Processing food before eating likely played key role in human evolution, study finds

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Credit: Jm Verastigue/public domain

How much time and effort do you spend chewing? Although you probably enjoy a few leisurely meals every day, chances are that you spend very little time and muscular effort chewing your food. That kind of easy eating is very unusual. For perspective, our closest relatives, chimpanzees, spend almost half their day chewing, and with much greater force.

When and how did eating become so easy? And what were its consequences?

According to a new Harvard study, our ancestors between 2 and 3 million years ago started to spend far less time and effort chewing by adding meat to their diet and by using stone tools to process their food. The researchers estimate that such a diet would have saved early humans as many as 2.5 million chews per year, and made possible further changes that helped make us human. The study is described in a March 9 paper published in *Nature*.

One of the biggest puzzles in human evolution is how species such as Homo erectus evolved smaller teeth, smaller faces, and smaller guts, and yet managed to get more energy from food to pay for their bigger brains and bodies before cooking was invented. "What we showed is that...by processing food, especially meat, before eating it, humans not only decrease the effort needed to chew it, but also chew it much more effectively" said Katie Zink, the first author of the study, and a lecturer working in the lab of Daniel Lieberman, the Edwin M. Lerner II Professor of Biological Sciences.

By changing their diets to include just 33 percent meat, and processing their food - slicing meat and pounding vegetables - before eating, Zink and Lieberman found that the muscular effort required per chew and the number of chews required per day was reduced by almost 20 percent. They also found that by simply slicing meat with the sorts of simple tools available more than 2 million years ago, humans were able to swallow smaller, more easily digestible pieces than would have been possible without using tools.

"Eating meat and using stone tools to process food apparently made possible key reductions in the jaws, teeth and chewing muscles that occurred during human evolution," Zink said.

But testing a process as basic as chewing isn't as easy - or as attractive - as it might sound.

"What Katie did was creative but sometimes, frankly, a little stomach-churning," Lieberman said. "Not only did she have people come into the lab, chew raw meat and other foods, and spit them out, but then she had to analyze the stuff."

It wasn't just any food - or any meat - that subjects noshed on.

To approximate the toughness and texture of the game that early humans ate, Zink and Lieberman (after much experimentation) settled on using goat - which subjects chewed raw while Zink used instruments attached to their jaw to measure the effort involved.

In each trial, volunteers were given, in random order, a selection of foods prepared in several ways - raw, sliced, pounded and cooked goat, as well as several vegetables, including carrots, beets and yams. After chewing each morsel until they would normally swallow, subjects spit out the food. Zink then spread the individual food particles out onto a tray, photographed them, and digitally measured their sizes.

"What we found was that humans cannot eat raw meat effectively with their low-crested teeth. When you give people raw goat, they chew and chew and chew, and most of the goat is still one big clump - it's like chewing gum," Lieberman said. "But once you start processing it mechanically, even just slicing it, the effects on chewing performance are dramatic."

But why study chewing at all?

"Chewing is one of the key characteristics of being a mammal," Lieberman explained. "Most other animals, like reptiles, barely chew

their food—they just swallow it whole. The evolution of the ability to chew food into smaller particles gave mammals a big boost of extra energy because smaller particles have a higher surface area to volume ratio, allowing digestive enzymes to then break food down more efficiently."

Most mammals, however, eat a relatively low-quality diet- think of cows eating grass and hay - that they need to spend most of the day chewing. Even humans' closest ape relatives, with a diet that consists mainly of fruit, must spend nearly half their day chewing to extract enough energy from their food, Lieberman said.

"But we humans have done something really remarkable," he said. "We eat even higher-quality foods than chimpanzees, and spend an order of magnitude less time chewing them."

Making that change, however, presented early humans with a new challenge.

One of the critical components of that higher-quality diet is meat, which - despite being calorically dense - is very difficult for humans to chew effectively.

"Meat has a lot of nutrients, but it is also very elastic. You can think of it as being like a rubber band," Zink said. "So the problem is that we can't break it down with our flat, low-cusped teeth. But if you slice it up, then you do not need to use your teeth to break it down as much, and you swallow much smaller particles. Cooking makes chewing even easier."

That pre-processing, and the reductions in chewing effort that came with it, Zink and Lieberman said, may have opened the door to one of the most important lifestyle changes in human evolution - the emergence of hunting and gathering.

"With the origin of the genus Homo...we went from having snouts and big teeth and large chewing muscles to having smaller teeth, smaller chewing muscles, and snoutless faces" Lieberman said. "Those changes, and others, allowed for selection for speech and other shifts in the head, like bigger brains. Underlying that, to some extent, is the simplest technology of all: slicing meat into smaller pieces, and pounding vegetables before you chew them."

The impact that higher-quality diets and easier chewing could have on early humans is clear if you imagine what day-to-day life might have been like millions of years ago.

"Suppose you go out hunting for antelopes like impala or kudu, but at the end of the day you come back empty-handed, which happened fairly often for early humans," Lieberman said. "Chimps couldn't survive that way - they would then have to spend all night eating.

"Following the invention of hunting and gathering, though, humans can benefit from a division of labor," he continued. "Someone else may have come back with an impala, or some tubers you could eat. And instead of spending all night eating it, you'd spend a lot less time, energy and effort to chew it by pounding it or cutting it with just a few stone stone tools. What a dramatic shift!"

Though many aspects of our biology changed when the genus Homo evolved, Zink and Lieberman said that processing food before eating almost surely played a significant role.

"One of the innovations that helped make us human is cutting up and pounding our food," Lieberman said. "Extra-oral processing first by using stone tools and then by cooking played a very important role in human evolution because it released selection for big faces and big teeth, which then enabled selection for shorter faces which were important for

speech, and enabled us to grow big brains and have large bodies. We are partly who we are because we chew less."

More information: Impact of meat and Lower Paleolithic food processing techniques on chewing in humans, nature.com/articles/doi:10.1038/nature16990

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