The Scientific Newsletter

N°94 • November 2014

« An updating on Antioxidants and F&V consumption »

Editorial

Ongoing studies continue to establish consensual relationships between diet and health with particular emphasis on the beneficial role of fruits and vegetables (F&V) on decreasing risks of diverse pathologies (cancers, osteoporosis, glaucoma and obesity-related physiopathology) together with improvements of biological functions (vascular response, blood pressure, grip strength, immunity).

F&V have been sequentially seen as providers of bioactive compounds such as fibres, vitamins, minerals, trace elements, and phytochemicals including carotenoids and more recently the polyphenols. As oxidative stress is associated with the pathogenesis of diseases and, since most of these compounds have potential to increase the antioxidant capacity of the body, oxidant-antioxidant balance has been hypothetically considered a basis to explain the beneficial role of F&V.

However, many studies on the health potential of these bioactives are based on particular design including experimental models metabolically far from human physiological situations and administration of pharmacological rather than nutritional levels, far from usual dietary conditions. As a result, none of clinical studies administering bioactives out of the food matrix, has proven their efficiency as curative compounds on at-risk individuals, even increasing the mortality as seen with ATBC and CARET studies. Therefore the causal relation between F&V and health cannot be only linked to the biological properties of each of these nutrients but rather as a complex mixture interacting between them and with the other metabolites engendered by the diet and the lifestyle of the individuals. Fortunately, experimental approach of complex systems is within reach through the high throughput or "omics" technologies and with some convincing results. Thus, the "food metabolome" or what is emerging as "personalized nutrition" will bring a holistic vision of the interest of F&V in prolonging "healthy life years" of the consumers.

Dr Edmond ROCK
National Institute of Agronomical Research
Human Nutrition Unit, UMR 1019
Centre Clermont-Theix - FRANCE

Total antioxidant capacity of blood plasma depends on fruits and vegetables intake

Joanna Harasym[a], Remigiusz Oledzki[b]

a. Bio-Ref Laboratory, Food Biotechnology Department, Institute of Chemistry and Food Technology, Wroclaw University of Economics, Wroclaw, Poland

b. Food Biotechnology Department, Institute of Chemistry and Food Technology, Wroclaw University of Economics, Wroclaw, Poland

Increased consumption of fruits and vegetables is considered as closely related to protection of human health and well-being. A huge number of health problems as diabetes, cancer and neurodegenerative or cardiovascular diseases have been connected with not only specific nutrition habits but also lack of many essential nutrients in consumed food as well. Human system benefits from fruit and vegetables, the intake of which is also related with anti-nutrients such as the consumption of low-molecular antioxidant substances. Antioxidant compounds provided with the diet improve total antioxidant capacity of human blood and tissues. Provided in the diet, antioxidants neutralize reactive oxygen species (ROS, which are produced in the system during physiological processes).

Total antioxidant status

The most popular description in scientific literature related to antioxidant activity is total antioxidant activity (TAC) which determines the ability of substance, materials, food to neutralize oxygen-free radical specific form, irrespectively to specific antioxidant activity of present antioxidants[1]. Many methods have been developed to measure TAC of different samples. The last one with direct transferrable results for human health is the oxygen radical absorbance capacity (ORAC) technique, which is also an effective method for measuring TAC of human blood plasma[2].

Antioxidant potential of different fruits and vegetables

Analysis of the fresh weight of the edible part of the fruit led to the conclusion that strawberries have a higher TAC than fruits such as plums, oranges, kiwi, grapefruit, red and white grapes, bananas, apples, pears, and melons (listed in order of decreasing antioxidant capacity). It also has been shown that TAC value of dry mass of strawberry fruit is higher compared with the dry weight of fruits just mentioned[1,3,4]. TAC analysis of edible vegetable fresh mass provided observation that vegetables such as kale, spinach, Brussels sprouts, alfalfa, and broccoli have a significantly higher antioxidant capacity than other species such as beets, red pepper, onion, corn, or lettuce[3,5,6].

Effect of consumption of selected fruit species on total plasma antioxidant capacity

Research suggests that the possibility of human plasma antioxidant defences can be intensively increased in response to the consumption of certain types of fruits. It was observed that eating bilberry (*Vaccinium myrtillus L.*) fruit results in significant increases of TAC in blood plasma. This increase occurs after consumption of larger portions of fruits of at least 200g. It was observed that this effect was a result of activity of both hydrophilic and lipophilic antioxidants present in fruit[7]. It is believed that a significant effect of blueberry consumption compared with red grapes fruit on plasma TAC increase may be due to the higher concentration of anthocyanin in these fruits. Red grapes are characterized by the presence of large amounts of resveratrol, a stilbene polyphenol derivative, a compound that blueberries do not contain, and which in the opinion of experts, shows a much weaker free-radical scavenging properties of oxygen than anthocyanins. Research on the effects of blueberry on organisms has shown that to effectively prevent decline of TAC in the plasma of human blood, this fruit should be eaten in larger doses of 100 to 200g[8]. It also was shown that consumption of sweet Bing cherries has a clear effect on plasma TAC. Eating cherries contributes to a significant increase in TAC due mainly to lipophilic antioxidant activity (ORACL) in plasma. A similar correlation was not observed for hydrophilic antioxidants, which had no effect on total plasma antioxidant status after eating larger portions of fruit (280g). Sweet cherries are fruits, which are characterized by a large amount of hydroxycinnamic acid and its derivatives, which account for about 42% of total content of phenolic compounds (the amount is estimated to be 163mg/100g wet weight)[9]. A second important group of phenolic compounds having an effect on a high TAC of sweet cherry is the anthocyanins and proanthocyanidins, which represent 23% of the total phenolic compounds in fruit[9,10].

Changes in antioxidant activity of fruits and vegetables during cooking and technology

Both traditional food-processing technologies (e.g. drying, and methods such as microwave cooking) and extent of shelf life also contribute to significant changes in food TAC[11]. The results of research indicate that effect of different food processing methods on the antioxidant capacity of fruits, vegetables, legumes, and grains is not clear. The contents of one type of antioxidant were reduced as the effect of processing may be accompanied by an overall increase in TAC due to easier availability of other groups of antioxidants. An example of this phenomenon is the breakdown of cell walls under influence of heating or enzymatic hydrolysis, which can improve the availability of some antioxidants, such as b-carotene[11].

Based on : Harasym J, Oledzki R. Effect of fruit and vegetable antioxidants on total antioxidant capacity of blood plasma. Nutrition. 2014;30(5):511-7.

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Flavonoid-rich fruits and vegetables improve vascular function in men at risk of cardiovascular disease - FLAVURS: a randomized controlled trial

Anna L. Macready[a], Trevor W. George[a,b], Mary F. Chong[a,c], Julie A. Lovegrove[a]

a. Hugh Sinclair Unit of Human Nutrition and Institute for Cardiovascular and Metabolic Research, University of Reading, Reading, Berkshire RG6 6AP, United Kingdom

b. Northumbria University, Faculty of Health and Life Sciences, Newcastle upon Tyne NE1 8ST, United Kingdom

c. Clinical Nutrition Research Centre, Singapore Institute for Clinical Sciences, 14 Medical Drive, Singapore

The health benefits of fruits and vegetables (F&V) are widely promoted, with higher F&V consumption commonly suggested as an effective therapy in the prevention of cardiovascular diseases (CVD)[1]. Known cardio-protective components of F&V include fibre, folate, nitrate, vitamins and phytonutrients such as flavonoids. Flavonoids in particular are believed to benefit vascular function by reducing progression to atherosclerosis[2]. Flavonoid groups such as anthocyanins, flavonols and flavanones are found in high concentrations in a variety of fruits and vegetables, especially berries, citrus fruits, apples, grapes, peppers, onions, broccoli and herbs[3], and may in part be responsible for the observed cardiovascular benefits of F&V consumption.

Findings from epidemiological studies suggest that lower CVD risk is associated with higher F&V and flavonoid intakes[1]. While limited, intervention studies suggest that consumption of F&V rich in flavonoids may improve CVD risk markers, including endothelial dysfunction, inflammation and oxidative stress[4-8]. However, little is known about the extent to which flavonoids from F&V contribute to cardiovascular health and the corresponding optimal amounts of F&V required. At present, public health guidelines vary considerably between countries in relation to recommended quantity and type of F&V[9]. To address this question, an examination was conducted of the FLAvonoids and Vascular University of Reading Study (FLAVURS) to explore the optimal quantity and type of F&V required to promote vascular health and to reduce other established CVD risk markers.

The FLAVURS Trial

The study recruited 174 free-living men and women who were low consumers of F&V (e.g. eating less than the United Kingdom average of 4.4 F&V portions per day), aged 26 to 70 years, and who were identified as being at risk of CVD[10]. Participants were randomly assigned to one of two dietary treatment groups (high or low-flavonoid F&V), or the control group, who were asked to maintain their habitual F&V intake throughout the 18-week study. The 18 weeks were divided into three phases, consisting of six weeks per phase. Participants in the treatment groups were asked to increase their habitual daily F&V intake by +2 (phase 1), then +4 (phase 2), then +6 additional F&V portions a day (phase 3). Weekly supplies of commonly available high or low flavonoid F&V were delivered to participants. To assess treatment progress and compliance, vascular, blood, urine, anthropometric, dietary and lifestyle assessment measures were taken at baseline, 6, 12 and 18 weeks from all participants. Participants in both F&V treatment groups broadly achieved the target amounts of F&V at all phases of the study with 154 participants completing the study[11].

Key Findings

For men consuming an additional two portions of high flavonoid F&V per day (≥6 portions total F&Vs), improvements in endothelial-dependent microvascular reactivity, a key marker of vascular function ($p=0.017$) was observed, with concomitant improvements in their inflammatory markers, (reduced C-reactive protein ($p=0.001$), E-Selectin ($p=0.0005$) and vascular cell adhesion molecule ($p=0.0468$)).

We also found improvements in plasma nitric oxide for both men and women ($p=0.0243$) consuming an additional three portions of high flavonoid F&V (≥7 portions in total), which was not seen for controls or for those consuming equivalent amounts of low flavonoid F&V. This suggested more general benefits to endothelial and vascular function from high flavonoid F&V compared to low flavonoid F&V and low F&V diets in general.

Finally, we noted that an increase in F&V consumption, irrespective of flavonoid content in the groups as a whole, appeared to counteract the decline in vascular function observed in the control group during the course of the study, namely increased vascular stiffness, as measured by Pulse Wave Analysis ($P=0.0065$), and reduced plasma nitric oxide levels ($P=0.0299$).

Overall, increased F&V consumption conferred benefits to vascular function in both men and women at risk of CVD who consume less than the daily recommended amounts of F&V. In addition, high flavonoid F&V appeared to be particularly beneficial to the men in this sample. The greatest overall benefits were seen for both men and women when consuming three portions of high flavonoid F&V in addition to their usual daily intake.

How does this translate to public health nutrition guidance?

Our findings support recommendations to increase F&V intake to approximately six portions a day, with additional benefits from F&V rich in flavonoids. In FLAVURS this was found to be particularly relevant for men with an increased risk of CVD.

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Dietary intake of carotenoid may reduce risk of hip fracture in lean men

Zhaoli Joy Dai
Nutrition Epidemiology, Singapore

Osteoporosis is an epidemic problem affecting both elderly men and women worldwide. Although the prevalence of osteoporosis is higher in women than in men, men experience greater comorbidity and mortality after hip fracture than women.

Leanness has been established as an independent risk factor of hip fracture. Recently, several observational studies have reported that low body mass index (BMI) could be related to increased oxidative stress, particularly, in men. Experimental and epidemiologic data suggest that carotenoids in vegetables and fruits may benefit bone health due to their antioxidant properties. This study examined the relationship between dietary total and specific carotenoids, as well as vegetables and fruits, and risk of hip fracture among middle-aged to elderly Singapore Chinese.

Study design

Data was used from a prospective cohort of Chinese men and women in Singapore. The study followed up 63,000 middle-aged to elderly participants for hip fracture incidence from 1993 through 2010. Cox proportional hazards model was used to estimate relative risk after adjustment for age, dialect group, body mass index, level of education, daily total energy intake, smoking status, physical activity, dietary intake of calcium, soy isoflavones, and vitamin B6, menopausal status for women, use of hormone replacement therapy for women, and medical history of diabetes and stroke.

Results

It was found that dietary intake of vegetables was significantly associated with reduced hip fracture risk in men. Similarly, dietary intake of total carotenoids, α, β-carotene and lutein/zeaxanthin were inversely associated with hip fracture risk in men ($P<0.05$). Compared to men in the lowest quartile intake, men in the highest quartile had statistically significant lower risk of hip fracture by 26% to 39%. Interestingly, the greatest protective effects of vegetables and carotenoids were found in men with body mass index < $20 kg/m^2$. However, no association was observed between dietary intake of carotenoids or vegetables/fruits and hip fracture risk among women.

Plausible explanation of the results

It is proposed that the benefits of carotenoids on bone might be via their counteractive effects against oxidative stress, which has been shown to play a possible etiologic role in age-related bone loss and consequent osteoporotic fractures by increasing osteoclastogenesis and stimulating osteoclastic differentiation through the receptor activator of NF-kB ligand (RANKL) expression and signaling mechanism. Furthermore, low BMI has been associated with increased oxidative damage indexed by 8 - hydroxy - 20-deoxyguanosine particularly in men; the molecule 8 - hydroxy - 20 - deoxyguanosine is a reliable biomarker for the measurement

of systemic oxidative stress. Following this, it is speculated that lean men possibly have higher oxidative stress in bones leading to hip fracture, and the antioxidant effects of carotenoids may counteract this mechanism of osteoporosis related to leanness. In addition to the high carotenoid content in vegetables, another possible mechanism for the beneficial effects on bones includes the alkaline nature of vegetables. In particular, potassium in vegetables may neutralize excess metabolic acid to maintain an acid - base homeostasis and to promote calcium balance in bones.

Conclusion

Findings from the study demonstrated increased dietary intake of vegetables or carotenoids from fruits and vegetables may reduce risk of hip fracture in men. The apparent protective effect was observed particularly among lean men with body mass index less than $20 kg/m^2$. This is potentially due to the antioxidant effects of carotenoids, which may counteract the mechanism of osteoporosis related to leanness.

Take home message

Besides maintaining a healthy lifestyle, a balanced diet with increased consumption of carotenoid-enriched vegetable and fruits, such as carrots, sweet potatoes, green leafy vegetables, cantaloupe and papaya, may benefit bone health, especially in lean men.

Based on : Dai Z, Wang R, Ang LW, Low YL, Yuan JM, Koh WP. Protective effects of dietary carotenoids on risk of hip fracture in men: the Singapore Chinese Health Study. J Bone Miner Res. 2014;29(2):408-17