AnThocyanin and polyphenol bioactives for Health Enhancement through Nutritional Advancement

Adding colour to your life

Findings from the ATHENA project

Highlights from the ATHENA Collaborative Project funded by the European Commission

ATHENA

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Why anthocyanins?

Anthocyanins are health promoting pigments made by plants belonging to the family of compounds known as flavonoids. These compounds have powerful antioxidant properties and major sources are represented by blueberries, cherries, raspberries, strawberries, black currants, purple grapes and red wine. A large body of studies has shown that anthocyanins are able to convey protection against cardiovascular disease, cancer and obesity in preclinical studies with animals. Actually, the diet followed by the majority of people living in the Western world does not appear to be sufficient to guarantee an adequate intake of flavonoids and anthocyanins, present in many fruits and vegetables. The Western diet model is far more characterized by high intakes of saturated fats and "touch and go" meals, quitting the protection offered by these natural supplements mainly contained in fruits and vegetables. Thus millions of people lack these helpful natural compounds and need to find new ways to fill up on the nutrients they need.

Flavonoid intake of adults (18 to 64 years) in the European Union by region

REGION	FLAVONOIDS (mg/d)
NORTHERN Denmark Finland Sweden	348
CENTRAL Belgium Czech Republic Germany Hungary Ireland Latvia Netherlands United Kingdom	506
SOUTHERN France Italy Spain	301
EUROPE	428

Data from Vogiatzoglou et al. PLoS ONE 10(5): e0128132)

The habitual intake of flavonoids in Europe is below the amounts found to have a significant health effect. (Vogiatzoglou et al. PLoS ONE 10(5): e0128132)

ATHENA's mission

Cardiovascular disease and tumours cause more than two thirds of deaths in the Western World, representing an authentic burden not only for individuals but also for society due to the high costs for therapies and health care and due to lost income. A significant proportion of chronic diseases are preventable by reducing behavioural risk factors, the most significant of which are unhealthy diets. The ATHENA project represents a focused and effective contribution to meeting this challenge by exploring the basis for dietary improvements to protect societies against chronic disease. The main task of the ATHENA project is to provide a robust scientific foundation for improved dietary recommendations that include foods with high levels of anthocyanins and related polyphenols to promote health and to protect against chronic disease.

Top foods rich in anthocyanins

Source: Pojer E et al. Comprehensive Reviews in Food Science and Food Safety. 2013; 12: 483–508

Major dietary sources of anthocyanins

Foods	Anthocyanins	Concentration mg/100 g FW
Black grapes (*Vitis vinifera*)	mv-3-glc	39.23
Red wine	mv-3-glc	9.97*
Bilberries (*Vaccinium myrtillus*)	cy-3-glc	405.00
Blueberries (*Vaccinium corymbosum*)	peo-3-glc	365.00
Blackberries (*Rubus sp.*)	cy-3-glc	138.72
Blackcurrants (*Ribes nigrum*)	dp-3-rut	304.91
Chokeberries (*Aronia melanocarpa*)	cy-3-gal	557.67
Strawberries (*Fragaria x ananassa*)	pl-3-glc	47.14
Elderberries (*Sambucus nigra*)	cy-3-sam	462.96

**In red wine mg/100 mL*

Benefits for health

Blood pressure
Higher anthocyanin intake is associated with lower arterial stiffness and central blood pressure in women. Authors suggest the intakes of anthocyanins associated with these findings could be incorporated into the diet by the consumption of 1-2 portions of berries daily and are, therefore, relevant for public health strategies to reduce cardiovascular disease risk. (Jennings A et al. Am J Clin Nutr. 2012;96:781-8).

Ovarian cancer
Data from the Nurses' Health Study and Nurses' Health Study II suggest that higher intakes of flavonols and flavanones as well as black tea consumption may be associated with lower risk of ovarian cancer (Cassidy A et al. Am J Clin Nutr. 2014;100:1344-51).

Cholesterol and blood lipids
Anthocyanins have been shown to exert benefits on the lipid profile in many animal models. In one human study, a total of 120 subjects (age 40–65 y) with high lipid levels were given 160 mg anthocyanins twice daily or placebo for 12 wk in a double-blind, randomized, placebo-controlled trial. Supplementation in humans decreased LDL cholesterol level and increased HDL-cholesterol concentrations. These benefits may be due to the inhibition of plasma cholesteryl ester transfer protein (Qin Y et al. Am J Clin Nutr. 2009;90:485-92).

Diabetes
Data from two large cohort studies including nearly 160,000 women (Nurses' Health Study) and 40,000 men (Health Professionals Follow-Up Study) showed that a higher consumption of anthocyanins and anthocyanin-rich fruit was associated with a lower risk of type 2 diabetes (Wedick NM e tal. Am J Clin Nutr. 2012;95:925-33).

Enriched foods to get low-cost healthy habits

Eating healthy food is not just a matter of goodwill. In most cases, eating behaviours are somehow linked to reasons other than personal choices. One of those is economic reason. Many studies have highlighted so far that healthy dietary habits are strongly related to greater economic availability showing how poorer people end up with having unhealthy diets because of the needing of saving money. It is unquestionable that healthy food is quite expensive. Buying fresh fruits and vegetables or fish for example has become a luxury choice for families all over the world. Moreover, the lack of time to prepare proper food is strongly influencing dietary habits shifting toward westernized eating models with sneaky consequences for health. The increasing epidemic of obesity registered at every latitude of the globe is a striking evidence of this trend. That is why science has decided to put a brake on this by thinking about new ways to help people getting safer food. Enhancing traditional foods with healthy compounds could represent a good solution. Having a daily amount of berries is definitely a good habit for everyone. They're rich in anthocyanins which have been proven to have healthy effects on human health. The point is that not everybody can afford such an expense. Berries are extremely expensive. Eating 100 grams a day might drain families' budgets. Increasing availability of sources of bioactive compounds, as new foods developed within the ATHENA study, may represent a valid solution.

THE STATEMENT

"A role for plant scientists in promoting health "

What should be the best for me, as a fundamental scientist, would be that plant science was recognized as being able to contribute very innovative ways of looking and understanding the benefits of food in our diets. I'd love to see one day medical people finally saying "yes, the plant scientist can help me in evaluating the content of anthocyanins in foods". This is very important, I think.

Cathie Martin

ATHENA project coordinator

A diet rich in polyphenols keeps your inflammation low

A diet rich in polyphenols, natural compounds largely present in fruits and vegetables, reduces the low-grade inflammation.

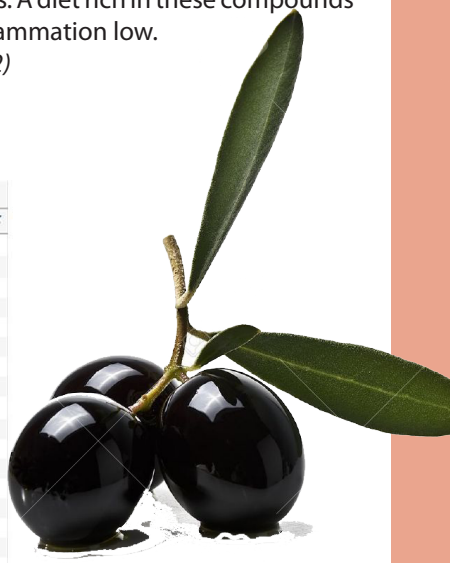
The findings came up from a study performed on nearly 25,000 Italian citizens recruited within the MOLI-SANI study. Low-grade inflammation is a chronic condition characterized by increased levels of some biomarkers; this should not be confused with acute inflammation which is rather a common reaction of the body to some external attacks, such as flue or dental pain. A low-grade inflammatory status has been recognized as a risk factor for a number of chronic diseases including cardiovascular disease, cancer, neurological disease, pulmonary disease and osteoporosis. The good news is that this status is sensitive to lifestyle modifications. Polyphenols are plant derived and generally involved in defense against ultraviolet radiation or aggression by pathogens and belong to four main classes of flavonoids, phenolic acids, stilbenes and lignans. A diet rich in these compounds turned out to be effective in keeping low-grade inflammation low.

Reference: Pounis G et al Thromb Haemost. 2015;115(2)

Polyphenol content in the 20 richest foods

Food	Food group	Polyphenols [a]	
		Content	Rank
Cloves	Seasonings	15188	1
Peppermint, dried	Seasonings	11960	2
Star anise	Seasonings	5460	3
Cocoa powder	Cocoa products	3448	4
Mexican oregano, dried	Seasonings	2319	5
Celery seed	Seasonings	2094	6
Black chokeberry	Fruits	1756	7
Dark chocolate	Cocoa products	1664	8
Flaxseed meal	Seeds	1528[c]	9
Black elderberry	Fruits	1359	10
Chestnut	Seeds	1215	11
Common sage, dried	Seasonings	1207	12
Rosemary, dried	Seasonings	1018	13
Spearmint, dried	Seasonings	956	14
Common thyme, dried	Seasonings	878	15
Lowbush blueberry	Fruits	836	16
Blackcurrant	Fruits	758	17
Capers	Seasonings	654	18
Black olive	Vegetables	569	19
Highbush blueberry	Fruits	560	20

Data from Pérez-Jiménez J et al. Eur J Clin Nutr. 2010 Nov;64 Suppl 3:S112-20.



A super tomato as powerful as 50 bottles of red wine

Scientists of the Athena study have found a way to produce industrial quantities of useful natural compounds efficiently, by growing them in tomatoes.

The compounds are phenylpropanoids like Resveratrol, the compound found in wine which has been reported to extend lifespan in animal studies, and Genistein, the compound found in soybean which has been suggested to play a role in prevention of steroid-hormone related cancers, particularly breast cancer.

In this way, one tomato can produce the same quantity of Resveratrol as exists in 50 bottles of red wine. One tomato has also produced the amount of Genistein found in 2.5kg of tofu. Researchers have been studying the effect of a protein called AtMYB12 which is found in Arabidopsis thaliana, a plant found in most UK gardens and used as a model plant in scientific investigation. The protein AtMYB12 activates a broad set of genes involved in metabolic pathways responsible for producing natural compounds of use to the plant.

What was interesting about the effect of introducing this protein into a tomato plant was how it acted to both increase the capacity of the plant to produce natural compounds (by activating phenylpropanoid production) and to influence the amount of energy and carbon the plant dedicated to producing these natural compounds.

The work will be of interest to different research areas including fundamental research on plants, plant/microbe engineering, medicinal plant natural products, as well as diet and health research. Medicinal plants with high value are often difficult to grow and manage, and need very long cultivation times to produce the desired compounds. The research provides a fantastic platform to quickly produce these valuable medicinal compounds in tomatoes.

The cob secret

Athena researchers have obtained a new purple corn to get a special flour which is 8-times richer in anthocyanins compared to the flour obtained from seeds. This is because the flour was extracted from the cob – the hard part of the ear - which has high content of anthocyanins. The anthocyanin-rich flour was used to make a special blend to be used in the human trial of the Athena project which aims at seeing whether large consumption of anthocyanins is able to reduce the skin damage caused by radiotherapy in women affected by breast cancer.

Anthocyanins to keep at bay stress damage

Among the most interesting experimental results already obtained within the ATHENA project, scientists found an association, in experimental models, between anthocyanins intake and longevity or protection from metabolic disorders. Very interesting data were obtained, in addition, on the extension of the area of an experimental myocardial infarction. Indeed, in animals (rats) fed a diet enriched in anthocyanins the tissue damage around the ischemic injury was markedly reduced in comparison with controls; as if there was a reinforcement of defense mechanisms allowing the healthy tissue surrounding the ischemic insult to react. Coming to normal eating habits in humans, ATHENA researchers found that consumption of blood orange juice reduces oxidative stress in patients with metabolic disorders, protects DNA from oxidative damage and may reduce cardiovascular risk factors to the same extent, as other anthocyanin-rich foods as fruits and vegetables.

Breast cancer: purple flour against skin damage

The purple flour used in the human trial

Athena has set one of the biggest human studies on anthocyanins and health. The human trial has been conducted within women receiving radiotherapy after surgery for breast cancer.

Among side effects, this treatment can cause skin inflammations both short and long term. In these conditions it is not always possible to follow a certain type of diet due to the interference caused by radio and chemotherapy treatments. Researchers from the Athena study have then tried to enhance the defensive potential of these people through dietary supplementation of a special flour obtained from the cob of a new purple corn specifically developed within the project. This high anthocyanin-rich supplement during radiotherapy should limit the side effects of radiation on the skin. The skin-damage is detected by a cutometer, a sensitive device able to measure the magnitude of the damage provoked on the skin by radiation.

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