Research shows how cranberry juice fights bacteria at the molecular level

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Terri Camesano, associate professor of chemical engineering at Worcester Polytechnic Institute (WPI), studies the effect that compounds in cranberries have on bacteria at the molecular level. Credit: Worcester Polytechnic Institute

Revealing the science behind the homespun advice, a team of researchers at Worcester Polytechnic Institute (WPI) has identified and measured the molecular forces that enable cranberry juice to fight off urinary tract infections in people.

The data is reported in the paper "Direct adhesion force measurements between *E. coli* and human uroepithelial cells in cranberry juice cocktail," which was published on-line, ahead of print, by the journal *Molecular Nutrition & Food Research*. The research illuminates the basic

mechanics of *E.coli* infections, which has implications for developing new antibiotic drugs and infection-resistant materials for invasive medical devices.

The research team led by Terri Camesano, professor of chemical engineering at WPI, focuses on the virulent form of *E. coli* bacteria that is the primary cause of most urinary tract infections. This strain of *E. coli* is covered with small hair-like projections known as fimbriae, which act like hooks and latch onto cells that line the urinary tract. When enough of the virulent *E. coli* adhere to cells in this way, they cause an infection. Previous work by Camesano has shown that exposure to cranberry juice causes the fimbriae on *E. coli* to curl up, reducing their ability to attach to urinary tract cells. In the new study, Camesano's team presents the first specific measurements of the mechanical forces involved in the attachment of the virulent *E. coli* to human urinary tract cells. The study also documents how the force of attachment is reduced in the presence of cranberry juice cocktail. "This is not a clinical study—it's a mechanical study that shows us the direct forces that can lead to infection," Camesano said.

To make measurements at the molecular level, Camesano's team developed a method to attach a single *E. coli* cell to the tip of a probe mounted on a device called an atomic force microscope (AFM). The probe was then dipped in a solution containing human uroepithelial cells, which line the urinary tract. The fimbriae on the *E. coli* latched onto to specific structures on the human cells, similar to the way the two halves of a Velcro fastener come together. The probe on the AFM was then pulled away from the human cells, measuring the amount of force needed to tear the *E. coli* away. "We know, on average, how many fimbriae are on each *E. coli* cell. And the total force we measured correlates with that number. So the data lead us to believe that the fimbriae each bind to a specific receptor on the uroepithelial cells," Camesano said.

The experiment was repeated numerous times with solutions containing human cells and various concentrations of commercially available cranberry juice cocktail. The data showed that the attachment force of the virulent *E. coli* weakened as the amount of cranberry juice cocktail increased. The study also showed that a strain of *E. coli* without fimbriae did not bind well to the human urinary tract cells, regardless of the concentration of cranberry juice cocktail, providing further evidence that fimbriae are essential for infection.

Furthermore, Camesano's team found that in the absence of cranberry juice, the strength of the virulent *E. coli*'s bond to the human cells was so strong that it could not be broken by the typical force of urine flowing through a person's urinary tract. However, as the cranberry juice concentration increased, the bond weakened to the point where the *E. coli* could be stripped away by the force of flowing urine. "The shear force created by flowing urine is a defense mechanism against urinary tract infection," Camesano said.

Since bacterial adhesion is required for infection, Camesano said understanding the specific mechanisms and forces involved will help direct future studies aimed at identifying potential drug targets for new antibiotics. The data may also be useful in studies aimed at engineering the surfaces of invasive medical devices like catheters to make them more resistant to bacterial adhesion.

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