human brain development, controlling inflammation and immune response. While omega-3 and omega-6 LCPUFA can be obtained directly from animal-based diets, they are absent from plant-based diets. Vegetarians require FADS1 enzymes to biosynthesize LCPUFA from short-chain fatty acids found in plants (roots, vegetables and seeds).

Analysis of ancient DNA revealed that prior to humans' farming, the animal-based diets of European hunter-gatherers predominantly favored the opposite version of the same gene, which limits the activity of FADS1 enzymes and is better suited for people with meat and seafood-based diets.

Analysis of the frequencies of these alleles in Europeans showed that the prevalence of the allele for plant-based diets decreased in Europeans until the Neolithic revolution, after which it rose sharply. Concurrently, the opposite version of the same gene found in hunter-gatherers increased until the advent of farming, after which it declined sharply.

The researchers also found a gradient in the frequencies of these alleles from north to south since the Neolithic Era, including modern-day

populations. All farmers relied heavily on plant-based diets, but that reliance was stronger in the south, as compared to northern Europeans – whose farmer ancestors drank more milk and included seafood in their diet.

Ofer Bar-Yosef, a Harvard University anthropologist who specializes in the Neolithic revolution and is a co-author of the study, helped Keinan and Ye scour the anthropological literature for evidence of diets of pre-Neolithic hunter-gatherers and post-Neolithic farmers in different parts of Europe.

"We made predictions based on our evolutionary observations, and then with Ofer's assistance, we were able to verify them and to conclude that diet was the driving force behind all our evolutionary results," Ye said.

Plant-based alleles regulate cholesterol levels and have been associated with risk of many diseases, including inflammatory bowel disease, cardiovascular disease, arthritis and bipolar disorder.

"I want to know how different individuals respond differently to the same diet," Ye said. Future studies will investigate additional links between genetic variation, diets and health, so that "in the future, we can provide dietary recommendations that are personalized to one's genetic background," he added.

Ye and Keinan previously discovered related patterns in the same genomic region in Indian, African and some East Asian populations that followed a plant-based diet for hundreds of generations.

More information: Kaixiong Ye et al. Dietary adaptation of FADS genes in Europe varied across time and geography, *Nature Ecology & Evolution* (2017). DOI: 10.1038/s41559-017-0167

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