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The historical role of milk and dairying in shaping European societies

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1. Summary

Based on results recently published in the scientific literature, the author briefly outlines in this mini-review how dairying has become, over thousands of years, a basic activity of humankind. Following the domestication of cattle, goats and sheep, which had begun approximately 10,500 to 11,000 years ago in the Middle East, milk was already in use in northwestern Anatolia by the seventh millennium BC. In lack of lactase, however, milk consumption resulted in unpleasant outcomes (e.g., flatulence, cramps, diarrhea, etc.) in the vast majority of prehistoric farmers. The negative symptoms associated with lactose intolerance were later considerably alleviated by the introduction of simple milk processing techniques such as fermentation. Thus, for instance, Neolithic farming communities in north-central Poland started producing cheese between 6800 and 7400 years ago. Intriguingly, the ability to digest lactose in adulthood, termed lactase persistence (LP), emerged as a result of a genetic mutation at about the same time in central Europe, and the LP allele has been subject to strong positive selection afterwards. As the so-called gene–culture coevolutionary model suggests, the cultural evolution of dairy farming tightly entwined with the biological evolution of LP over millennia, and these processes are likely to have profoundly influenced the genetic composition of European populations.

2. Historical role of milk and dairying

Approximately 11,700 years ago, after the last glacial period ("Ice age"), and the beginning of the New Stone Age (Neolithic), in the region of the Middle East called the Fertile Crescent and also in Anatolia, the hunting-gathering lifestyle characteristic of the Middle Stone Age (Mesolithic) was slowly replaced by conscious agricultural activities, and then it gradually spread to other parts of the Middle East, the Caucasus region, Europe and Africa **[18]**.

The first opportunity for milk consumption came when the ancestors of sheep *(Ovis aries)*, goat *(Capra hircus)* and cattle *(Bos taurus)* were domesticated in the area between the Zagros and Taurus Mountains, probably in the middle Euphrates valley, 11,000 years ago in the case of goats and sheep, and 10,500 years ago in the case of cattle. Some researchers even argue that the aim of the domestication of the wild goat *(Capra aegagrus)*, the wild sheep *(Ovis orientalis)* and the aurochs *(Bos primigenius)* was to establish an opportunity for regular milk consumption **[18]**, **[27]**.

About 1,500 to 2,000 years later, domesticated animal species were already present in large numbers in the Middle East and Anatolia, and from there they spread to the area of present-day Greece and the Balkans 8,400 years ago. From here, further penetration took place via two routes: a seaside and a continental route. The former meant the area of the Aegean, Adriatic and Tyrrhenian Seas, while the latter meant the Danube line and the Balkans, all the way to Central Europe **[18]**, **[26]**.

Sequence analysis of mitochondrial DNA samples obtained from bones revealed that the first farmers in Central Europe, members of the linear pottery culture that evolved in the area of present-day western Hungary and southwest Slovakia, were not descendants of the indigenous people following a hunting-gathering lifestyle, but immigrants who arrived in Central Europe in large

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numbers at the beginning of the New Stone Age from southwestern Asian areas close to the center of evolution of the Neolithic culture. These incoming groups, at least in the beginning, did not mix with the indigenous people **[3]**. Likewise, cattle, domesticated in the Middle East, came to Europe with the first farming communities. Herds of cattle with fragile bodies and under human control, were sharply distinct from groups of indigenous, wild and robust aurochs; they did not mix genetically with them, and gradually displaced them **[9]**.

Following the domestication of dairy animals and the start of the use of clay pots, utilisation of milk has begun within a relatively short period of time. Based on the fatty acid composition analysis of milk residues from more than two thousand clay pot fragments, Evershed et al. **[11]** found that in the northwestern part of present-day Turkey, around the Sea of Marmara, milk consumption was already an everyday occurrence 8,500 years ago. Examination of animal bones also revealed that, in this region, the main milk-producing species was cattle. Roughly 7,500 (±400) years old ceramic pot fragments containing primarily milk fat residues and lipid thermal degradation products of small ruminant origin were found in Ecsegfalva (Békés county) and in Schela Cladovei (Romania) **[6]**.

It is not an overstatement to say that the introduction of dairy farming was a major innovation, because it provided food to our ancestors in a sustainable way, i.e., without the need to slaughter valuable livestock **[2]**, **[21]**. Milk, available regardless of the season, was a safe food source for people who could digest lactose, providing a high degree of protection against periodic food shortages due to the seasonality of crop production and the unpredictability of weather **[12]**, **[23]**. Towards the north, the role of milk in the fight against famine further increased, and its shelf-life also extended **[7]**.

So, although certain early Neolithic populations were engaged in dairy farming activities, in the absence of lactase enzyme they could not consume milk without having unpleasant consequences (bloating, abdominal cramps, diarrhea). However, they soon realized that more digestible foods (cheese, yogurt, butter and other dairy products with reduced lactose contents) could be produced from this valuable raw material causing digestion problems and, in addition, these products could be stored and transported more easily than milk which spoils readily **[18]**.

The oldest evidence indicating cheese production was found in the Kuyavia region in the northern-central part of present-day Poland **[21]**. These are roughly 7,100 (±300) years old clay pot fragments, densely perforated by holes of 2 to 3 mm diameter, about which it was revealed by the composition of fatty acids found on them, that they served as filters to separate cheese curd from whey. The clay fragments come from the time of Eastern European linear pottery culture and from the region of its origin. Analysis of animal bones from the same period also revealed that cattle dominated among milk producing animal species (68-80%), whereas small ruminants played a significantly smaller role (13-18%) in livestock breeding and milk production **[21]**.

This means that the practice of milk production and dairy processing developed when, when the occurrence of the ability to digest lactose in adulthood, i.e., lactase persistence was negligible (practically zero).

It has become clear over the last decade and a half that, in Europeans, lactase persistence is closely related to a single-nucleotide polymorphism in the regulatory region upstream of the lactase gene, called –13,910 C/T, the C allele of which causes the inhibition of lactase activity, whereas the T allele causes its persistence **[10]**. Positive natural selection of the –13,910 T allele started roughly 7,500 (±1200) years ago in the northern part of the Balkans and in Central Europe **[16]**, probably in parallel with the above-mentioned evolution and initial spreading of the linear pottery culture **[18]**. In addition to the –13,910 T allele of Central European origin, three additional polymorphisms (–14,010 G/C, –13,915 T/G, –13,907 C/G), responsible for lactase persistence were found in East African livestock herding tribes **[25]**. The evolution of these took place similarly to but independently of the European allele over the last 3 to 7 thousand years **[4], [15].**

It has been shown that access to milk had a strong positive natural selection pressure on the lactase gene, which is almost unprecedented in the history of human genetics **[1]**, **[5]**, **[6]**, **[11]**, **[13]**, **[14]**, **[18]**, **[27]**. According to the calculations of Bersaglieri et al. **[1]**, the selection advantage due to the presence of the allele ensuring lactase persistence could be as high as 15 to 19%, i.e., in Scandinavia, for example, the individuals carrying the –13,910 T allele could produce almost 20% more fertile offspring compared to those who lacked it. Prevailing through hundreds of generations, such an advantage may well have helped a starting population to take over an entire continent. **[7]**.

The biological evolution of lactase persistence and the cultural evolution of milk production and dairying have been going on for millennia in a closely interlinked way, because the ability to digest lactose could only mean a selection advantage if fresh milk was always available and, on the other hand, individuals with lactase persistence benefited much more from dairying than did lactose intolerant people **[16], [18]**. This so-called gene-culture coevolution process was greatly assisted by a northwestern demographic expansion, accompanied by a decline in the significance of small ruminants and an increase in the importance of cattle breeding, as a result of which developed economies emerged in Central and Northern Europe 6,500 years ago, based on cow's, and partly on goat's milk **[16]**.

As a result of the thousands of years long processes outlined above, lactase persistence in Europe has become fairly widespread; however, it is much more common in the people of Northern Europe (>90%), than it is in Central (≈60%) and Southern Europeans (<40%). This suggests that the selection pressure on the lactase gene began to prevail after Neolithic farmers had settled in southern Europe. More specifically, the –13,910 C/T polymorphism developed in Central Europe after Neolithic farming communities had settled in the southern regions of the continent **[1]**. As far as the global situation is concerned, only one third of the world's current adult population is lactase persistent **[15]**, but the spatial distribution of the data is very uneven, because it is related to the that dairying has played in the everyday life of different populations **[1]**, **[17]**, **[22]**, **[24]**. Among the Hungarian adult population, the proportion of lactase persistent individuals is 61-63% **[8]**, **[19]**, **[20]**.

It is apparent from the above that the significance of milk is far greater than what its current role in our diet would indicate, because milk production and milk consumption have played a huge or, in the words of Curry **[7]**, a "revolutionary" role in the evolution of European peoples during the last 5 to 10 thousand years, and in the evolution in their genetic makeup. It is quite conceivable that most of Europe's current residents are descendants of the first lactase persistent milk producers.

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