## TEACHING PHYSICS WITH FOOD AND DRINK

*Set 'em up: (left to right) an egg, beetroot juice, salad oil and water in visible and near-infrared light.*

*A brighter shade of pale: see how the dark-green cucumber becomes as bright as the celery in NIR light.*

# A photoshoot for food and drink:

Most digital cameras use charge-coupled devices (CCDs) to detect images. Essentially, the light-sensitive part of the CCD consists of an array of small photodiodes – a set of three for each image pixel.

In most digital cameras, each diode is covered by a colour filter – red, green or blue. They are sensitive not only to visible light but also to near-infrared (NIR) light of wavelengths of up to about 1200 nm. So digital cameras can 'see' part of the electromagnetic spectrum, from about 700–1200 nm, that is not visible to our eyes.

RGB colour filters are practically transparent for NIR light, so all three diodes in a pixel detect NIR light with about the same intensity, making final images obtained in this wavelength region look to us like black-and-white photographs.

How can you take digital images in near IR light? For this activity you will need a digital camera (preferably one with adjustable exposure time) and a suitable IR filter that transmits light that has wavelengths longer than about 850 nm. The images shown here were obtained using a Canon G2 camera and Kodak filter no 87C (a piece of filter measuring 10 × 10 cm costs about €20 and can be bought from photographic equipment shops).

All you have to do is to cut a circle of filter foil to match the diameter of your camera objective and fix it onto the objective with self-adhesive tape. If you are unable to get a suitable IR filter, you can make one from two perpendicularly crossed polarizing filters, one placed on top of the other, cut into circles and fixed over the objective in the same way.

Take a picture with the IR filter right in front of the camera. Adjust the exposure time to larger val-

*Now you see it, now you don't: the cartoon concealed by the beetroot juice becomes visible in NIR light.*

*Fade to grey: the vibrant M&Ms become indistiguishable greys in NIR light, while the rose stands out.*

# camera 'sees' more than you think

ues (about 1 s) and use the brightest lamp possible (or sunlight) to illuminate the scene. Also take a picture of the same scene in visible light.

After I transferred my IR images to the computer I converted them to 'greyscale' (just to reduce the size) and applied 'auto equalize levels', which is one of the standard functions in all image-processing programs (I use Corel PhotoPaint 8).

Comparing visible light images and NIR images of the same objects shows that the interaction of light and matter can vary dramatically with different wavelengths of light (i.e. the energy of photons).

For example, water is colourless and transparent in visible light while salad oil absorbs some light, giving it a yellowish appearance. In NIR light, however, water is dark and salad oil almost transparent. This means that at these IR wavelengths water absorbs more light than salad oil does. On the other hand, beetroot juice, which absorbs most of the visible light, is transparent in the NIR. The rules of optics still 'work' in 'non-visible' light (note the magnified drawing behind both glasses, above).

Cucumber is one of the darkest vegetables in visible light but is as bright as celery in the NIR. M&Ms are coloured in visible light but look nearly the same in the NIR, whereas the flower of a deep-red rose that looks dark in visible light appears to be much brighter in the NIR.

There are many other substances that you can examine in this way. Try fruits, meat, utensils, cereals and the printing on different packaging.

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