

Slippery Chocolate: the Gradient That Makes the Difference

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Why Do Some Chocolates Taste Better Than Others

In early 2023, scientists from the University of Leeds studied the physical processes happening inside the mouth when eating chocolate. In the experiment, by making a three-dimensional bionic tongue-like surface which imitates the shape, deformation, and degree of wetness of the human tongue, they realistically simulated the problems related to lubrication when tasting dark chocolate.

At the moment of entry, the sensation of chocolate comes from the way the chocolate is lubricated, from the ingredients in the chocolate itself, from saliva, or a combination of both. Fat plays a key role almost immediately when the chocolate comes into contact with the tongue, releasing a fatty film that coats the tongue and other surfaces of the mouth. It's this fatty film that makes the chocolate feel smooth throughout the mouth. Afterwards, solid cocoa particles are released which become important in the tasting experience.

This study is groundbreaking to propose three stages (licking, initial mastication/molten, and bolus before the swallowing) when chocolate is digested after it enters the mouth and the solid lubrication behavior before its deformation. The conclusion proves that the classical lubrication theory cannot completely explain the complex tribological principles of chocolate in the mouth. Since the chocolate here can be regarded as an edible PCM (Phase Change Material), it also provides a new idea for designing a healthier food with better taste: the gradient design suggests the surface of the chocolate to contain a higher concentration of cocoa butter while the concentration of solid cocoa particles is increased inside, so that the chocolate will contain lower calories while retaining a pleasant taste.

See and Touch the Layers of Chocolate

The original research paper contains complex formulas and graphs that demonstrate the lubrication mechanism of dark chocolates inside one's mouth. Therefore, we aim to show these outcomes in a more interesting and vivid form through illustration and tactile experience.

By creating a small 4-page booklet and a 3D model, we transformed the major findings from this study in three ways:

1. Using illustration, we demonstrate the three stages that a piece of chocolate will go through inside one's mouth. In the licking stage, the solid chocolate directly contacts the oral surface, which will stimulate glands to produce saliva; in the molten stage, the fat-rich layer of the chocolate is in contact with the tongue, leaving less friction and forming chocolate droplets that give off the smooth, satisfying sensation; in the last stage, the mixture of melted chocolate and secreted saliva is ready for being swallowed.

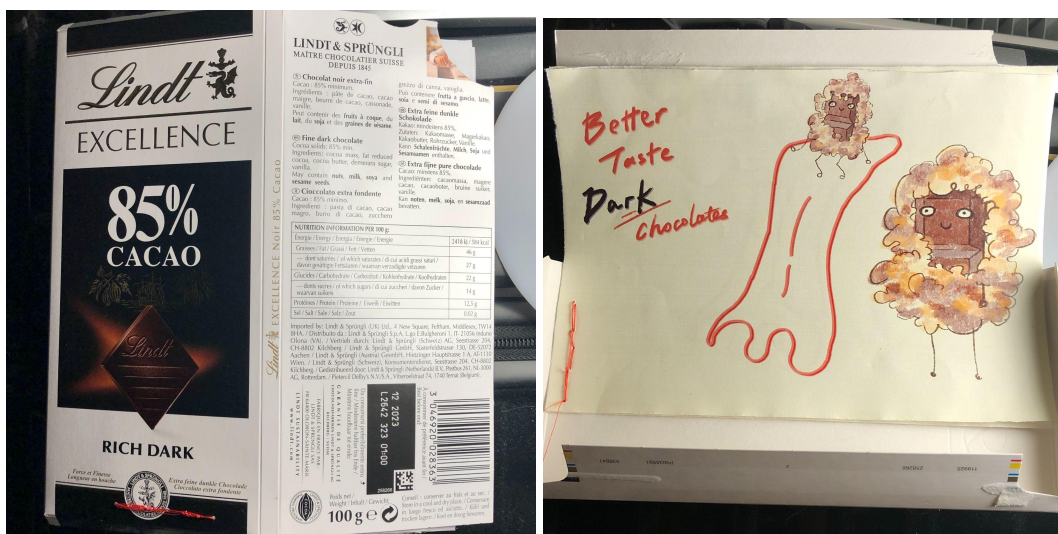
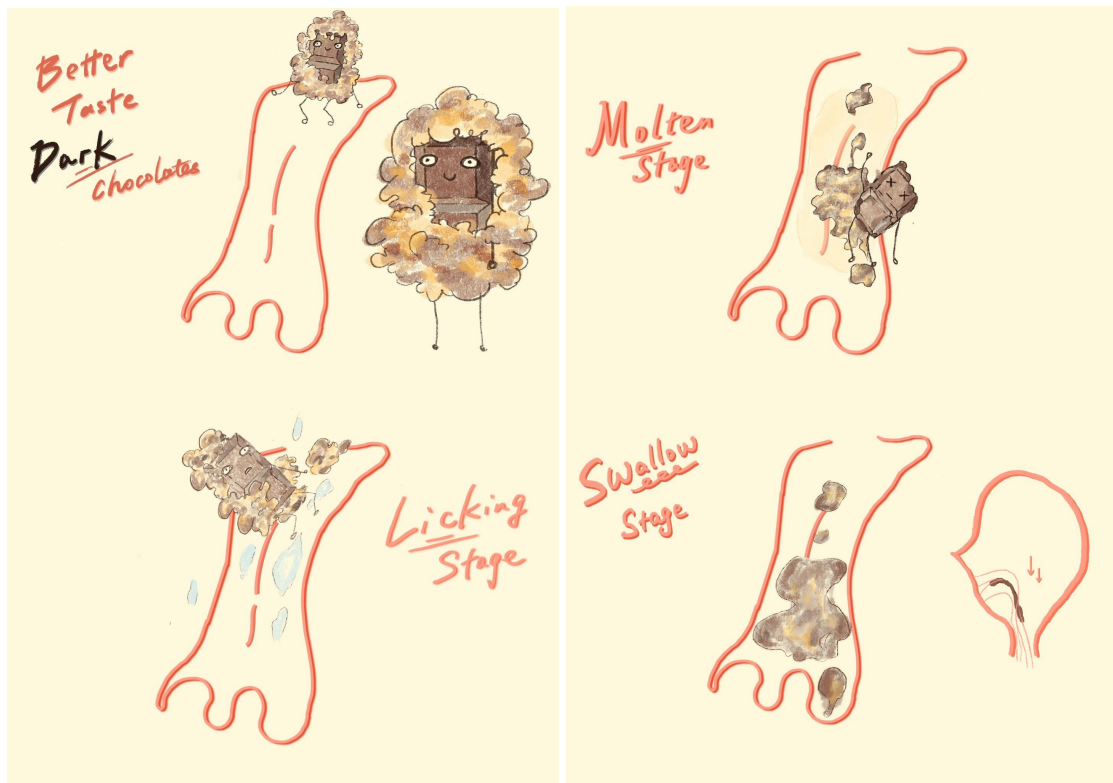


Fig. 1: Booklet Nested in a Real Dark Chocolate Wrapping

- One key finding from the researchers is the percentage of fat in shaping the lubrication behavior and tasting experience. They hence proposed a gradient architecture for dark chocolates where there's high fat at the surface and less fat in the bulk. We demonstrate this by creating a box with layers of different materials that give different touches. The oral perception is transformed into hand touch: one is invited to press and slide his or her hand down the layers to experience the differing levels of roughness created by the materials. The outermost layer is the softest and

most comfortable to touch, simulating the fat-rich layer of a chocolate. Further down, the materials would give a harder and rougher feel as a way to simulate the increased friction when tasting solid cocoa particles.



Fig. 2: Images of the Layered Chocolate Model

3. We then invite the user to wear a glove containing liquid (in this case, we are using dishwashing liquid) to experience the effect of saliva in the process of lubrication. According to this study, the lubrication between tongue and chocolate surface is disturbed when saliva comes into play. During the licking stage, the solid chocolate is in direct contact with the papillae or the salivary membrane on the surface of the tongue, and the secreted saliva is between the solid chocolate and the oral surface. Hence, the glove containing liquid functions as the saliva that goes between the tongue (hand) and the chocolate (our model), allowing the user to experience the mixture of chocolate and saliva during the lubrication process.

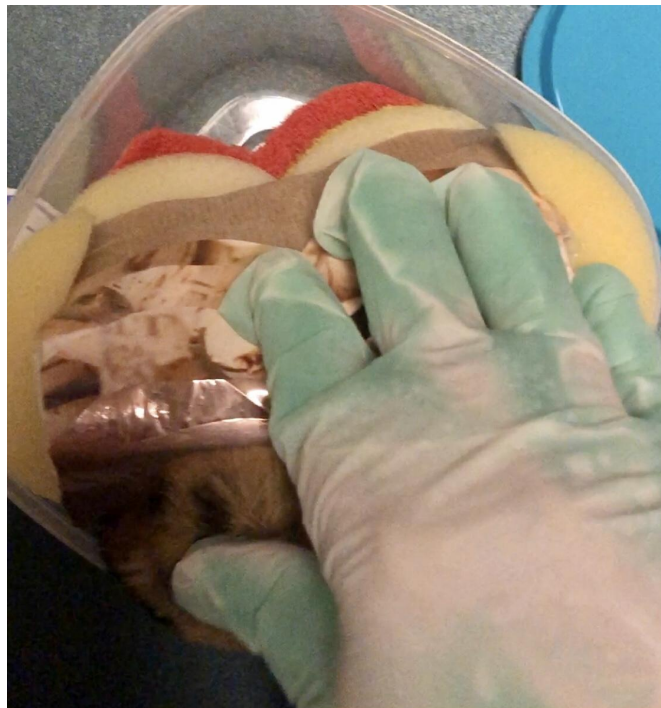


Fig. 3: Experiencing the Effect of Liquid on Tactile Perception

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