

Macadamia — a hard nut to crack!

Why do *Macadamia* nuts have hard shells?

Nuts have been an important nutrient source for people for an astonishingly long time. A 2016 article in *New Scientist*, reports on an archaeological site, the Gesher Benot Ya'agov in northern Israel, which provides the first evidence of the type of plants eaten by our Palaeolithic human ancestors, probably *Homo erectus* or a related species, and dated at 780,000 years before present. Why is this site so important? Because more than 50 different kinds of plants were preserved at the site, suggesting that Palaeolithic human ancestors not only ate meat and fish, whose remains are far more likely to be preserved, but also a great diversity of *nuts*, fruits, seeds, leaves, stems roots and tubers from a wide range of herbs, shrubs and trees!

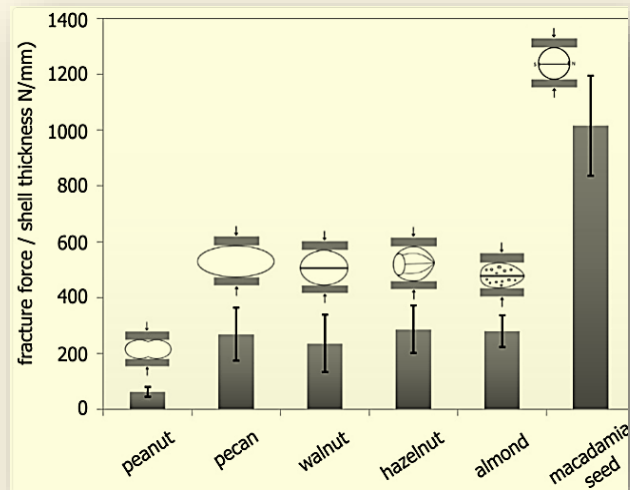
Nut is a technical term, and it refers to fruits which have only one seed and a hard, thickened coat which doesn't split when they mature to release the seed. Well-known examples include chestnuts, oaks (acorns) and hazelnuts.



A *Macadamia* fruit is technically not a *nut*, but rather a *follicle* because it splits along one side to release its seed. The fruit has a green, leather coat, enclosing a smooth, *exceptionally hard* shell that encloses the white kernel. This kernel looks as if it originated from a single ovule, but it was the larger of twin ovules. After fertilisation, the other ovule aborts, leaving the larger to grow into the globular *nuts* with which we are so familiar.

Although they have relatively thin walls, seed coats of *Macadamia* nuts are

exceptionally hard to crack. Engineers interested in applying nature to modern materials (biomimetics) have taken an obvious interest in these hard shells. Fracture forces ranging from 1800 to 4000 Newtons (~ 400 kg-force) are necessary to crack *Macadamia* seed coats, five times more than for other *nuts* such as hazelnuts, walnuts and almonds: the seed coats have the same specific tensile yield and strength as pure, annealed aluminium! In the natural world, hard seed coats provide protection from environmental impacts, such as water loss, UV radiation and mechanical damage but biologists are asking deeper questions relating to the evolutionary advantages of investing into such high-strength materials.



Fracture forces related to shell thickness for different seeds and nuts and legumes. From Schöler P, Speck T, Bührig-Polaczek A, Fleck C., 2014.

Forest ecologist Rob Kooyman tells us that several genera in the family Proteaceae, including *Macadamia*, have nuts that provide rich rewards for rodents (rats), possums and (of course in the case of *Macadamia*) hominids; all now play a role in dispersal. Curiously, we accept *adaptation* as a key part of the evolution of living organisms but some lineages, including *Macadamia* and other species in the Proteaceae, are characterised by phylogenetic and trait conservatism. In other words, constant *adaptation is not always what plants do!* Hard shells and nutrient-rich embryos secure well-provisioned potential young *Macadamia* seedlings, despite providing a rich reward for seed predators like rodents. The loss of larger (animal) dispersers may have limited the restricted the range of many large-seeded species. So, what we have now in the case of *Macadamia* and other large-seeded species are patchy distributions and locally persistent populations in reduced areas of suitable habitat - an evolutionarily risky but still successful strategy for survival. This explains why *Macadamia* species are often listed as *Threatened Species* despite being very persistent in the remaining areas of natural habitat. In evolutionary and ecological terms, if environmental conditions change in their favour, *Macadamia* and other large seeded species may re-emerge as more abundant species with larger and more widespread populations – if not, they may go extinct! Life is an evolutionary lottery!



In addition to predation and dispersal in natural habitats by rodents, conservation palaeontologist Matthew Kosnik has drawn our attention to a situation in horticulture where he observed Sulphur Crested Cockatoos feeding on the nuts on his backyard tree. In that case, the cockatoos prefer the green, fleshy, leathery outer portions of the *Macadamia* nuts. When they feed on *mature* nuts, the *hard-shelled* nuts fall intact to



Cockatoos eating immature *Macadamia* nuts with green leathery outer husks. Photographs: Sean Kosnik

the ground intact where the enclosed, protected seeds eventually germinate and grow. However, when they feed on *immature* nuts, their beaks easily penetrate the *not-fully-hardened* shells, damaging the seeds to the point where they are no longer viable, nor worth eating! A shell hard enough to withstand a cockatoo's beak is impressive... and certainly provides great protection for the next generation.

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Alison Downing, Rob Kooyman, Brian Atwell, Karen Marais, Kevin Downing, and with special thanks to Spencer Ferrier for posing the question!



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