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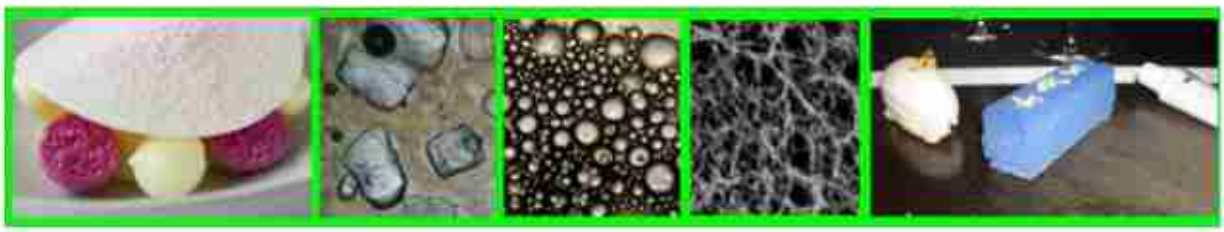

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Image for Thought

Corking and uncorking a bottle of wine

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Figure 1. Vintage corking apparatus and corkscrews. Left: hand-held bottle corker; right: four types of cork removers including a portable blade or prong cork remover (top center), double twist mechanism corkscrew (center below), simple corkscrew and (right) anthropomorphic handcrafted version of a corkscrew for uncorking beer bottles.

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Abstract

The image invites gastronomy scientists to observe the beauty and simplicity of a wooden corking device and some antique corkscrews. The article discusses the physical principles involved. A friction force predominates as the screw penetrates the cork. During pulling the cork out, a force must overcome the static friction holding the cork in the bottleneck, and the sliding or dynamic friction as the cork moves out.

Keywords

cork, corkscrew, wooden corker, wine bottle, mechanical forces

Introduction

In winemaking, wood is mostly associated with aging barrels or wine casks. We are possibly unaware that cork is produced by trees and in foregone times wood was an important material in kitchen utensils and tables, known generically as treen (Levi, 1998). The history of the corkscrew is stylishly presented by Gendzier (2001), who suggests that the first mention of a “corkscrue” dates from 1681. Wooden hand-driven devices to place corks in the bottleneck and uncork wine bottles were made by dedicated artisans often using the finest wood (Figure 1).

Although the image does not represent a scientific phenomenon, as usual in this section of the journal, it is an invitation for gastronomy scientists to observe the beauty of devices used in the culinary, whose ingenious mechanisms and involved physical principles are still valid in many modern metal or plastic, and electrically-driven devices. From a sustainability viewpoint, the wooden objects shown in Figure 1 were made from renewable material (except for the metal spiral) and operated by human energy.

Cork as a material

Cork is the periderm (outer protective tissue) in the bark of the oak *Quercus suber* L., harvested every 9 or 10 years. Cork is unique in that it is formed largely by dead cells whose cell walls are high in suberin (over 40%), a lipophilic macromolecule (Azevedo *et al.*, 2022). Structurally, cork is a natural light solid foam (density 120–180 $kg.m^{-3}$) that shows buoyancy in most liquids, has a low permeability to liquids and gases, and deforms on compression without fracturing (Silva *et al.*, 2005; Pereira, 2015; Dharmadhikari, 2016).

Here comes the physics

The corking and uncorking of wine bottles involves forces acting on the cork. In artisanal wine production, cellar workers use hand-held corkers (Figure 1, left). A wooden corker has a plunger that pushes a humidified cork (5-7% moisture, for plastic deformation) through a conical bore (wide opening at the top) hidden at the bottom of the apparatus in Figure 1 (left). As the cylindrical cork (24 mm in diameter) passes through this tapered geometry, it is evenly compressed from all sides to fit the 18 mm diameter of the bottleneck. Around 0.8 MPa of pressure is needed to compress a cork by 25% in the radial direction (Sergi *et al.*, 2021).

Pulling a cork is usually done with a corkscrew whose mechanism may be simple, mechanical, or lever, or with a twin-blade remover (Crestin-Billet, 2001). Uncorking a bottle of wine with a simple corkscrew is dominated by friction between the expanded cork and the inner wall of the bottleneck.

As the screw (usually a spiral) rotates by a force exerted through the corkscrew handle, the torque is converted into a vertical force that drives the screw into the cork. This force must overcome the friction force between the screw surface and the cork material that opposes the motion. Once the screw is inserted, pulling the cork out requires overcoming the static friction holding the cork in the bottleneck, and the sliding or dynamic friction as the cork moves out

(Kasper & Vogt, 2024). Surprisingly, a maximum force of 200 to 400 N (about the force required to lift a 20-40 kg mass) has been reported during the transit of the cork (natural or synthetic) through the bottleneck and then it slowly decreases until the cork is released (Godden *et al.*, 2001; Silva *et al.*, 2003: Giunchi *et al.*, 2008; Kasper & Vogt, 2024).

All this effort may be reduced by using a pivot-and-lever mechanism as those in corkscrews used by bartenders (Kasper & Vogt, 2024). In a twin-blade "cork puller" or "wine cork extractor" (Figure 1, center), two parallel metal prongs (often of different lengths) attached to a handle are inserted between the cork and the bottleneck. Turning alternate from one prong to the other while gently pressing downwards, allows removal of the cork by pulling without it being pierced or crumbled. The many (some are odd) ways to open a bottle of wine can be found at https://www.wikihow.com/Open-a-Wine-Bottle-Without-a-Corkscrew.

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