Down on the farm, 10 000 years ago

An archaeologist investigates dairying

Mélanie Salque

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To find out about how people lived in the past, archaeologists look at the items (called artefacts) these cultures left behind. Using chemical analysis of residues in the artefacts an enormous amount of additional information can be gleaned. In this article, ***Mélanie Salque*** *of Bristol University describes how she investigates early dairy farming.*

The domestication of sheep, goats and cattle took place around 10 000 years ago in the Fertile Crescent in the Near East (see map). Neolithic culture, technology and economy (pottery, domestic plants and animals) came to Britain nearly 6000 years ago. When farming began, only meat was exploited, and it was later that people realised the benefits of exploiting the so-called 'secondary products', such as milk, wool, manure or muscle power, which can be obtained without slaughtering the animal.

Milk can be obtained from cattle, sheep and goats (ruminant animals). For each unit of their food, their milk yields 4 to 5 times the amount of energy and protein compared to meat. Therefore, the regular consumption of milk would have been highly beneficial to prehistoric people and a very important step in human prehistory.

The fertile crescent - the region of the Middle East where many agricultural crops and animals were first domesticated.

Archaeologists systematically excavating pottery and bones from a neolithic site

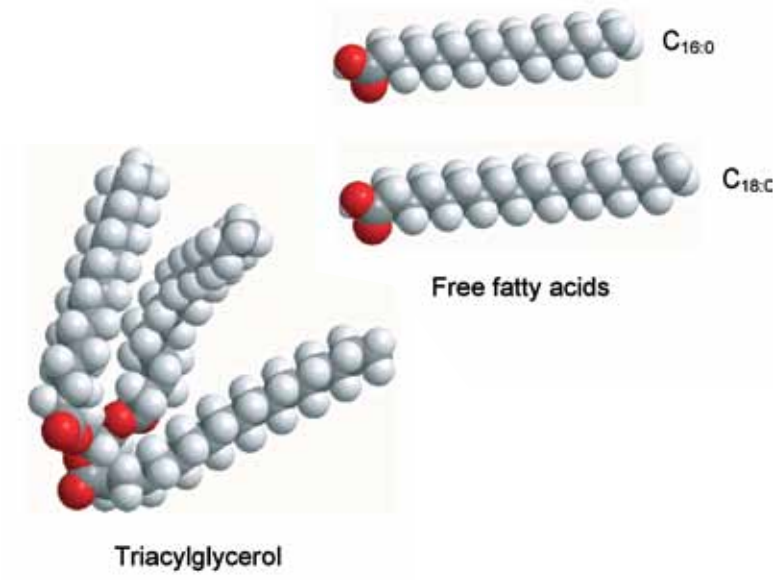
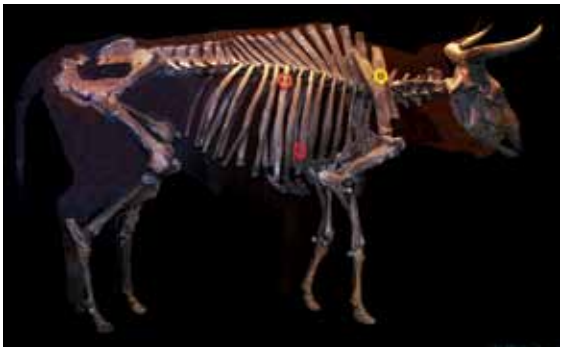


Figure 1 *Triacylglycerol (a lipid) can be split up to produce free fatty acids. $C_{16:0}$ is palmitic acid, $C_{18:0}$ is stearic acid.*

Ancient clues

Milk production and processing in the past have left clues that archaeologists, archaeozoologists (specialists in ancient animals) and chemists are now recovering. Just imagine yourself as a Neolithic herder, 6000 years ago. To get the maximum amount of goats' milk, most of the kids are slaughtered so that you can keep all the milk produced for yourself. To store and process the milk you use very porous pottery, as glaze has not been invented yet. You usually make cheese and yoghurt, so that you can transport the milk and its calcium, vitamin D and fat very easily and keep it for a long time (when you do not have a fridge, it's the only way to preserve milk!). It is also easier for you to digest than raw milk as after childhood drinking fresh milk makes you ill because you have become lactose intolerant.

When processing the milk, lipids (fat) are absorbed in the pottery clay wall and trapped. Even if you wash it, you can still see that the inside of the pottery is darker than when it was new – it's a bit fatty. When you break the pottery by accident, you put the shards into the rubbish pit.



9500 year old skeleton of a domesticated aurochs, the ancestor of modern dairy cattle.

Neolithic pots found during an archaeological dig

Analysing fatty acids

Many thousands of years later, archaeologists are excavating the site that you were living in. Their discoveries include animal bones and jaws with teeth and pottery; lots of broken potsherds. The study of animal bones and teeth by archaeozoologists shows that young goats (kids) were often killed, indicating a milk exploitation strategy. For a cooking pot, it is impossible to say what kind of foodstuff was prepared in it without crushing few grams of the potsherd to open the pores and extract the lipids (fats) with solvents. After analyses by gas-chromatography or mass spectrometry, which allow the separation of compounds and their characterization, we usually find some molecules which are very common in plants and animals; these are called fatty acids.

In fresh foods, fatty acids are found as parts of

larger molecules called triacylglycerols or TAGs (tri=3, 3 fatty acids attached to a glycerol), which are themselves the building blocks of meat fat and dairy fats. When fats in pots are degraded, because of the time and the burial conditions, fatty acids become detached from the triacylglycerol, yielding glycerol and three free fatty acids (see Figure 1). These are the fatty acids we recover from the archaeological pottery.

When fresh, it is easy to distinguish dairy from meat fats, as they have different compositions; there is a much broader range of TAGs in dairy fats than in meat fats. However, when they are degraded, the smaller molecules get lost and the range of TAGs in milk becomes narrower, to resemble meat fats. Palmitic (containing 16 atoms of carbon) and stearic acids (with 18 atoms of carbon) are usually the main fatty acids that are left behind in the potsherds.

A chemist searches for molecular and isotopic 'fingerprints' in an extract from an ancient pottery sherd.

Carbon isotopes

So how can we distinguish milk from meat in sheep/goat/cattle (ruminant) fats? We have to use something that does not change with time and will allow us to distinguish between all these types of fats. Their isotopic composition is the answer. These fatty acids are mainly made of carbon (together with hydrogen). The majority of this carbon is ^{12}C (98.9%), followed by ^{13}C (with one neutron more than ^{12}C, 1.1%) and ^{14}C (present in trace amounts). ^{14}C is radioactive, so once the animal dies the amount of ^{14}C decreases, and this property can be used to date organic remains via radiocarbon dating. ^{13}C and ^{12}C are stable, which means that their ratio, $^{13}C/^{12}C$, remains constant through time. The concentration of carbon in the atmosphere is roughly 7‰ (parts per thousand).

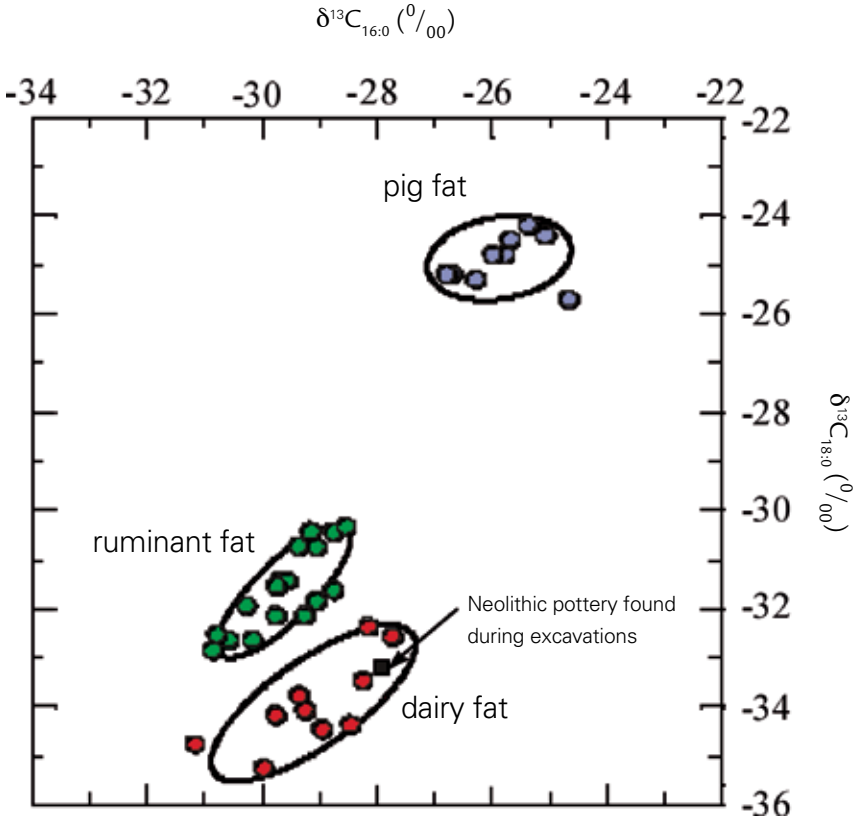


Figure 2 *Fatty acids from different sources have different proportions of the carbon isotope ^{13}C, as indicated by the $\delta^{13}C$ values. This chart shows the $\delta^{13}C$ values for modern reference fats, represented by plain circles. The ellipses indicate the areas where different fats coming from archaeological pottery are expected ('ruminant' = cow, sheep, goat).*

When incorporating the carbon from the air using photosynthesis, plants take up less ^{13}C because it is heavier than ^{12}C. So, proportionately, less ^{13}C is absorbed into the plant than is available in the source (air). This phenomenon called 'fractionation' is reflected in the animal's fatty acids with the exact value depending on the plants animals eat, the type of animal (ruminant or non-ruminant) and the type of fats (meat or dairy). The isotopic composition is measured by the $\delta^{13}C$ value, which shows how much less ^{13}C there is, relative to a carbonate standard. When we measure the $\delta^{13}C$ values of palmitic and stearic acids (the two major fatty acids found in pottery) of different modern animal fats, we find that they divide into different groups (see Figure 2). By undertaking the same analysis on archaeological pottery, it is now possible to distinguish ruminant from non-ruminant fats, and even meat from dairy fats!

One of the sherds recovered from your archaeological site is represented as the black square on the graph (see Figure 2). So, were you boiling your goat's milk in this pot?

Mélanie Salque is a PhD student at Bristol University working on the emergence of dairying in Prehistoric Europe through the analysis of lipids preserved in pottery vessels.