Natural Colorant For Food: A Healthy Alternative

Mohamad Faizal Mohamad, Daniel Joe Dailin, Sara E. Gomaa, Muktiningsih Nurjayadi, Hesham El Enshasy

Abstract: Natural colorant have great interest in the market. Colorant are an important aspect that affect the way we feel and judge towards foods. The color of foods is normally associated with the safety, flavor and nutritional value of the products. Therefore, it is an important characteristic that give reason for colorant to be added in foods. As a natural colorant, it can replace the synthetic dyes. Since, an artificial color additive tends to impart undesirable taste, negative health issues related to their consumption such as allergic and intolerance reactions. Food with good texture, nutrients and flavor should be of appealing color then only it can be desirable for human consumption. It is therefore, essential to explore various natural sources of food grade colorants and their potential uses. This review summarizes the important of natural colorant in human health and wellness, economic impact and different groups of natural colorants as a healthy alternative compare to conventional colorant used.

Index Terms: Natural, colorant, food, health, wellness

1. INTRODUCTION
Colorant has been added to food products for centuries. Candy makers in ancient Egyptian cities around 1500 BC were adding natural extract and wine to improve product appearance [1]. Some spice such as saffron believed to have been utilized as both flavor and colorant since ancient time. The industrial and urban development in the 19th century has leads to massive production of food and garments. In conjunction to this development, the requirement of colorant also grew to improve the appearance of food and textile products. It was around this time that colorant derived from minerals were introduced as food additives. Unfortunately, some of the colors account for serious health problems. For example: addition of copper sulfate and lead chromate to processed food caused some cases of death because of the contamination of toxic impurities such as arsenic. Concurrently, synthetic colorants were also introduced by the derivation from tar colorants and other petroleum derivatives. The first synthetic color (mauvine) was developed in 1856 by Sir William Henry Perkin. This development was followed by other synthetic colorant and widely utilized throughout the USA and Europe in foods, medicines and cosmetics. During this time, more than 80 artificial coloring agents were used, although some of them are intended for dyeing textiles and not for food applications. Nowadays, most of synthetic colors were derived from toxic petroleum product, and natural colors from plant, mineral and animal available, economic incentives kept manufacturers from utilizing the latter. Synthetic colorants are easier to produce and can introduced to the market with cheaper prices. In addition, they added in small amount to give the desirable color. Widespread use of synthetic colors has increased safety concerns which led to the development of many new regulations in many parts of the world to control the extensive and unsafe use of chemical coloring agents. Current awareness and affinity towards natural colorant can be attributed to the environmental activist movements in USA during the 1960s and 1970s. Colorant was inevitable target by this movement because it only provided cosmetic value and it has possibility to cause health damage. Consequently, manufacturers were pro-actively developing colorant from natural sources and introducing nutritional characteristics as marketing tools. Nowadays, the uses of natural colorant are reinforced by scientific findings on the health benefit of several groups of pigments such as anthocyanins and carotenoids. For example: Hibiscus sp which contain up to 2.5% (dry weight) anthocyanin[2] have historically been used in reduce liver disfunction and hypertension[3,4]

2 DEFINITION OF NATURAL COLORANT
Color is a perception that is manifested in response to a narrow span of electromagnetic spectrum emitted by light sources [5]. Colorants are defined as substance that modify the perceived color of objects, or impart color to otherwise colorless objects. On the other hand, the term “natural” means “present in or produced by nature; not artificial or man-made” and “Not altered, treated or disguised”. Consequently, the term natural colorant means; substance produce by nature (obtained from plant, animal or mineral) that modify the perceived color of objects, or impart color to otherwise colorless objects.

3 LEGISLATION ASPECT OF NATURAL COLORANT
Legislation wise, the term ‘natural color’ is not used by the European Union member states (EU) and United States Food Drug Administration (USFDA). Colorant in EU is grouped under food additive categories, which include ‘colors’ (94/36/EC), ‘sweeteners’ (94/35/EC) and ‘additives other than colors and sweeteners’ (95/2/EC). Under the directives, foodstuffs which have coloring properties e.g. spices and spinach are not classified as colors. Certain material will be considered color additives when the color is concentrated at the expense of removing the other components, such as flavoring. Color additive in the US are divided into two main categories:

- Certified color additives – FD&C color. Colors under this category are synthetically produced organic molecules that have their purity checked by USFDA.
- Colorants exempt from certification. Colors under this category are derived from animal, vegetable, mineral origin or are synthetic duplicates of naturally existing colors.

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From regulatory point of view, the term ‘natural color’ in the US is not permitted to be listed in labeling as it may indicate that the color occurs naturally in products. Labeling that can be used to convey the message to the consumer that the color additive in products are from natural source is by stating e.g. ‘colored with Annatto’.

4 IMPORTANCE OF NATURAL COLOR

4.1 Economic Impact
Consumer perception that ‘natural is best’, sociological changes and technological advances in food processing has contributed significantly to the increased in utilization of natural colorant1. In 2016, food color market size was estimated at USD 1.79 Billion globally with CAGR growth at approximately 5.9%. Global population growth is expected to contribute to increase in demand for food and beverage products which in turn likely to drive demand for colorants. Worldwide demand for natural colorant is increasing substantially as a result of increasing awareness among consumers regarding the health benefit related to natural food colors. It is estimated that natural food color is the largest segment in food colorant industry, amounting to over 80% of total market revenue7. Frost & Sullivan reported that Europe alone spends USD 198.1 million in 2006 on “natural and nature-identical food colors” and forecast to be worth USD 247.7 million in 2013. Carotenoids sector is enjoying rapid sales growth in the food industry because it is being promoted as both “natural” colorants and as antioxidant. Global expenditure on carotenoids alone is expected to reach USD 1.7 Billion by the year 2022.

4.2 Natural Colorant in health and wellness
We consume a lot of food which contain attractive colors. In fact, color is widespread throughout nature in fruit, vegetables, seeds and roots that our daily diets might contain large quantities of many pigments especially anthocyanins, carotenoids and chlorophyll. Consumption of colorant from processed foods which are colored with natural colorant is fairly insignificant when compared with color we ate from foods[1]. However, natural colorant is more preferred by the consumer as compared to synthetically produced colorant due to safety concern. For instance, a research team at the Southampton University published findings from an experiment involving 300 children randomly chosen from the total population. The findings demonstrated a measurable change in various behavioral factors associated with hyperactivity and attention-span, after drinking two different mixes of fruit drinks ‘spiked’ with certain food colorants (based on coal-tar derivatives) and the preservative sodium benzoate[10,11]. Although consumption of natural color additive is fairly insignificant as compared to natural color consumed from food, the health benefit offered by the colorant should offer strong incentive to limit the usage of synthetic colorant thus promotes healthier processed foods.

Table 1 Potential source of natural colorant in Malaysia

<table>
<thead>
<tr>
<th>Organism</th>
<th>Phytochemical</th>
<th>Color</th>
<th>Application</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Higher Plants</td>
<td>β-carotene</td>
<td>Golden</td>
<td>Feed and food additive and dietary supplement</td>
<td>ii</td>
</tr>
<tr>
<td>Palm Oil fruit</td>
<td></td>
<td>Yellow to orange</td>
<td>Traditionally being used as colorant for food in South East Asia. Have potential to be used as food additive and a patent has been issued in Japan for producing citoria ternatea l. flower extract.</td>
<td>ii, iv</td>
</tr>
<tr>
<td>(Elaeis guineensis)</td>
<td></td>
<td>Purlish</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunga telang</td>
<td>Anthocyanin</td>
<td>Blue to red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Citroia ternatea)</td>
<td></td>
<td>depending on pH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purple fleshed Potato</td>
<td>Anthocyanin</td>
<td>Red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Solanum tubersum L.)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purple sweet potato</td>
<td>Anthocyanin</td>
<td>Purple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Ipomoea batatas)</td>
<td></td>
<td>Lavender purple</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Purple Yam</td>
<td>Anthocyanin</td>
<td>Brilliant Red</td>
<td>Potential application as food colorant at low pH value and possesses similar hues to FD&amp;C Red #40</td>
<td>i</td>
</tr>
<tr>
<td>(Dioscorea alata)</td>
<td></td>
<td>Red</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Roselle (Hibiscus sabdariffa)</td>
<td>Anthocyanin</td>
<td>Purple-red</td>
<td>Potential application as food colorant at low pH value and possesses similar hues to FD&amp;C Red #40</td>
<td>i</td>
</tr>
<tr>
<td>Dragon fruit/ Pitaya</td>
<td>Betalain</td>
<td>Green</td>
<td></td>
<td></td>
</tr>
<tr>
<td>(Hylocereus costaricensis)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pandan (Pandanus amaryllifolius Roxb.)</td>
<td>Chloroplyll</td>
<td>Yellow to deep orange</td>
<td>Commonly used to produce jam and fruit juices in Thailand</td>
<td>39</td>
</tr>
<tr>
<td>Daun Suji (Dracaena angustifolia)</td>
<td>Curcum inoid</td>
<td></td>
<td>A potential source of colorant. Betanin from red beet already being used as colorant.</td>
<td>5, 41</td>
</tr>
<tr>
<td>Turmeric (Curcuma longa)</td>
<td>Ground powder, Oleores in,</td>
<td></td>
<td>Being use traditionally as additive in food for flavoring and green</td>
<td></td>
</tr>
</tbody>
</table>
Amin Groups of Natural Colors

5.1 Carotenoids

5.1.1 Definition and Classification
Carotenoids are compound constituted by eight isoprenoid unit (ip). The ip units are joined in a head-to-tail pattern, but the order is inverted at the molecule center (figure 1). According to this structure, a numbering system (semi systematic) was assigned to name carotenoids. Lycopene (C_{40}H_{56}) is considered the first colored carotenoids in the biosynthesis of many other natural carotenoids and it is linear. Carotenoids can also exist in acyclic, cyclic, and shortened carotenoids form, among others. Carotenoid biosynthesis involves many chemical reactions to form diverse structures[9]. However, carotenoids are classified according to two main criteria:
1. Chemical structure; two groups are formed (carotenes and xanthophylls)
2. Functionality; they are grouped as primary and secondary carotenoids.
3. Period.

5.1.2 Distribution
Carotenoids are widely distributed in nature. Every form of life is considered to have carotenoids in their chemical composition and different colors can be observed from this group of pigments (e.g., red, pink, orange, yellow). Large number of carotenoid can be found in marine organisms especially marine algae (fucoxanthin). Another large source of carotenoid is green leaves (lutien, violaxanthin, and neoxanthin). The carotenoid composition in leaves is virtually the same in all species: β-carotenes (~25-30%), lutien (~45%), violaxanthin (~15%), neoxanthin (~15%) and small amount of α-carotene, α- and β-cryptoxanthin, zeaxanthin, and antheraxanthin.

5.2 Anthocyanin

5.2.1 Definition & classification
Anthocyanin comes from Greek word anthos, a flower; and kyanos, dark blue. Anthocyanins are glycosides of anthocyanidin, aglycone possessing a fundamental skeleton of 2-phenylbenzopyrylium, known as the flavylium cation (figure 3). More than 90% of all anthocyanins isolated in nature are based on the following six anthocyanidins: pelargodin (plg), cyanidin (cyd), delphinidin (dpd), peonidin (pnd), petunidin (ptd) and malvidin (mvd) (figure 3). They are differentiated by the substitution pattern on the B ring. A recent novel structure has been found in wine and called proanthocyanin. To obtain an anthocyanin, the anthocyanidin must be combined with at least one sugar molecule; therefore, anthocyanins are also classified by the number of sugar molecules in their structure (e.g., monosides, biosides, triosides). An anthocyanin diversity is associated with the number of sugars found in nature but glycosylated anthocyanins are formed with glucose, rhamnose, xylose, galactose, arabinose, and fructose. In addition, diversity is further increased by the chemical combination of these sugars with organic acids (the most common are coumaric, caffeic, ferulic, p-hydroxy benzoic, synapic, malonic, acetic, succinic, oxalic, and malic) to produce acylated anthocyanin[5].

5.2.2 Distribution
Anthocyanin structure exhibit a great range of colors (e.g., red, purple and blue) in flower, fruits, leaves and storage organ of higher plants. Anthocyanin is common in higher plants but are absent in some lower plants and algae. Anthocyanin concentration in most fruits and vegetable ranges from 0.1 to 1% dry weight.
Figure 3 Structure of anthocyanidins and pyroanthocyanidins occurring in foods[42]

5.3 BETACYANIN

5.3.1 Definition & classification

Betalains are immionium derivatives of betalamic acid and the general formula are shown in figure A. It is based on the protonated 1,2,4,7,7-pentasubstituted 1,7-diazahectamethin system[5], an extended π-electron system exhibiting a canary yellow color[43]. Betalamic acid may condense with cyclo-dopa to yield betanidin, the common precursor aglycon of the red betacyanins. Betanidin in turn may be glycosylated and/or acylated, yielding 29 genuine structures currently known. The number doubled due to stereoisomerism at C15, with the exception of neobetanin (14, 15-dehydrobetanin) which is devoid of the chiral center at C-15[43,44]. The yellow analogues betaxanthins (Figure C) are composed of betalamic acid with amino acids or amines, respectively, amounting to 26 structures known to occur naturally[44]. Common names of betalains are assigned in relation to the plant from where they were first isolated (e.g., betacyanins amaranthine-I from Amaranthus tricolor).

5.3.2 Distribution

Betalains are known to occur in 13 plant families of the Caryophyllales and have never been found to co-occur with anthocyanins in the same plant[5]. Betalains are found in different plant organs and they are accumulated in cell vacuoles, mainly in the epidermal and sub-epidermal tissues. However, betalains are sometimes accumulated in plant stalks such as in the underground parts of red beet. Betalains are also present in the higher fungi Amanita, Hygrocybe, and Hygrosporus.

6.0 CONCLUSION AND FUTURE PERSPECTIVES

Plant natural colorant is of growing business based on the increased awareness about the necessary to have non-toxic, and non-hazard chemicals as food additives. However, based on the limited natural resources, the growth of this natural colorant market will be also attributed to the increased growth of microbial pigments market in food and cosmetic industries. Therefore, natural color pigment for human wellness will grow further and need not only new discovery of new compound but also to increase the stability and ease the application of the current known compounds.

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