Letter to the Editor

Garry Duthie

Answer to Prof. Galvano's Letter to the Editor

Unlike most fruit and vegetables, berries are rich sources of dietary anthocyanins. These glycoside-linked flavonoids are responsible for the red to purple colouration of the fruits. Several *in vitro* studies indicate that anthocyanins may have biological properties that may benefit health including anti-oxidant and anti-inflammatory activities [1]. However, the bioavailability of anthocyanins is poor in that less than 1% of that in ingested fruits may appear in blood and urine [2]. This may suggest that dietary anthocyanins may be rapidly degraded *in vivo* thus calling in to question the nutritional relevance of anthocyanins in relation to disease prevention [3].

In their letter "Protocatechuic acid: the missing human cyanidins' metabolite", Prof. Galvano and colleagues cite evidence suggesting that simple phenolic acids are major colonic metabolites of some anthocyanins such as cyanidin glucosides. Moreover, such phenolics may be subsequently absorbed from the colon in to the systemic circulation. This may be important for health as many phenolic acids have the ability to inhibit the formation of pro-inflammatory prostanoids which are linked to major diseases such as cancer and heart disease [4]. Indeed, in the special edition of Molecular Nutrition & Food Research on berry fruits, Russell *et al*. [5] provide corroborative evidence for the mechanism of production of phenolics in the colon as they quantified and identified a plethora of benzoic and cinnamic acids when blueberries were treated with human faecal inoculants.

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As Prof. Galvano points out, the value of *in vitro* studies using pure dietary anthocyanins therefore is questionable as these are rarely the compounds that are presented to cells and tissues *in vivo*. It may be the metabolic products rather than the parent compounds which exert important biological effects. This is also true for many other flavonoids found in berries including flavonol glycosides such as quercetin and myricetin glucosides and galactosides and flavan-3-ol monomers such as (+)-catechin and (-)-epicatechin. Saturation of metabolic pathways by "pharmacological" doses appear to be required to obtain the free form in the blood and labelling studies suggest that there is rapid formation of numerous metabolites in both the small and large intestine [6].

Absorption of phytochemicals including anthocyanins will depend on numerous factors including molecular structure, the amount consumed, the food matrix, degree of bioconversion in the gut and tissues, the nutrient status of the host and genetic factors. As Prof. Galvano rightly points out, it is not adequate to predict the potential health effects of polyphenols by merely considering their native structures. Metabolomic approaches will hopefully begin to provide more information on the levels and identity of the numerous *in vivo* metabolites that appear in the colon and circulatory system after ingestion of berries. Consequently, *in vitro* studies investigating the potential health benefits of berry phytochemicals will need to use genuine *in vivo* metabolites rather than the aglycones or glycosides which are generally not detected in the body.

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