

Antioxidant advances

Consumers are increasingly intrigued and concerned by the direct link between their diet and their health. Professor Gary Williamson, head of nutrient bioavailability at the Nestlé Research Centre, examines the prospect of adding polyphenol supplements to food products.

It is now widely recognised that the foods we eat and the chemicals we are exposed to throughout certain periods of our lives (for example, during developmental stages) may well determine the diseases we develop in later years. Vitamins and minerals have long been considered essential to a healthy diet, but recently other nutrients (especially antioxidants) have become equally vital. A group of phytochemicals called polyphenols are currently the most commonly found antioxidants in the human diet.

Polyphenols are found in high concentrations in wine, tea, grapes, cocoa and a wide variety of plants. Phenolic compounds are responsible for the brightly coloured pigments (and intense flavours) of many fruits and vegetables. One of the most nutritionally important classes of polyphenols is the flavonoids. Flavonoids have been linked to counteracting cardiovascular disease, cancer and osteoporosis as a result of their antioxidant, antibacterial, antiviral, anti-inflammatory and anti-allergenic properties. More than 4000 flavonoids have been identified, but the majority fall into the following overlapping groups:

- ❖ Lignins (nuts, wholegrain cereals)
- ❖ Proanthocyanidins (grapes, pine bark, cocoa)
- ❖ Anthocyanins/Anthocyanidins (brightly coloured fruits and vegetables, berries)
- ❖ Isoflavones (soybeans)
- ❖ Catechins (tea, grapes, wine)
- ❖ Tannins (tea, nuts)
- ❖ Quercetin (grapes, wine, onions)
- ❖ Naringenin/Hesperidin (citrus fruits)

Molecular structure

Polyphenols are commonly viewed as a complex family of molecules, with several hundred compounds present in food. There is a wide gap between the wealth of data measured in vitro on the advantageous effects of polyphenols, and the lack of evidence regarding their beneficial effect on human health. However, we can assess their intake and bioavailability

(the degree to which any given nutrient is available to the body). The speculated health-promoting effects of polyphenols are generally attributed to their antioxidant action, but other biological mechanisms are probably more important. Soy isoflavones, for example, function as phytoestrogens. These may play a role in bone metabolism, which in turn improves bone mineral density.

Recent experimental studies in both humans and animals have shown that an increased intake of polyphenol can prevent LDL cholesterol from becoming oxidised, reduce the blood's tendency to clot, lower blood pressure and elevate the total antioxidant capacity of the blood. In general, polyphenols (or flavonoids) are thought to directly quench free radicals, while ensuring the protection and regeneration of other dietary antioxidants (such as vitamin E). This is the key to the 'French paradox', where the regular, moderate consumption of red wine (rich in polyphenols) is associated with low rates of coronary artery disease.

Uptake and absorption

Despite the complexity of polyphenols, much progress has been made in recent years to estimate their intake in the average human diet, and to determine their fate in the body. Polyphenols show considerable structural diversity, which largely influences their bioavailability. Phenolic acids are easily absorbed through the gut, whereas polyphenols of large molecular weight, such as proanthocyanidins, are very poorly absorbed. Following absorption, polyphenols are fused to glucuronide, sulphate and methyl groups in the gut and inner tissues; isolated polyphenols are virtually absent in plasma. These reactions facilitate the excretion of polyphenols, limiting their biological activity at dietary doses and increasing their potential toxicity at high doses.

The polyphenols that do reach the colon are metabolised into a variety of low molecular weight phenolic acids by microflora. However, there are some potential effects of polyphenols that may not require their absorption through the gut barrier. They can also act as iron chelators in the intestine, reducing the production of free radicals and oxidative stress.

Dietary supplements

Given the obvious health-improving properties of polyphenols, there is a growing demand to optimise their levels in various food products. This will involve the production of more appropriate fruit and vegetable varieties, selective breeding, modified processing or modified ingredients. As with any new additive, it is essential that foods with altered polyphenol content are safe for consumers. As yet, there is no evidence of any significant side effects from regular consumption of dietary supplements containing polyphenols or flavonoids. However, it is always best to obtain a wide range of antioxidant compounds from natural sources such as fruits, vegetables, nuts and wholegrain cereals. Dietary supplements should only be taken as a means of antioxidant support – not to compensate for a poor diet.

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The polyphenol content of fruit and vegetables can vary significantly, depending on cultivation and harvesting methods, the degree of ripeness, the part of the plant used, storage conditions and processing methods. The statutory recommendation to eat five servings of fruits and vegetables daily would result in a total flavonoid intake of about 150–300mg per day. Environmental and technological factors need to be controlled to optimise the polyphenol content of foods. Factors such as soil type, sun exposure, rainfall and fruit yield all play a significant role in determining polyphenol content. Many polyphenols are directly involved in a plant's response to different types of stress. They contribute to healing and possess anti-microbial properties, which means that polyphenol concentrations in a plant will increase after an infection.

Food for thought

The main difficulty with incorporating polyphenol into existing products is to present it in a form that is bioavailable. The bioavailability of polyphenol is enhanced in its glycoside form (the naturally occurring form with the sugar still attached), rather than the more readily available free (or aglycone) form.

Currently, there are two ways to introduce polyphenol supplements into food products. Firstly, producers can modify 'fermentation' processes. This method has been used to accelerate the antioxidant properties of tea and soy for many centuries. The process of fermentation increases the amount of

bioavailable polyphenol, and consequently the amount that is absorbed. The second method available is to add polyphenol-rich extracts to food as natural additives. There are very few additives available, but there are many polyphenol-rich supplements on the market. One example is the Inneov product Fermeté, containing soy isoflavones. Inneov also produce Capillaire, which contains green tea extract.

Bioavailability appears to differ greatly between the various types of polyphenol. Those found most commonly in the diet are not necessarily those with the best bioavailability profile. Proanthocyanidins and anthocyanins are either very poorly absorbed or not absorbed at all. Flavanones and isoflavones have the best bioavailability profiles. Polyphenols are an incredibly complex group of compounds. Their metabolism means that the polyphenol found in natural foodstuffs is not necessarily the one that is active. The process of activation occurs in the human body, but to different extents in different people. The actions of microflora and enzymes in the gut on the chemical structure of polyphenols may change their bioavailability.

Polyphenols can also form complexes with reactive metals such as iron, reducing their absorption. At first glance, this may seem to be a negative side effect, but excess levels of iron in the body can promote the generation of free radicals and contribute to the oxidative damage of cell membranes and cellular DNA. Polyphenols also function as potent free radical scavengers within the body, neutralising free radicals before they can cause significant cellular damage.

Clinical evidence

While *in vitro* evidence supports the anticarcinogenic properties of flavonoids, this has yet to be corroborated by human studies. However, there is now good *in vivo* evidence that polyphenols exert some beneficial effects on the health of humans (especially for vascular function and bone mineral density). There have now been over 100 human clinical studies examining the effect of polyphenols on health biomarkers and 100 human bioavailability studies on polyphenols. The collective conclusions of these studies will contribute to the promotion of improved dietary advice. Furthermore, information about the optimal levels of dietary phytochemicals could facilitate the appropriate development of novel and functional foods. There is already a growing range of products on the market aiming to improve health with polyphenol supplements. Given that the Western diet does not tend to favour those foods already shown to be naturally abundant in polyphenols (such as green tea polyphenols and isoflavones in soy), it is inevitable that the modification and enhancement of basic foodstuffs with polyphenols will soon become common practice. ●