

# Why fruit are groovy

Pumpkins, melons and gourds are ribbed and ridged by the buckling of their skin.

[Philip Ball](#)

The different shapes of fruits and vegetables could be determined largely by the stretchiness of their skins. *Punchstock*

Why doesn't a pumpkin look like a balloon? Pumpkins and many other fruits and vegetables, such as gourds, melons and some tomatoes, aren't simply smooth, sphere-like shells with soft or empty interiors, but are marked by ribs, ridges or bulges that divide them into segments. A team of researchers in China [**Li Chaorong, Zexian Cao!**] and the United States [**Yin Jie, Chenxi!**] think that there's a simple, universal reason for these patterns: they are caused by buckling as the fruits grow.

The patterns formed in plants, such as the spiral arrangement of pine cones, combine mathematical regularity with complexity in ways that are hard to describe and explain; according to Charles Darwin, they could "drive the sanest man mad". But increasingly, botanists and mathematicians are coming to suspect that simple physical principles might underlie these shapes and structures.



Xi Chen of Columbia University in New York and his co-workers think that buckling of the outer skin could explain the appearance of fruits ranging from long, thin, ridged gourds to the pitted surface of the cantaloupe melon<sup>1</sup>.

## Squashbuckling

A balloon's surface stays smooth as it inflates, because it is equally stretchy everywhere. But fruits typically consist of a soft, pulpy interior surrounded by a thin,

stiffer peel or skin. In this case, the different mechanical properties of skin and core can cause buckling, just as they induce wrinkling of a paint film stuck to wood that swells and shrinks.

These buckling patterns are not arbitrary, the researchers say. For spherical or ovoid (spheroid) objects, they depend on three key factors: the ratio of the skin thickness to the width of the spheroid; the difference in stiffness of the core and skin; and the shape of the spheroid – whether, say, it is elongated (like a melon or cucumber) or flattened (like a pumpkin).

The calculations of Chen and his colleagues predict the buckling patterns for different values of these quantities. The patterns are generally either ribbed (with grooves running from top to bottom), reticulated (divided into regular arrays of dimples) or, in rare cases, banded around the circumference.

Ribs that separate segmented bulges are particularly common in fruit, being seen in pumpkins, some melons and varieties of tomato such as the striped cavern or beefsteak. The calculations show that spheroids shaped like such fruits may have precisely the same number of ribs as the fruits themselves.

For example, the ten-rib pattern of Korean melons remains the preferred state for a range of more or less elongated spheroids comparable to the shapes seen naturally. "The mechanical principles suggest that the fruit morphology of a given breed could be quite stable during its growth," says Chen. Meanwhile, differences of, say, skin thickness, would explain why different breeds of fruit with comparable spheroidal forms have different morphological features.

### **A wrinkly wrapper**

The idea that shapes of plants might stem from buckling during growth has been mooted before. Michael Marder of the University of Texas in Austin and his co-workers have proposed that this can explain the wrinkling patterns of leaf edges and the fluted shapes of daffodils<sup>2</sup>. And Alan Newell and Patrick Shipman, working at the University of Arizona in Tucson, have shown that the ridges on some cacti and the spiral arrangements of budding stems at the head of a plant shoot might result from the buckling of the stiff film or 'tunica' that covers the surface<sup>3</sup>.

But this is the first extension of the idea to spheroid surfaces. It might also help to account for the shapes of some seed pods and other biological structures. "These mechanical principles can explain the undulation patterns formed in nuts such as almonds, wrinkle patterns in the skin and trunk of elephants and wrinkles in butterfly eggs," says Chen.

"Mechanical buckling can indeed give rise to a range of spectacular patterns, and is likely to play an important role in plant morphology," says Lakshminarayanan

Mahadevan, a specialist in the deformation mechanics of thin films at Harvard University in Cambridge, Massachusetts. But although he finds the present study interesting, he adds that so far "it raises more questions than answers".

For example, Mahadevan points out that the authors' assumption that the skin is elastic doesn't seem realistic. "If one cuts a fruit, or separates the skin from the flesh, it doesn't recoil elastically or relax back," he says.

Chen and his colleagues acknowledge that their study is quite preliminary. Some of the shaping, for example, might be influenced by subtle biological factors such as different growth rates in different parts of the plant, or direction-dependent stiffness of the tissues, Chen adds.

### **References**

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2. Sharon, E. , Marder, M . & Swinney, H. L . *Am. Sci.* **92**, 254-261 (2004).
3. Shipman, P. D . & Newell, A. C. *Phys. Rev. Lett.* **92**, 168102 (2004).