Challenging synthetic food dyes: natural colours and ingredients

Many food manufacturers have considered replacing synthetic colours in their products with natural alternatives in response to pressure from their customers and, more recently, from regulators. The market for food colours derived from natural sources has been growing steadily as sales of synthetics have declined, but natural colours can bring a new set of problems, without necessarily dispensing with all of the old ones. Some now see colouring foodstuffs as the answer, but is it really that simple?

There is no getting away from the fact that food manufacturers often need to add colour to processed products. The colour of food is a surprisingly large part of its appeal and is closely associated with consumer perceptions of flavour and quality. An inappropriate colour can completely change expectations of how the product will taste.

Unfortunately, processing and storage can have a significant effect on the colour naturally present in many foods. For example, many canned fruits and vegetables assume an unappealing grey or brown hue after retorting, which detracts considerably from their acceptability. That is why product developers spend so much time getting the colour right and ensuring that it remains stable during shelf life.

The importance of colour to the food industry is also reflected by the size of the market for colouring additives. According to an updated report from Leatherhead Food Research published in August 2010, the global market for food colours is likely to be worth US$1.6bn by 2015. This represents growth of 10% over the current market size and demonstrates just how important food colours are to the food industry. But that predicted growth is due almost entirely to increasing demand for natural colours and colouring foodstuffs, rather than for synthetic colours. The report shows that the demand for natural colours has grown by nearly 35% since 2005, while sales of synthetic colours are in decline. In Western Europe, the market for natural colours is expected to be bigger than that for synthetics within a few years.

Health concerns over synthetic colours

Until recently problems of colour loss and stability in foods could be easily tackled by using azo dyes, originally derived from coal tar. These additives have a long history of use and are capable of producing a broad palette of consistent and vibrant colours that are stable, resistant to fading, inexpensive and water-soluble. Their only real disadvantage as food colours was that they are not soluble in oil. But this view has changed over the last five years as concerns about possible adverse health effects of synthetic colours have grown.

There have been worries about the toxicity of some synthetic azo dyes for at least 50 years and many are no longer approved for use in food in Europe. As recently as 2007 the EU suspended the use of the dye Red 2G in response to fears over its breakdown to aniline, a known carcinogen. But recent concerns focus on the possible effect of some azo dyes on child behaviour. This is actually an old issue, first raised in the 1970s by Dr Benjamin Feingold, who suggested a link between some food colours and hyperactivity. Despite many attempts to test the "Feingold Hypothesis" no conclusive evidence has ever emerged that eliminating synthetic colours from a child's diet produces any effect on hyperactivity. Nor has any causal link between synthetic food colours and behaviour been established. Despite this, concerns remain and are now arguably greater than ever.

The pivotal moment came in 2007, with the publication of the so-called "Southampton study" in the UK. The Southampton University study investigated the effect of two cocktails, each of four artificial colours plus the preservative sodium benzoate, on the behaviour of children in two age groups, under 3 years old and 8-9 year olds. The colours used were sunset yellow, tartrazine, carmoisine, ponceau 4R, quinoline yellow and allura red. The results suggested that one or more of the colours tested could be linked to an increase in hyperactive behaviour, but did not identify which colour could be responsible and did not demonstrate any causal link. The UK Food Standards Agency, which funded the study, decided that the findings were sufficiently worrying for it to call for a voluntary ban on the use of the six colours in the UK food and drink industry.

Despite an EFSA Additives panel evaluation of synthetic food colours in general and the Southampton study in particular, which concluded that no changes in EU law were necessary, changes have nevertheless been made. In 2008 the European Parliament reacted to the findings of the study by adding a new provision to a package of additive regulations, which came into force in 2010. This stated that any foods containing the six food colours would have to be labelled with the relevant E-numbers and with the phrase "may have an adverse effect on activity and attention in children." While not an outright ban on these colours, it has certainly encouraged manufacturers to consider replacing them with alternatives.

Sources of natural occurrence	Colour	Pigment	EC No
Black Grapes Blackcurrants Cherries Elderberries Red Cabbage Strawberries	Red/blue	Anthocyanins	E 163
Beetroot	Pink	Betanin	E 162
Cochineal	Red	Carminic acid	E 120
Alfalfa Grass Nettles Parsley Spinach	Green	Chlorophylls and Chlorophyllins	E 140 E 141
Annatto Carrots Oranges Prawns Red Peppers Saffron Tomatoes Palm Fruit	Yellow Orange Red	Carotenoids: Mixed Carotenes beta-Carotene Bixin/Norbixin Capsanthin/Capsorubin Lycopene Apocarotenal Apocarotenal (Ethyl Ester) Lutein Canthaxanthin	 E 160a (i) E 160a (ii) E 160b E 160c E 160d E 160e E 160f E 161b E 161g
Turmeric	Yellow	Curcumin	E 100
Eggs Milk Yeast	Yellow	Riboflavin	E 101
Carbonised vegetable material	Black	Carbon black	E 153
Caramel	Brown	Melanoidins	E 150a-d

Table 1. Natural food colours available for food use in Europe (Source: The Natural Food Colours Association).

Naturally coloured beverages
(image courtesy of Chr. Hansen).

The publicity attached to the Southampton study and the reaction of the regulators to its findings is an important driver for change in the colours market. The Food Standards Agency has established a list of products that do not contain the six colours used in the study, which consumers can find on its web site. As manufacturers phase out the use of the colours they are invited to add their products to that list. There is also a broader antipathy towards food additives in general among European consumers and this too is an important driving force for manufacturers to reformulate products. Major retailers have got behind this trend, especially in the UK where many supermarket own-label products have already been reformulated without synthetic colours. The owners of established brands have been rather less ready to reformulate their products. Some are reported to be waiting until they have evidence of a real effect on sales before committing to expensive reformulation.

The natural alternative

A natural colour is generally understood to be a concentrated extract of a naturally occurring pigment, but a clear definition of natural is problematic. The waters are muddied further by 'nature-identical' colours, which are synthesised copies of naturally occurring pigments. Although chemically the same as natural pigments, these are clearly not natural, even though they may be indistinguishable from the real thing.

The rapidly growing demand for natural alternatives to synthetic food colours has prompted food colour manufacturers to invest heavily in improving their natural colour ranges and in increasing their applications expertise. Companies like Chr. Hansen, Overseal Natural Ingredients, DDWilliamson, Naturex and Kalsec® Europe are all able to offer a range of natural colour extracts and blends suitable for food applications. There are now products available to reproduce most synthetic colours, although blues and purples present more of a problem than other colours. Table 1 shows the main natural pigments that are currently available.

At first sight it might seem that natural colours provide a ready-made answer to the problem of replacing synthetics in foods, but unfortunately they bring problems of their own. The most obvious drawback is that natural colours do not necessarily perform as well as synthetic colours when added to real food products. They are usually less vivid than synthetics and an exact match may be difficult to achieve, even by blending several colours. Natural colours are also generally less stable than their man-made counterparts and can interact with other ingredients in the product. For example, anthocyanins fade very rapidly at neutral pH values. Although more stable under acid conditions, they appear increasingly red, rather than blue or purple, at low pH. Some natural colours are not heat stable and must be added after processing, others fade when exposed to light, or are prone to oxidation during storage and some precipitate in acid foods. Although some of these problems can be solved by product reformulation and changes to processing and packaging, the additional development costs involved can be considerable and are a potential barrier to replacing synthetic colours. Technological developments like microencapsulation may be a way forward, but these too add cost, at least in the short term.

If all the drawbacks associated with natural colours were technical, it is likely that they could be solved. Unfortunately, some of the legislative and acceptability issues that have plagued synthetics are beginning to impact on natural colours in turn. As is clear from the table above, the range of natural colours approved for food use in the EU is still quite limited. European legislation dictates that novel colour pigments and extracts need to complete a lengthy authorisation process before they can be approved for use as food additives. Furthermore, regular scientific safety evaluation sometimes reveals unexpected problems. For example, the EFSA Food Additives Panel recently re-evaluated caramel colours and recommended a reduction in the acceptable daily intake (ADI) of class III caramel (E150c) in response

Ice-cream circle (image courtesy of Chr. Hansen).

to new toxicological information about one of its constituents. Questions of a different kind are being raised about colours based on carmine, because it is derived from the cochineal insect. Although undeniably natural, the insect origin is a problem for vegetarians and in certain diets governed by religious principles.

Yet another hurdle in the path of natural colours is the growing opposition among consumers to additives in general and E-numbers in particular. There is evidence that many consumers do not understand the difference between synthetic and natural colour additives. The move towards a 'clean-label' is gaining support from retailers and some manufacturers. On the face of it the clean label lobby could bring the industry back to square one, rendering natural colours just as undesirable as synthetics. That is why food colour suppliers are devoting a good deal of attention to a second alternative.

Colouring ingredients

The Natural Foods Colours Association defines colouring ingredients as follows: *"A food ingredient derived from a food source or characteristic ingredient of food processed in such a way so as not to selectively extract the pigments(s), even when used principally for the purpose of coloration of the final application".*

Colouring foodstuffs are highly coloured concentrates of fruits, vegetables and other edible plants, rather than extracted natural pigments. Their big advantage is that they can be can be listed on food labels as ingredients rather than additives and, provided that they are derived from recognised foods, they do not require further approval for food use and do not need to be identified by an E-number. An additional selling point of some colouring foodstuffs is that they can deliver not just colour, but also health benefits. Many coloured fruit concentrates contain antioxidants that may help protect against some cancers and other illnesses. Examples of colouring ingredients used as alternatives to colour additives include elderberry, grape, tomato, spinach, carrot, turmeric, paprika, cocoa, coffee and red wine. Although it is possible to achieve the same range of colours with colouring foodstuffs as with natural colours, the stability problems are also similar, especially in regard to heat and light. So far, this has largely limited their use to products like ice cream and dairy products, soft drinks and confectionery. There may also be unwanted effects on product flavour when using some colouring ingredients, such as beetroot. Nevertheless, the Leatherhead Food Research report on the colours market predicts that natural colours will face growing competition from colouring ingredients in the next few years.

Several food colour suppliers have already launched colouring ingredient products. Chr. Hansen launched its FruitMax® range in 2007 and extended the range of available shades from 21 to 29 in 2009. The GNT Group markets the EXBERRY® range, which it describes as "clean label, natural food ingredients." Indian company Roha has developed its Natracol range of fruit and vegetable extracts, which can be labelled as ingredients.

French natural ingredients specialist Naturex is to launch a range of colouring foodstuffs later this year, while its UK-based subsidiary Overseal Natural Ingredients has developed its Ingredients from Nature range.

It is clear that natural alternatives to existing synthetic food colours have important advantages, but also carry significant drawbacks for food manufacturers. But the technology of natural colours is still in its infancy and will surely develop solutions for many of the challenges. For example, Unilever has already patented an alternative to titanium oxide, currently the only truly white food colour available, for sauces and dressings. The range of colours available will grow and their performance and stability will certainly improve.

It seems probable that some products, especially canned fruit and vegetables, will always need to use synthetic colours, unless consumers are prepared to radically alter their expectations. For the moment manufacturers have a wide choice of colours, synthetic and natural, that they can use. All of that could change if EU legislators proceed to impose a wider ban on the use of synthetic colours, as seems possible. But until that happens, synthetics will continue to have an important role in making processed foods appealing enough for consumers to go on buying them.