

Eating fruit and vegetables gives your skin a golden glow

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DESPITE WORLDWIDE CAMPAIGNS to increase fruit and vegetable consumption, intake is commonly inadequate, precipitating an estimated 2.6 million premature deaths per year worldwide.¹ A British Academy Wolfson Research Professorship awarded to David Perrett has provided support to explore a new basis of motivating dietary change, essentially by appealing to vanity. With that support we found that eating carotenoid-rich fruit and vegetables leads to an attractive looking skin colour, and that showing people these appearance benefits can encourage dietary improvement.

The health problem: knowledge is not enough

Insufficient fruit and vegetable consumption is associated with higher incidence of cardiovascular disorders, stroke, diabetes, some cancers and obesity.² The ramifications of these diseases are widely felt. Not only are there debilitating consequences for personal well-being, but also illness overburdens health-care systems, and adds to countries' financial woes through the lost productivity of sufferers and their supporters.

Fruit and vegetable consumption is particularly poor in parts of the United Kingdom. For example, only one in five Scottish adults meet the World Health Organization's recommended intake of five fruit and vegetable portions per day.³ Amongst younger adults the situation is even worse, with more than 20% of 16- to 24-year-olds reporting eating no fruit or vegetables at all. Since adolescent habits are likely to last, the poor diet of today's youth is likely to magnify the already substantial burden of chronic disease in the coming decades. There is a clear need for dietary improvement, particularly amongst the young and those living in deprived areas, but there is room for substantial improvement in diet throughout the whole population.

Current attempts to encourage dietary change at a population level, such as the high profile '5-a-day' campaign, provide individuals with information on what

a healthy diet is and how it benefits health in guarding against chronic diseases.⁴ Yet the provision of health information *alone* does not seem sufficient to motivate adherence to recommendations. Two decades after the inception of 5-a-day campaigns, diet remains a key determinant of preventable sickness and death.⁵ There is all too often a discrepancy between good dietary intentions and what people actually eat:⁶ most individuals are aware of what constitutes a healthy diet but fail to act on this knowledge.

The question is: how do we get people to act on knowledge and good intentions? Inspiration may come from considering sex and the role of diet in coloured ornaments in the animal kingdom. For many species, bright ornaments are pivotal in gaining the attention of sexual partners. Humans go to extraordinary lengths to improve their chances of finding a suitable partner, so people may take on a better diet if they know it improves their sex life.

Of birds and fish

Many animals wear a health badge in the form of a colourful ornament. Examples in the United Kingdom are the yellow breast of great tits, yellow bills of blackbirds, red comb of grouse, and the red belly of male stickleback fish. All these ornaments are brighter in individuals who are healthy and duller in individuals with infections. Perhaps understandably the individuals with brighter ornaments in these species are more attractive to potential mates.

We might assume red ornaments are a sign of good blood supply, but the colour in many animal ornaments is based not on blood supply but on a large family of (600+) carotenoid plant pigments that are obtained through diet. Carotenoids are a family of red-yellow chemicals that are abundant in coloured fruit and vegetables. Examples include lycopene that makes tomatoes red, carotene that makes carrots orange, and lutein that can impart yellow

¹ K. Lock, J. Pomerleau, L. Causer, D.R. Altmann and M. McKee, 'The global burden of disease attributable to low consumption of fruit and vegetables: implications for the global strategy on diet', *Bulletin of the World Health Organization*, 83:2 (2005), 100-108.

² World Health Organization, *Global Strategy on Diet, Physical Activity and Health* (2004), available at www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf (accessed June 2012).

³ The Scottish Government. Scottish Health Survey. April 2012, available at www.scotland.gov.uk/topics/statistics/browse/health/scottish-health-survey (accessed June 2012).

⁴ World Health Organization, *Diet, Nutrition and the Prevention of Chronic Diseases: Report of a WHO Study Group* (Technical Report Series, 797; Geneva, World Health Organization, 1990), available via www.who.int/dietphysicalactivity/publications/trs916/intro/en (accessed April 2011).

⁵ World Health Organization, *World Health Statistics 2011*, available at www.who.int/gho/publications/world_health_statistics/EN_WHS2011_Full.pdf (accessed April 2012).

⁶ Foods Standards Agency, *Consumer Attitudes to Food Standards, Wave 6: UK Report, 2005*, (February 2006), available at www.food.gov.uk/multimedia/pdfs/casuk05.pdf (accessed June 2012).

coloration to peppers. Note: green fruit and vegetables often contain the same amount of carotenoids as orange yellow and red ones, but chlorophyll in these foods masks their outward appearance. The appeal of coloured fruit and vegetables (Figure 1) is fitting to the benefits that their consumption can bring.

Carotenoids do more than produce pretty colours in animals and plants. They help neutralise reactive oxidising chemicals formed as an unfortunate by-product of normal living and obtaining energy from carbohydrates. These dangerously reactive chemicals are also produced by the frontline agents of the immune system, the white blood cells, when destroying bacteria and virus-infected cells. The carotenoids are antioxidants and help protect cell membranes, enzymes and DNA from oxidising damage; but the carotenoids are expended in this neutralising role, so carotenoid levels in the blood fall during an infection. The only way they can be replenished is through diet – eating more of the right kind of food. Hence, the carotenoids can act as an ‘honest’ cue to the bearer’s health. Since healthy individuals do not get infected often, they don’t use their carotenoids in the war against infections, and can deploy them in showy ornaments.

In the animal kingdom, choosing a mate with extravagantly coloured ornaments has both short-term and long-term benefits. Long-term benefits take the form of healthy offspring. More immediate benefits come from the fact that a partner who is fit and well can execute duties, provisioning and defence of the family, and is unlikely to be a source of contagious disease.

Carotenoids and human skin colour

Carotenoid pigments are found in all layers of human skin. Therefore, we wondered whether diet would have a measureable impact on human appearance as happens in many animal species. Mammals in general have poor colour vision and don’t generally have coloured ornaments. In an evolutionary timescale, it is only recently that primates evolved good colour vision (based on three colour photoreceptors). Like birds and fish, this sets the scene for the development of colour signalling and raises the question whether humans (with their three colour vision) convey signal health status to one another through colour. To find out, we asked European students to record how frequently they ate different types of food,



Figure 1. Fruit and vegetables contain a range of nutrients including carotenoids – a large class of red and yellow pigments.



Figure 2. Skin colouration associated with diet. Images on the left represent a decrease in fruit and vegetable consumption of 8 portions a day, images on the right represent an increase in consumption of 8 portions day. NB: colours may vary with print reproduction. Under natural lighting conditions, images simulating increased consumption were seen as healthy and attractive.

and measured the colour of their skin. The results were clear: the more fruit and vegetables a person ate, the yellower his or her skin was. The way the skin reflected light of different wavelengths showed that this was due to people's consumption of the colourful carotenoid plant pigments, rather than them getting sun-tanned.

While this set the scene, we did not know how quickly the skin changed in response to diet change, or whether the colour made a difference to perception. In our new work, we found that, if people made consistent changes to their diet, then within six weeks their skin colour changed. When people ate more fruit and vegetables their skin colour took on a redder and yellower tint. Conversely, if people stopped eating as much fruit and vegetables, then their colour literally faded.⁷

But does the colour matter? Recent experiments reveal just how much skin colour does impact on attractiveness. Indeed, the variation in skin colour across a population has a bigger impact on judgements of men's attractiveness than how masculine a man's face shape is.⁸ Therefore, our next step was to determine if people could see diet-related skin colour differences. We showed students faces that varied in the amount of colour from fruit and vegetables, and asked them to adjust each face until it looked most healthy and attractive. Virtually all the faces became better looking when the amount of plant-pigment colour was increased (see Figure 2). The evaluators did not go to excess and turn the faces into a tangerine colour – that did not look healthy – but they did raise the level of fruit and vegetable pigmentation for an optimal appearance.

The dietary pigment colour effect is evident across different cultures: Asian and African faces are adjusted for yellow colour in the same way as European Caucasian faces, and this doesn't depend on the nationality and skin colour of the people doing the evaluation. Across all the cultures we've tested, people raise the amount of yellow in the face in order to maximise apparent health.⁹ While the association between skin lightness and beauty does change across culture, the association between health and slightly raised skin yellowness generalises across cultures.

It is equally important to note that observers are able to detect skin colour differences associated with modest increases in fruit and vegetable consumption, suggesting that humans are very sensitive at discriminating subtle differences in skin carotenoid pigmentation. Our latest estimate is that the skin colour changes associated with two extra portions a day or just one extra portion visibly improve skin appearance.

Moreover, for Europeans, the colour associated with a good diet seems far more important than anything that can be achieved through altering the level of suntan. When given the choice of altering both tan and skin dietary coloration in European faces, evaluators alter dietary pigmentation but barely adjust tan levels. To optimise skin colour, pigmentation from diet was three to four times as important as pigmentation from suntan.¹⁰

Intervention studies

We are now well armed to start a campaign to persuade people to change their behaviour. Consider the facts: (a) diet can improve skin colour; (b) the change in diet required is small – an increase of one or two portions of fruit and vegetables per day is sufficient; and (c) the benefits are relatively quick to realise – six weeks should see an improvement. All this comes with a general agreement from health professionals that the change in diet improves long-term health.

The carotenoids in fruit and vegetables should contribute to health by providing antioxidants, but there are a whole raft of benefits from eating fruit and vegetables. They contain multiple sources of antioxidants, vitamins, trace elements and fibre that can have important effects. Consuming more vegetables is likely to decrease the appetite for less healthy foods – those energy dense foods that make it so easy for us to increase in girth.

We conducted two intervention studies,¹¹ in which university student participants were given leaflets containing National Health Service information about the nature and benefits of a balanced diet. In the studies we also showed one set of participants their own facial image and how their skin colour could be affected by changing what they ate. This experience of seeing the more attractive skin colour associated with a high fruit and vegetable diet was effective in triggering a change of behaviour and the adoption of a more healthy diet. We tracked the eating habits of the groups of participants who had seen their own face colour manipulated, and those in the control group who had received only NHS information. The NHS information alone had no effect on diet whatsoever (perhaps because people already know what they *should* be doing). By contrast, those seeing their own appearance changed at the outset of the study reported an increased fruit and vegetable consumption that was sustained for the 10-week study period.

⁷ R.D. Whitehead, D. Re, D-K. Xiao, G. Ozakinci and D.I. Perrett, 'You are what you eat: Within-subject increases in fruit and vegetable consumption confer beneficial skin-color changes', *PLoS ONE*, 7 (2012), e32988.

⁸ I.M.L. Scott, N. Pound, I.D. Stephen, A.P. Clark and I.S. Penton-Voak, 'Does masculinity matter? The contribution of masculine face shape to male attractiveness in humans', *PLoS ONE*, 5 (2010), e13585. I.D. Stephen, I.M.L. Scott, V. Coetzee, N. Pound, D.I. Perrett and I. Penton-Voak, 'Cross-cultural effects of color, but not morphological masculinity, on perceived attractiveness of men's faces', *Evolution and Human Behavior*, 33 (2012), 260-7.

⁹ I.D. Stephen, M.J. Law Smith, M.R. Stirrat and D.I. Perrett, 'Facial skin coloration affects perceived health of faces', *International Journal of Primatology*, 30 (2009), 845-857. I.D. Stephen, V. Coetzee and D.I.

Perrett, 'Carotenoid and melanin pigment coloration affect perceived human health', *Evolution and Human Behavior*, 32 (2011), 216-27.

¹⁰ R.D. Whitehead, G. Ozakinci and D.I. Perrett, 'Attractive skin coloration: harnessing sexual selection to improve diet and health', *Evolutionary Psychology*, 10:5 (2012), 842-54. I.D. Stephen, V. Coetzee and D.I. Perrett, 'Carotenoid and melanin pigment coloration affect perceived human health', *Evolution and Human Behavior*, 32 (2011), 216-227.

¹¹ R.D. Whitehead, D.I. Perrett and G. Ozakinci, 'Appealing to vanity: does seeing the potential appearance-benefits of fruit and vegetable consumption motivate dietary change?', *Annals of Behavioral Medicine*, 41 (2011), s214. R.D. Whitehead, G. Ozakinci and D.I. Perrett, 'Brief report: a randomised controlled trial of an appearance-based dietary intervention', *Health Psychology* (in press).

Although our results are encouraging, they are preliminary; one wants a dietary improvement to last years not just months. We worked with young adults and this group may have greater concern over appearance than other age groups.¹² Nonetheless, appearance-based interventions at an early age could be important in establishing life-long beneficial dietary habits. Further, our sample was largely European. Hopefully the intervention can be rolled out in larger clinical trials to establish the efficacy across people from all walks of life.

We do not know the ingredients of a successful campaign, but there are several aspects of our approach that are novel and might prove persuasive. We can stress the short-term benefits that can be made. Avoidance of illness later in life is a threat that may not be particularly motivating. Our intervention stresses positives, better looks and achievable goals that are attainable within relatively short time frame (six weeks). One doesn't have to wait decades to cash in on good dietary behaviour.

On the technological side we are able to personalise the information and this may make it salient. Each participant can see how their *own* appearance is affected by a high fruit and vegetable diet. In future studies we hope to test whether or not seeing images of another person can be persuasive. If so, images demonstrating appearance

benefits would be an immensely cost-effective means of health education. Even if the major benefits derive from the personalisation of images, with some development and care it should be possible to perform realistic transformations across the internet. Such possibility supplies health educators with persuasive tools, and provides the internet-savvy public with the means for self-motivation.

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¹² S.J. Chung, S. Hoerr, R. Levine and G. Coleman, 'Processes underlying young women's decisions to eat fruits and vegetables', *Journal of Human Nutrition and Dietetics*, 19 (2006), 287-98.