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# Make it snappy

From chocolate and cookies to crisps and celery, **Philip Ball** explores the roles of sound and feel in our appreciation of food

What's wrong with a biscuit that's gone soft? It has all the same ingredients as a crisp, fresh biscuit, so shouldn't it taste the same?

But it doesn't. A soft biscuit is nothing like as enjoyable as a fresh one. Yes, all the sugars and fats are still in there, but – and this is no news to master chefs and bakers – the sensory impact of eating food isn't just about composition. Texture plays a big role too: how the stuff feels in your mouth. In other words, food isn't just a matter of chemistry, but of physics too.

## Acoustic appetite

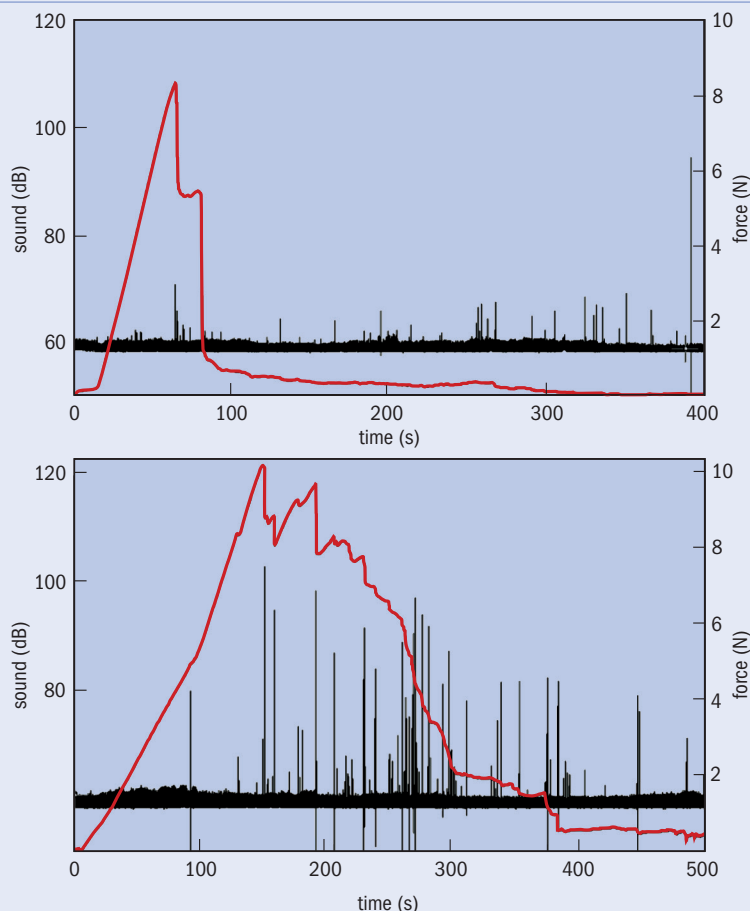
As with cooking in general, creating the right texture in a food is still as much of an art as a science. That's not for want of study: the food-science literature is full of mouth-watering papers on the crispness and snap of crisps, biscuits, chocolate and other guilty pleasures. The problem is us. Measuring the hardness or fracture strength of a chocolate bar only gives us part of the story, because the mouthfeel of food as we munch it is a complex, many-factored quality that is difficult to put into scientific terms.

Malcolm Povey, a physicist in the Department of Food Science and Nutrition at the University of Leeds, UK, is one researcher trying to do that. "Mouthfeel can't be reduced to one number," he says. In particular, crispiness and crunchiness are vital to the enjoyment of many foods, but – as he puts it – "it's notoriously difficult to get people to agree on their meaning". There's a subtle but important difference between, say, the sensation of biting into a brittle crisp and into a piece of fresh celery. Indeed, in China – a culture that takes its food rather more seriously than was long the case in the UK – there are about 11 different words for crispness.

Still, there's common ground. Povey and his colleagues have found that one of the defining features of the sensation of crispness is the noise produced when the food is fractured. We tend to imagine this as a single sound – "Crunch!" – but in fact there is a spectrum of sounds. Members of Povey's Leeds team analyse texture and fracture using an instrument in which a downwards load is applied to a small region in the centre of a piece of food, such as a biscuit,

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## 1 Crunch time for biscuits



The sound output (black) and force output (red) from a soft biscuit (top) are very different to those from a crispy biscuit (bottom). The mechanical “bite” is slow here in order to resolve individual crack events and associated jumps in force.

which is supported at its edges. The device is like a mechanical tooth – except that the researchers can precisely monitor the applied force and detect, with millisecond time resolution, the noise made as the food snaps. Even so, they need to initiate the fracturing about 100 times more slowly than a typical human bite speed, in order to see the signal clearly.

In this way, they find that the crunch is in fact made up of many spikes of acoustic emission: pulses of sound released erratically but typically several milliseconds apart. Each corresponds to a fracturing event, and each is accompanied by a sudden drop in the applied force (figure 1).

The difference between the acoustic spectrum for a dry and a soft biscuit is striking. A soft biscuit, left too long in the tin, produces only a few tiny acoustic bursts, whereas for the fresh, crisp biscuit there is a dense forest of them. What’s more, perception tests that the Leeds researchers conducted on students from a variety of cultural backgrounds showed a very high correlation between the subjects’ assessment of crispness and the intensity of sound pulses produced as they bit down. “Sound plays a crucial role in determining how much we like the experience,” says Charles Spence, an experimental psychologist at the University of Oxford, UK, who is an expert in the

“multisensory” aspects of eating.

Interestingly, this spiky acoustic spectrum is similar to that produced by the crumpling and rustling of materials such as the metallized plastic typically used in the packaging of crunchy foods such as crisps. This is no coincidence, says Povey: manufacturers are, possibly unconsciously, exploiting the association to suggest that the product itself is crisp. The rustling of crisp packets might be as annoying to cinema audiences as the crunch of the crisps themselves, but the similarity is intentional.

Other snack foods also seek out this crunch factor. Think of roasted nuts, for example. The raw nut has a chewy texture, but when roasted it becomes more brittle. Povey, working with Susana Fiszman at the Institute of Agrochemistry and Food Technology in Valencia, Spain, and their co-workers, have shown that roasting almonds transforms their acoustic spectrum from one with a few spikes to one with many, and makes the fracturing much more complex (2006 *J. Chemometrics* **20** 311). Of course, roasting induces chemical changes that alter the taste too, but these alone are probably not what secures the moreishness of roasted nuts.

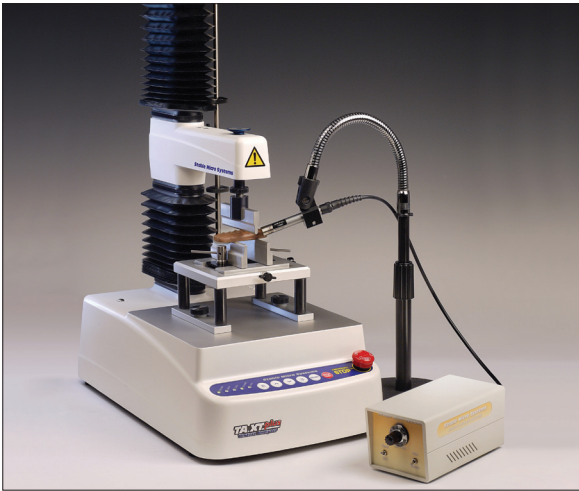
“Crispness and pleasantness are highly correlated when it comes to our rating of foods,” says Spence. No doubt that’s why some crisp adverts make the audible crunch a selling point. It’s not just a sales pitch – the sound of the crunch actually influences perceptions of texture and freshness. Spence, working with cognitive scientist Max Zampini of the University of Trento in Italy, showed that this was so by getting subjects to eat crispy snacks (Pringles, in case you’re wondering) while listening to the sound they made through headphones. When the sound was muffled, or just the high-frequency components were removed, the snacks were rated as softer and staler (2004 *J. Sens. Stud.* **19** 347). The same applies for apples.

Sound, says Spence, is “the forgotten flavour sense”, though the food industry now seems to appreciate that it’s worth remembering. “Global food companies have become increasingly interested in trying to perfect the sound that their foods make,” Spence says, “both when we eat them but also when we see the model biting into our favourite brands on the screen.”

This doesn’t bode well for the food range Silent Snacks launched recently by the UK theatre-ticketing company TodayTix, in conjunction with event-management company Teatime Production, specifically to minimize the nuisance of crunching and munching in the theatre and cinema. Their Quiet (Pop)Corn Bites, for example, are processed nuggets without any snap. Silent Slices of soft fruit replace crisps, and Muffled Truffles stand in for chewy chocolates. The company claims that 54% of people identify noisy eating (and rustling of packaging) as the most annoying disturbance in theatres. Perhaps so – but will audiences be prepared to forego the aural aspects of the taste experience to avoid it?

### Chocolate delight

Probably the food that has been subjected to the most intense research on texture is one for which the sensory, not to say sensual, experience has always



**From oral to aural** This acoustic envelope detector can measure the sound released in food tests, such as snapping a biscuit.

been a key selling point: chocolate. A good chocolate bar should have a satisfying snap when you break off a chunk. But it's not all about crispness – as is plain from all those adverts tempting us with molten chocolate being poured into lustrous folds. When you bite into chocolate, you don't want it to crunch with biscuit-like brittleness, but rather, to collapse with a kind of creamy “give”. It must feel firm between the teeth, but also dissolve silkily in the mouth. As “gastrochemist” Hervé This of research institute AgroParisTech in France explains, the crucial difference is between “consistency”, which is an innate property of the material, and “texture”, which depends on what you do with it. “When you put a piece of chocolate in your mouth and you wait, it melts,” he says. “But if you chew, it's crunchy.”

“Chocolate is very complicated,” says Povey. “The key attributes in a high-cocoa chocolate are snap, cooling in the mouth, sharp melting point, gloss and good release from the mould.” Balancing all of these attributes during processing and storage is a complicated affair.

The key textural ingredient of chocolate is cocoa butter, which is a complex fatty substance. In chocolate the fat is crystallized: the molecules are packed regularly. But cocoa butter has six different crystal forms or polymorphs, and only one (form V) has the glossy consistency and snap that we look for in a good chocolate. The usual methods of making chocolate confectionery produces a mixture of the desired form V and the softer form IV. Form IV will slowly change to form V over time, but the transformation is too slow to wait for. Besides, when it happens, some of the fat may be pushed out onto the surface, creating the white “bloom” of old chocolate.

So getting cocoa butter into the desired form V and then keeping it there is the secret to chocolate-making. Different types of cocoa butter have different melting characteristics in the mouth, and the best chocolate has a sharp melting point. Fat is also crucial for the all-important chocolate snap, but it's not exactly clear how. One of the problems is how to translate sensory perceptions of texture to independent materials properties that can be measured

## Global food companies have become increasingly interested in trying to perfect the sound that their foods make

instrumentally in the lab. That's because our brains don't seem to process these factors separately, but rather, integrate them into a subtle yet single and instant perception.

Povey has recently collaborated with colleagues at Aarhus University in Denmark to see how sensory perceptions of chocolate can be linked to mechanical and acoustic measurements (2015 *Food Res. Int.* **76** 637). They tested several fats used as cocoa butter alternatives in chocolate manufacturing, measuring properties such as hardness and sound emission and looking for correlations with perceptual qualities such as bite hardness and stickiness, brittleness in the fingers, and the perceived sound of the “snap”.

Some of these factors scarcely matched up at all: brittleness as reported from biting or manual snapping didn't bear much relation to brittleness measured by instruments. But sound intensity did: whether or not expert testers heard a satisfying snap when breaking and biting the samples could be predicted from objective acoustic measurements.

Direct testing of people's sensory assessments of food texture can be more expensive than sticking samples in a machine. But it's important, says Fiszman, who stresses that psychological tests can be made as “scientific” as instrumental ones. In the end, she says, “crispness” is a single perceptual quality, even if instrumentally it seems to be several. That's why panels of expert tasters are still essential. “The food industry has invested a huge amount in sensory testing using taste panels and marketing techniques,” adds Povey.

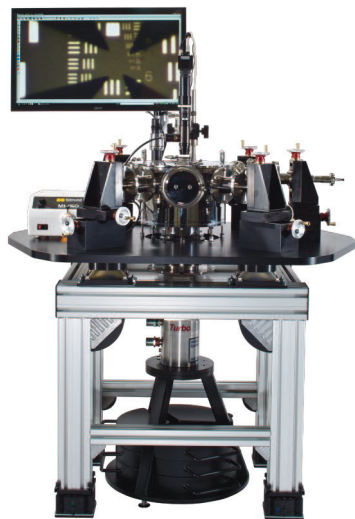
### Sounds tasty

Still, it's hard to get everything right. When Unilever modified the chocolate coating of its Magnum ice creams to stop the coating flaking and falling off when bitten – a common consumer complaint – the company found that people weren't too keen on the new variation either, because the chocolate then lacked the satisfying snap when bitten into. (Spence suspects that this cracking sound is magnified in Magnum adverts.)

Sometimes the sensory experience of eating a food is affected by factors that can't even be assigned to the food itself. Flavour perception, for example, depends on how much you salivate before popping the morsel into your mouth. Even the feel of a food in the hand can affect what it tastes like: tests have shown that subjects holding and biting into a composite pretzel with one end fresh and one end stale rate the taste as more fresh or stale depending on

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**Snap, crackle, yum** Chefs are increasingly experimenting with sound and texture in their cooking, to stimulate all the senses.

which end they're holding. Even the texture of the plates off which biscuits are eaten affects their taste.

Chefs are beginning to recognize the importance of texture, including the role of acoustics. "A growing number of chefs are now considering how to make their dishes more sonically interesting, using everything from a sprinkling of popping candy through to using the latest in digital technology," says Spence. He himself has collaborated with celebrity chef Heston Blumenthal to create foods that "maximally stimulate the senses". Another renowned chef – Ferran Adrià, whose restaurant-turned-creativity-centre El Bulli in Spain is at the cutting edge of experimental cuisine – feels similarly. "Cooking is the most multi-sensual art. I try to stimulate all the senses," Spence quoted him as saying a few years ago.

Why, though, should crispness and its acoustic signatures make food more tempting? Because this preference seems cross-cultural, it invites the notion that there is an evolutionary adaptation at work. As for This, he believes that texture preferences in food probably are adaptive to some degree. "Our sensory apparatus was designed by biological evolution so that we can get the most of plant or animal tissues," he says. "Chewing gives time for digestion to occur. And the more you masticate, the more flavour you get."

Povey says that most food likes and dislikes are learnt, but that liking crispy and crunchy sounds does seem to be innate to some extent. It may be no coincidence that the textural and acoustic features of a crisp or a biscuit resemble those of a fresh apple or green vegetable. The acoustics might be interpreted by the brain as a clue that the food is nutritious and good for us.

But snack foods, of course, often aren't. "The potato crisp is perhaps an example of the art of cooking fooling our senses," Povey says. The other possibility is that our brain might be responding to something else. Spence suspects that crunchiness instead serves as a sonic indicator for the presence of fat, which we are evolutionarily predisposed to crave. In which case the crisp is, on the contrary, sending out a sonic signal that is all too honest. And irresistible. ■