

Diet as a main source of natural antioxidants in the human diet: A special place for designer eggs

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Most of our lives have become extremely busy and more stressful over the last few decades. Stress can directly affect our health and general well being. In particular there is a great concern about cardiovascular disease and cancer, that together are responsible for well over 50% of deaths in modern society.

Scientists have made substantial progress in understanding the causes of these diseases. However, the molecular mechanisms of their development are still not clear. It seems likely that free radicals are involved and that natural antioxidants (e.g. vitamins E and C, carotenoids, flavonoids) can provide the necessary defence (Figure 1). In fact the antioxidant-prooxidant balance in our body is involved in the regulation of many different biochemical reactions and is ultimately responsible for maintenance of our health

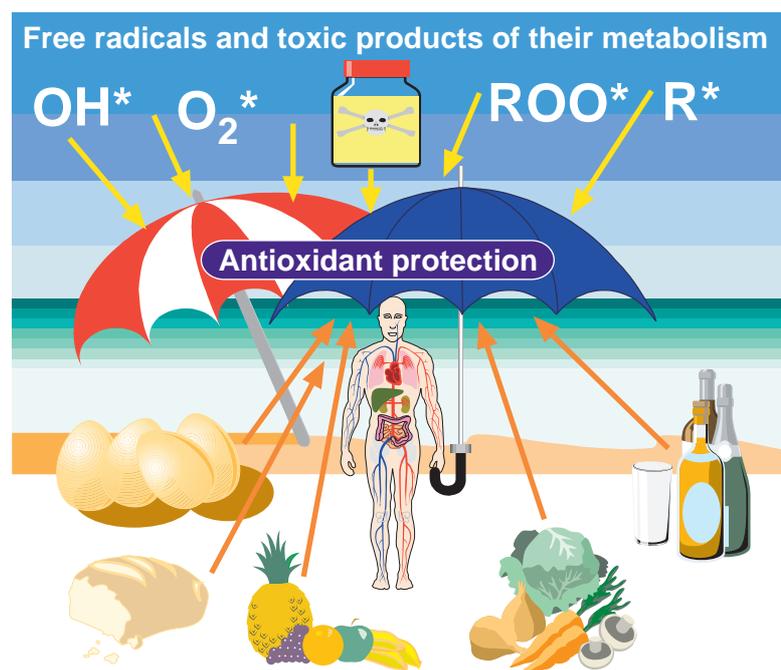


Figure 1. We are living in a world of free radicals.

status (Figure 2). From information accumulated for the last decade it is clear that our diet is a major determinant of our health. This idea is not new, Hippocrates observed the relationship between health and food choices many centuries ago. The effect of nutrition on human health has received tremendous attention and traditional medical teaching that diet and nutrients play only limited roles in human health is being revised. In most developed countries nutritional practice has changed its focus away from combating nutrient deficiencies towards addressing nutrient requirements for maintaining good health throughout life.

Arguably one of the most fascinating ideas in human nutrition is that selected foods and their components can improve physical or mental performance or decrease disease risk. Thus, beyond meeting nutrition needs, diet may modulate various body functions and may play detrimental or beneficial roles in the development of some diseases. Epidemiological findings, supported by animal studies, have led to recommendations that people should consume at least two servings of fruit and three servings of vegetables daily in addition to at least two servings of fish weekly. While findings and reports such as these have had an impact on the type and quantity of the food that many of us eat, the majority of adults in developed countries fall well short of meeting these healthy eating guidelines.

For example, the 'average' Scottish diet is deficient in many essential micronutrients:

- Among secondary school children, less than 5% achieved a healthy food choice score

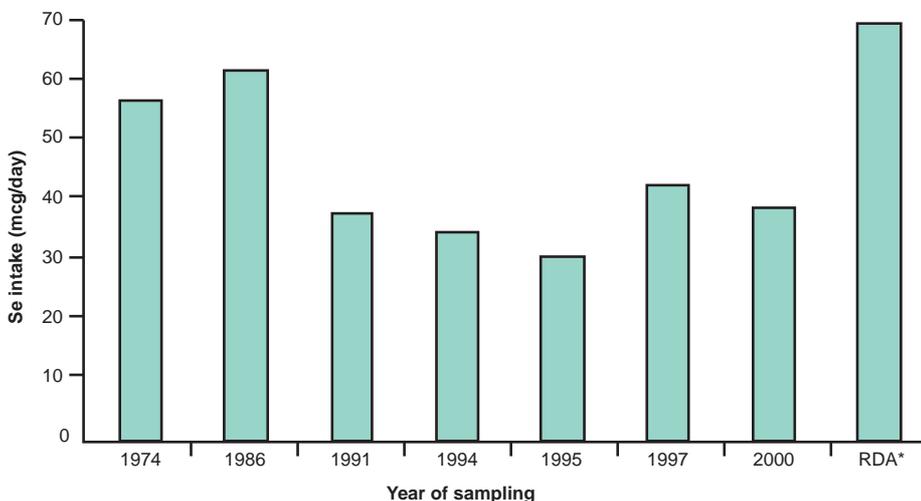


Figure 3. Selenium intake in the UK. *RDA - Recommended Daily Allowance

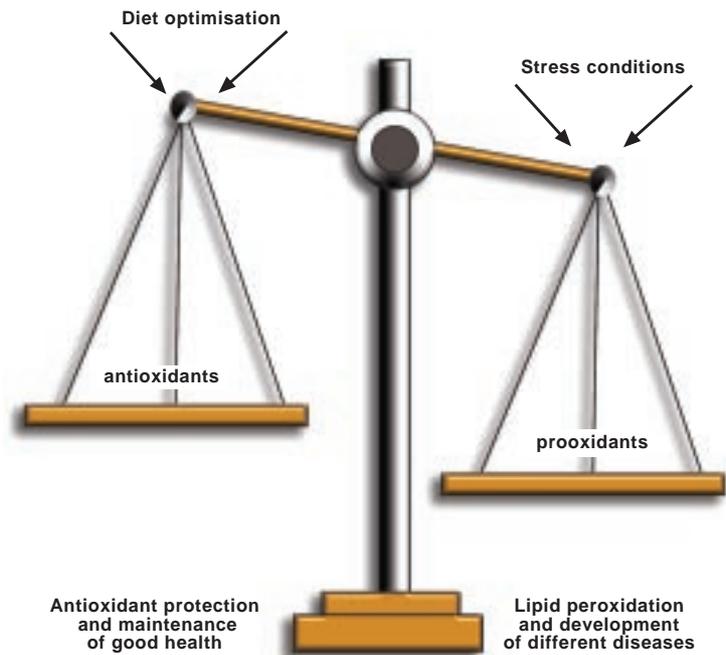


Figure 2. Antioxidant prooxidant balance in the cell/body.

- A high plasma cholesterol level was recorded with increasing body mass index
- There is inadequate antioxidant consumption: there has been a 50% decline in dietary selenium (Se) intake so that it now provides less than half our recommended daily requirement (Figure 3); intakes of the carotenoids and vitamin E are also low
- Low antioxidant consumption may well account, at least in part, for the relatively poor health record of those living in Scotland when compared to other European countries.

Is there a scientific solution to the poor Scottish diet? There are various options. The simplest option would be to buy antioxidant supplements in tablet or capsular form. However, this could be quite expensive.

The best option could be to educate people on the importance of various antioxidant nutrients especially those coming from various foods to encourage them to eat more fruits and vegetables. In addition to that, production of functional foods enriched with antioxidants could be a way to compensate for their lack in our general diet.

Development of super egg as a way for improvement of human diet

Recent scientific evidence reinforces the importance of eggs as a healthy food choice. Our attention has been attracted by eggs as the most convenient delivery system for essential nutrients including: vitamin E (the most abundant lipid-soluble antioxidant), lutein (one of the most important plant carotenoid pigments), Selenium (SE) (a trace element) and docosahexaenoic fatty acid (DHA; the most important long chain polyunsaturated fatty acid belonging to the omega-3 family). Our idea was to produce an egg containing vitamin E, lutein, DHA and Se in amounts comparable with the daily requirements of these nutrients in a palatable and visually

acceptable form. The main concept was 'healthy eggs from healthy birds' since all these four nutrients are as important for the hen's health as for human health.

By manipulating the feed of laying hens it was possible to enhance the levels of Se, vitamin E, lutein and DHA by 7.7, 26.8, 15.9 and 6.4-fold respectively compared to the control group. A single designer egg contained 50% of the Recommended Daily Allowance (RDA) of Se, 100% of the RDA of long chain n-3 Poly Unsaturated Fatty Acids (PUFAs), and 150% of the RDA of vitamin E. It also supplied 1.91 mg lutein (Figure 4).

Results from a human trial conducted with healthy adult volunteers indicate that the consumption of designer eggs (an egg a day for 8 weeks) significantly increased the plasma vitamin E concentration over that of the control group and was effective in all treated subjects. Similarly, lutein concentration in plasma significantly increased (Surai *et al.*, 2000; Figure 5). The increased concentrations of vitamin E and lutein would significantly increase the antioxidant potential of the plasma and help to protect polyunsaturated fatty acids from peroxidation. DHA concentration in plasma was also significantly increased due to designer egg consumption.

Our results indicate that two major antioxidant constituents of the egg, vitamin E and lutein, are stable during egg boiling. (Surai *et al.*, 2000). These eggs deliver key elements in the diets of pregnant women, the elderly, young children, etc. The inclusion of the eggs in different processed foods, for example, mayonnaise, cakes, etc. will increase their nutritional value. The eggs will be of great importance to people living in polluted areas, (e.g. Chernobyl, Ukraine) and in areas with very low temperatures (e.g. Polar expeditions) and extreme conditions (e.g. submarine teams). Eggs have not traditionally been regarded as a functional food, primarily due to concerns about their adverse effects on serum cholesterol levels. However recent findings indicate that there is little if any connection between moderate egg consumption and heart disease and this could help to change the bad image of eggs. In this respect eggs enriched with vitamin E, lutein, selenium and DHA, ideally fit in the category of a functional food enabling substantial improvement to the diet. Eggs are consumed regularly by most

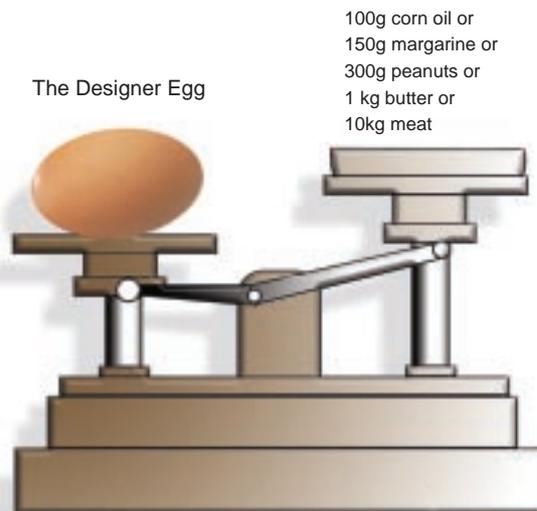


Figure 4. Vitamin E in the designer egg.

of the population and are served as an integral part of breakfast in many countries. The development of 'super egg' received a lot of publicity through mass media including radio, TV and newspapers. They clearly show great public interest in improvement of egg quality and in creation of 'healthy' eggs.

A crucial feature of these designer eggs is the synergistic combination of n-3 fatty acids with major antioxidants, vitamin E, lutein and Se, as an important approach to the improvement of the human diet. These eggs will not be able to replace vegetable and fruits as a major source of natural antioxidants and fish products as a source of DHA but can substantially improve the diet, especially in countries like Scotland, significantly contributing to the recommended daily intake of vitamin E, lutein, DHA and Se.

Commercially, it is possible to produce designer eggs enriched with the 4 enhanced nutrients as mentioned above or with only 3, 2 or 1 nutrient depending on

the consumer demand. As a result, the price for the production of such eggs could substantially vary. The idea of egg enrichment with antioxidants has recently been used to produce Se-enriched eggs in Ireland, Malaysia and Thailand. Furthermore, Se-enriched milk is produced in Australia and Se-enriched pork and chicken are on the market in Korea (Surai, 2002a). This solution awaits development in Scotland.

Therefore the introduction of the egg to the functional food category has started successfully (Surai and Sparks, 2001). Now required is consumer education to firmly place the idea of eggs as a functional food. Indeed, many categories of people will benefit from using designer eggs as part of their everyday diet. However, more research should be done in this area to convince customers to go for designer eggs. Improvement of the diet by balancing essential nutrients via designer/functional food without changing people's food preferences would bring clear health benefits.

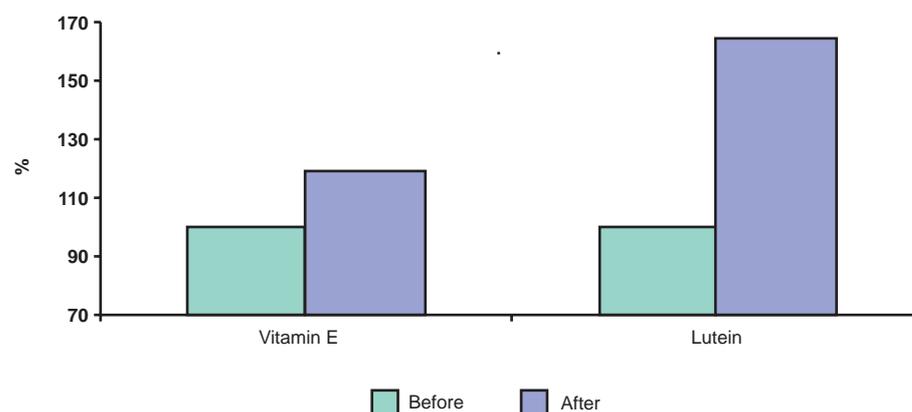


Figure 5. Effect of designer eggs on vitamin E and lutein in human plasma.