

生物策略表

類別	生物策略 (Strategy)	
生物策略 STRATEGY	加壓的支撐物能消散衝擊力 (Pressurized struts dissipate impact)	
生物系統 LIVING SYSTEM	柚子 <i>Citrus maxima</i> (Pomelo)	
功能類別 FUNCTIONS	#應付衝擊 #防止破裂/斷裂 #Manage impact #Prevent fracture/rupture	
作用機制標題	柚子果皮能透過充滿液體的支撐物破裂而吸收衝擊力 (Skin of pomelos absorb impact by rupturing fluid-filled struts)	
生物系統/作用機制 示意圖		
作用機制摘要說明 (SUMMARY OF FUNCTIONING MECHANISMS)		
<p>柚子 (<i>Citrus maxima</i>)，是世界上最大的柑橘類果實。果實通常重約 2 公斤，有時可達 6 公斤，而植株則可高達 15 公尺。這麼大的果實從如此的高度落下，有因衝擊力而受損的風險，但為了讓它們繁殖的成功率最大化，柚子樹需要讓掉落的果實維持良好的狀態越久越好。這讓吃柚子的動物有足夠的時間可以找到果實，帶走果實，並散播吃下的種子。柚子樹原生於炎熱潮濕的地區，果皮上任何因掉落而造成的小裂縫，都會讓微生物進入並造成果實腐壞。為了避免受到衝擊的損害，柚子果皮厚度約 2-3 公分，可被壓縮。大部分柑橘果實都經過選擇性育種 (selective breeding) 而有所改變，但柚子是三種「真柑橘類」 (true citrus) 之一，其厚重果皮的存在是基於保護果實的需要，並不是人類的介入。</p> <p>柚子的果皮有許多層。最外層稱為外果皮 (exocarp)，由細胞密集堆疊而成。接著一層是柚子皮的主體，稱為中果皮 (mesocarp)。在中果皮裡面的是內果皮 (endocarp)，包含果實內所有的種子及果肉瓣。中果皮或髓 (pith)，是主要負責保護果實免受衝擊的果皮層，是一種開放式的多孔泡沫狀構造 (porous foam)。也就是說，中果皮是由許多互相連接的氣室 (air cells) 所形成。當果實掉落時，這些小氣囊像減震墊 (cushion) 般癟掉，吸收衝擊的能量，保護內果皮和外果皮不受傷害。不像一般的泡沫減震墊，構成泡沫狀中果皮物理性構造的支撐物充滿液體且受到壓力。這些支撐物的破裂能吸收更多的能量，以確保柚子果實特別地能夠在掉落後無損傷。</p>		

多層次材料在壓力下可能分離或分層 (delaminated)。當這種情況發生時，會喪失材料的物理性特質。柚子果實的果皮分層沒有明確的界線，而是由外果皮逐漸轉變到中果皮，最初是細小的空氣間隙，隨著接近果實中心而逐漸變大。這種從高密度堅硬材質逐漸轉變到柔軟泡沫狀材質的特性，讓柚子皮不會產生分層現象，而保留其保護特性。

The pomelo, or *Citrus maxima*, is the largest citrus fruit in the world. The fruits usually weigh around 2 kg and occasionally as much as 6 kg, while the trees reach 15 meters in height. Such large fruit falling from such a height are at risk of being damaged by the impact, but to maximize their chances of reproducing, the trees need the fallen fruit to stay good for as long as possible. This gives time to the animals that eat pomelos to find them, carry them away, and spread the eaten seeds. The trees are native to hot and humid regions and any splits in the skin caused by the fall will give access to microorganisms that cause fruit to spoil. To protect from impact, pomelos have a compressible skin 2-3 cms thick. Most citrus fruit have been altered by selective breeding, but the pomelo is one of the three “true” citrus and so its thick skin is due to the need to protect the fruit and not due to human intervention.

The skin of the pomelo has multiple layers. The outermost layer, called the exocarp, is densely packed with cells. The next layer, which forms the bulk of the peel, is called the mesocarp. Inside the mesocarp is the endocarp, which contains all the seeds and pulp segments of the fruit. The mesocarp, or pith, is the layer primarily responsible for protecting the fruit from impact, and it is an open porous foam. That is, the mesocarp is made of many air cells that are interconnected with each other. When the fruit falls, these air pockets collapse like a cushion, absorbing the energy of impact, protecting the endocarp and exocarp from damage. Unlike a simple foam cushion, the struts that make up the physical structure of the foam mesocarp are fluid-filled and under pressure. Rupturing these struts absorbs even more energy and ensures the pomelo is exceptionally good at surviving a fall.

Layered materials can separate under stress, or become delaminated. When this occurs they lose their physical properties. The layers of the pomelo are not clearly defined. Instead, the exocarp gradually transitions into mesocarp that at first has small air-filled gaps that become gradually larger closer to the center of the fruit. By gradually transitioning from a dense, tough, material to a soft foamy one, the fruit cannot delaminate and its protective nature is preserved.

文獻引用 (REFERENCES)

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延伸閱讀

生物系統延伸資訊連結 (LEARN MORE ABOUT THE LIVING SYSTEM/S)

https://en.wikipedia.org/wiki/citrus_maxima
https://www.onezoom.org/life/@citrus_maxima
<https://eol.org/pages/488254>

撰寫/翻譯/編修者與日期

譚國銓翻譯 (2021/03/22)；洪麗分編修 (2021/04/10)

AskNature 原文連結

<https://asknature.org/strategy/pressurized-struts-dissipate-impact/>