PIGMENTS AS FOOD SUPPLEMENTS – FUNCTION, HEALTH AND DISEASES

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Pigments in food are a huge topic which includes several classes of molecules with different chemical and physical properties. Some of these molecule classes are: Carotenoids, flavanoids betalains and porphyrins, which all work as functional- and, or signalling molecules in the nature. Among thousands of different naturally occurring pigments, only relatively few of them are used as colorants in the food processing industry. Strong regulations regulate the use of colorants and testing of toxicity on animals, usually rodents, have to be done before legalisation. Often it is necessary to find a level of acceptable daily intake (ADI) to prevent the consumers of possible negative effects made by the supplements. However, most of the pigments in nature work as natural antioxidants and the use of them as food supplements could make food products in the category "functional food", which can positively influence on human health and give protection against some diseases caused by oxidative stress in the human body. In the food processing industry a lot of other colorants than is mentioned above, are used to make different kinds of colours in a huge assortment of products. Some of these colorants are: Turmeric, Caramel and inorganic and organic miscellaneous colorants, but the main focus of this lecture will be on the main classes of natural pigments, their use as colorants, functional properties and potential health benefits of these components.

The carotenoids are probably the best known of the food colorants and certainly they are one of the largest groups of pigments produced in nature. More than 600 different carotenoids are known and annually more than 100,000,000 tons are produced in nature. Most of this amount is in the form of fucoxanthin in marine algae and the three main carotenoids in green leaves: lutein, violaxanthin, and neoxanthin. Other carotenoids predominate in certain plants, such as lycopene in tomatoes and β-carotene in carrots. In the resent decades the presence of carotenoids in our food supply and their role in human health has been of unprecedented interest. Some carotenoids are provitamin A precursors, and about a dozen carotenoids are found in human plasma, depending on diets rich in fruits and green vegetables, and yellow/red vegetables. Carotenoids are potential antioxidants and are known to affect many different cellular pathways. Zeaxanthin and lutein are accumulated in the human eye and are known to prevent the eye against age-related macular degeneration. Numerous epidemical, interventional, and clinical studies have been performed, and some of them have found positive effects of different carotenoids on cancer and other diseases caused by oxidative stress. Oxidative stress diseases include inflammatory bowel diseases, retinal ischemia, cardiovascular disease and restenosis, AIDS, acute respiratory distress syndrome (ARDS), and neurodegenerative diseases such as stroke, Parkinson`s disease, and Alzheimer's disease. Treatment with antioxidants like carotenoids is possible because involvements of oxidative injury are presented in such diseases.

Golden rice is an example of a fortified food developed to be used in areas where there is shortage of dietary vitamin A. This rice is genetic engineered to produce β-carotene, a precursor of provitamin A in the editable part of the rice. The scientific details of the rice were published in *Science* in 2000. In 2005 a new variety of the rice was announced which were called *Golden rice 2*. This type is producing 23 times more β-carotene than the original variety of golden rice.

Among all carotenoids, 8 natural "groups" of carotenoids work as food colorants. They are α-, β- and γ-carotene (E160a), bixin, norbixin, annatto (E160b), capsanthin, capsorubin, paprika (E160c), lycopene (E160d), β-apo-8`carotenal (E160e), ethyl ester of β-apo-8`carotenal (E160f) and Lutein. According to human health E160a, E160d and E161 are probably most important, because they are extremely powerful antioxidant agents. Carotenoids work as antioxidants and together with health benefits they also inhibit peroxidation of lipids in food products and increase the shelf-life of especially products rich on highly unsaturated lipids.

Astaxanthin, a pink carotenoid is used as pigment in salmon feed. Salmonids accumulate astaxanthin and related carotenoids in muscle tissue which give the flesh the characteristic pink colour. This colour is related to good flesh quality of salmonids. Humans eating salmon consume relatively high amounts of astaxanthin, which could work as a good source of antioxidants and a source of provitamin A. Earlier another carotenoid, cantaxanthin, was used as well as astaxanthin in the salmon feed. Nowadays, canthaxanthin is illegal to use in the Norwegian farmed Atlantic salmon industry, due to efflorescence of canthaxanthin in the human retina, and possible toxicity of canthaxanthin when used in high doses.

Flavanoids are a huge class of pigments which are presented in nature as yellow-red-blue colours. Flavanoids are divided into six main subclasses, where anthocyanidines are the most known subclass. Of anthocyanidines, anthocyanins are most known due to the presence in the skin of blue grapes. Flavanoids has a series of biological effects. They work as; antioxidants, antiasthmatic-, antiallergic-,

antiviral-, antimicrobial-, antifungal- and anticancer agents, inhibitors of enzymes, regulating estrogens activity and have functions in regeneration of membrane-bounded antioxidants as vitamin C and E. As food supplement anthocyanins and hibiscus (both E163) are used and give a red-violet/red colour to the products.

Betalains are a small class of pigments containing of about 55 chemical structures with a wide range of different colours in the yellow-orange-red spectra. They are fitted for use in low-acid and neutral products where anthocyanins loose their performance and have spectacular changes in colour. Batalains are therefore substitutes for anthocyanins in the pH range 3-7. As a food colorant, extracted betanin (E162) from Beetroot is used.

Plant porphyrins consist of chlorophylls, green pigments that are ubiquitous in nature since they are responsible for the photosynthetic process. In spite of their abundance, however, it is primarily plants such as alfalfa, nettle and leaves of carrot which are used as sources of these colorants. Due to their chemical structure they are divided into two groups; chlorophyll A and chlorophyll B, where chlorophyll A is most widely used industrially. When used together with lipids, the pro oxidant activity of these components has to be taken under consideration. After extraction it is separated from the carotenoids such as lutein and subsequently purified. Chlorophyll is extremely sensitive to heat and light and it is converted into a substance where the magnesium ion is replaced by a copper ion, which means that it can no longer be considered as a “natural” product. The benefits of this compound are that it is more stable and have a more intense colour compared to natural chlorophyll A. To make these compounds soluble in aqueous media, alkaline hydrolyses made sodium and potassium salts of chlorophylls resulting in increased solubility of the colorant.

As a conclusion, natural pigments used as food colorants are good colorants in a wide colour-spectrum, and a source of healthy components in many food products. These healthy properties are mostly due antioxidant activity, and the opportunity to make functional food based on natural pigments is potential. Some natural pigments are already used in pharmacologic products, such as anti inflammatory drugs based on water soluble carotenoids.