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Review: Varieties of anthocyanin pigments extracted from colored plants and their applications

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Abstract

Anthocyanins are a class of flavonoids characterized by water-soluble color pigments found in the form of glycosides. They are associated with one or more sugar moieties. Anthocyanins are found within various plant organs, like flowers, leaves, fruits, roots, tubers, and grains. Depending on their structure, pH, and other factors, they appear in colors ranging from yellow to blue. These compounds have received great attention as they have replaced chemical dyes such as food coloring and the pharmaceutical industry. They also enhance plant tolerance to many abiotic stresses, such as salinity, drought, excessive light, ultraviolet radiation, and cold pressure. Besides, previous studies showed the importance of anthocyanins in human health and their protective properties against chronic diseases. It has also been of interest due to its ability to change color according to pH values and its uses as an acid-base indicator in quantitative analysis.

Keywords: Anthocyanins, Antioxidants, Antibacterial, Anti-inflammatory, Anticancer, Cyanidin, Indicator.

Introduction

Anthocyanins (the Greek syllable anthus: flower and kyanos: mean dark blue) are a class of phenolic compounds (1). Compounds of glycosides characterized by their solubility in water, and they have a color gamut of attractive pale yellow, orange, red, purple, violet and blue for various plant tissues in their parts leaves, flowers, fruits and roots (2,3).

Anthocyanin	R_1	R_2
Pelargonidin	H	H
Cyanidin	OH	H
Delphinidin	OH	OH
Peonidin	OCH_3	H
Petunidin	OCH_3	OH
Malvidin	OCH_3	OCH_3

Fig(1) structure of anthocyanins(2)

Types of anthocyanins:-

- Pelargonidine (Pg) appears orange in plants such as blueberries, strawberries, bananas, red radishes and potatoes. (4- 6).

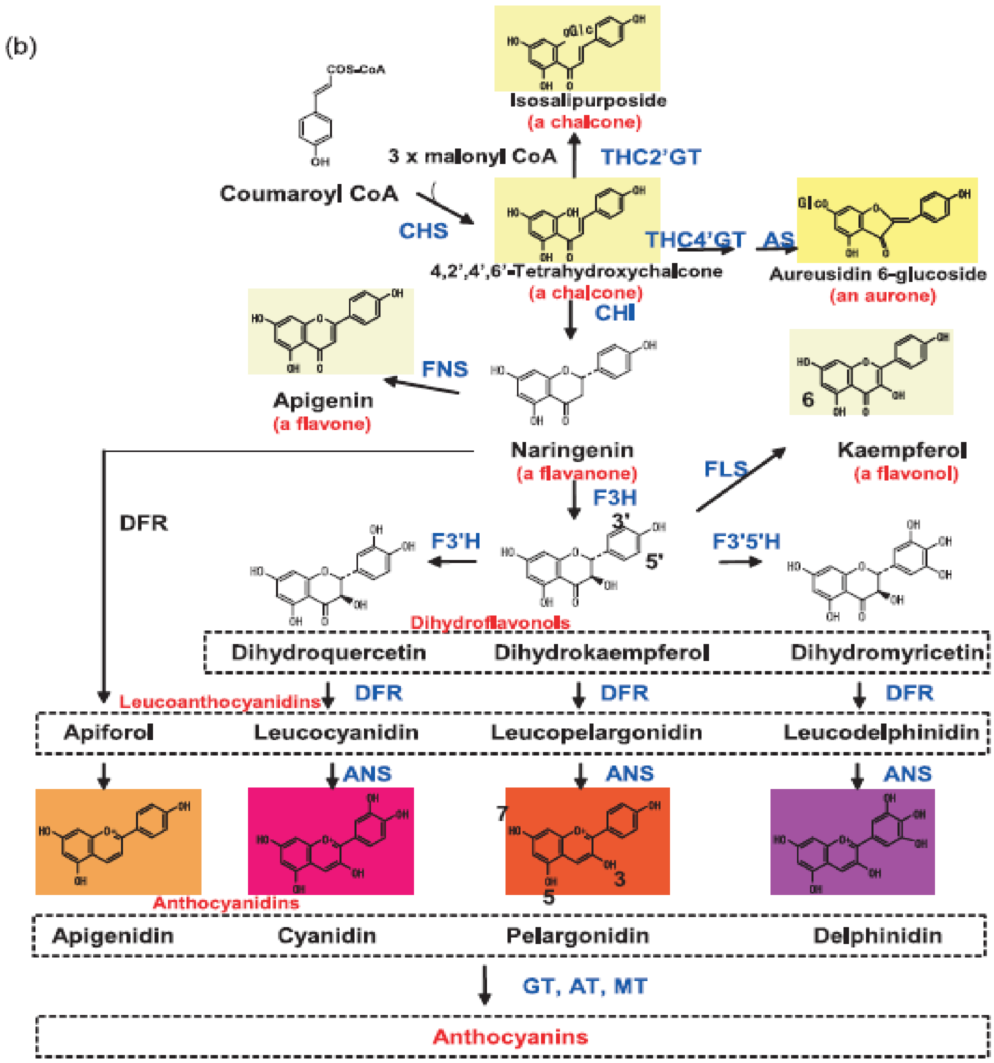
- Cyanidin (Cy) has purple and red colours. It is most commonly found in plants such as blackberries, blackberries, peaches, figs, cherries, red onions, red cabbage, plums, grapes, red sweet potatoes, strawberries and purple carrots. (4-7).

- its lilac color and abundance characterizes Peonidin (Pn) in a number of fruits such as mango, grapes and plum (4-7)

- Delphinidin (Dp) is present in violet and bluish-violet, so the blue color of the flowers is due to the presence of these compounds (8). It is also abundant in eggplant, red beans, pomegranate and grapes. (4,5,6,7,9) . - Petunidin (Pt) This pigment is present in red grapes and red berries appear in a purple color. It is mainly responsible for the purple color of the fruit (4-7)

Synthesis of anthocyanins:-

The biological pathway for the synthesis of anthocyanins in plant seeds is localized within the cytosol. The enzymes involved in synthesis reactions are classified into biosynthetic enzymes, including oxoglutarate-dependent dioxygenase (OGD), cytochrome P450 (P450) and glucosyltransferase (GT). Genetic analysis shows that enzymes that assist thiocyanidin synthase (ANS), also called leucoanthocyanidin dioxygenase), which belong to the (OGD) family, have a role in the synthesis of the corresponding pigment(10). Anthocyanins are synthesized through the phenylpropanoid metabolic pathway using the amino acid phenylalanine to produce 4-coumaroyl-CoA. It then combines with malonyl-CoA to produce the true skeletal flavonoids, called chalcones, that contain two phenyl rings. This is followed by the conjugate circular closure of the chalcone which is the familiar form of flavonoids, composed of triple rings of flavonoids. The metabolic pathway proceeds through a series of enzymatic modifications to produce flavanones → dihydroflavonol → anthocyanins. Through this path a number of products are formed(11).



Fig(2) The biological pathway for the synthesis of anthocyanins(76)

Application of anthocyanins:-

1-Antioxidative Effects:-

Antioxidants can be defined as compounds that prevent the oxidation of oxidative substances by getting rid of free radicals and reducing oxidative stress, an unbalanced state that causes an increase in the amounts of reactive oxygen or nitrogen species (ROS / RNS). hydroxyl radicals and peroxynitrite) on the amount of endogenous antioxidants, which leads to Free radicals oxidize different types of biomolecules, such as DNA enzymes, proteins and lipids. Oxidative stress causes the development of chronic diseases, including coronary heart disease, cancer and aging, but in recent years, there has been an inverse relationship between eating fruits and vegetables and the risk of vascular oxidative stress diseases(78). Osteoporosis is attributed to the fact that plants contain flavonoids. The mechanism of action of flavonoids has been suggested by the following mechanisms:

1-Sniping free radicals such as ROS/RNS.

2-Quin inhibiting ROS/RNS by inhibiting certain enzymes or chelating trace metals that contribute to the production of free radicals.

3-Protection of antioxidant defense(74).

Anthocyanins scavenge free radicals and are chelating compounds of minerals that act as free radical scavengers and chain breakers. It interferes with the oxidation of lipids and other molecules through the rapid donation of hydrogen atoms to the free radicals formed by the process of oxidizing molecules.(12-14). Studies have shown an inverse relationship between the consumption of fruits and vegetables and age-related diseases, due to the fact that they contain antioxidants, especially flavonoids, especially anthocyanins (15). There is a close relationship between the consumption of anthocyanins present in colored plant extracts with an increased antioxidant capacity that leads to reduced oxidation of plasma proteins, protection of endothelial function, inhibition of platelet aggregation, reduction of low-density lipoproteins (LDL), improvement of cardiovascular oxidation and neuronal recognition (16-18).

2-Anticancer :

Cancer can be defined as a multi-step disease related to environmental, chemical, physical, metabolic and genetic factors that play a direct role in the deterioration of cancers. Studies indicate a relationship between a diet that contains large amounts of fruits and vegetables rich in antioxidants and a reduced risk of many cancers. There are a number of dietary antioxidants that act as effective factors for preventing cancer and mortality (19-21), these substances in the diet are a useful and promising group due to their low toxicity and availability, including anthocyanins, one of the most complex of plant metabolism and an integral part of the human diet.

In addition to the role of anthocyanins as antioxidants, they have a role in reducing the risk of cancer and this has been proven in the laboratory by using a variety of anthocyanin extracts to determine their ability to suppress cancer cells. (22-30).

A study was conducted in Germany that subjects who consumed fruit or vegetable juices containing anthocyanins observed little damage to oxidative nucleic acids and an increase in decreased glutathione (31,32).and an anther study proved the mechanism of action of anthocyanins through the terminal differentiation of cancer cells and prevents the formation of tumors. It also acts as a kinase inhibitor in the cell differentiation process found that cyanidin-3 O-β-glucopyranoside (Cy g) stimulates the differentiation of the human myeloid leukemia cell line HL 60 in a manner that depends on the amount and course of doses of Cy g in activating PI3K as well as the effect of Cy g on the induction of melanoma cell differentiation (33,34).

3-Anti-inflammatory effect:

In addition to cell-derived polypeptides, there are a variety of molecules that function regularly for the inflammatory response, and they are known as cytokines(35). The production of proinflammatory and anti-inflammatory cytokines is controlled by complex reaction mechanisms of proinflammatory molecules, including tumor necrosis factor-alpha (TNF-α), interleukin (IL)-6, IL-8, and IL-1β. and are responsible for fighting pathogens such as adiponectin (36). Chronic inflammation is caused by a persistent imbalance between anti-inflammatory and pro-mediators(37).

Several studies have shown that anthocyanins can affect pro- and anti-inflammatory molecules in vitro. Decreased IL-concentrations were clearly observed by treatment of Helicobacter-infected human epithelial cells with anthocyanin extract from Java red soybean seeds (cyanidin-3-glucoside, delphinidin-3-glucoside, and petonidin-3-glucoside) for 24 hours (38) .Downregulation of IL-6 after treatment of arterial endothelial cells (39) was also observed after treatment of fat cells, while IL-6 expression was down-regulated by dose after treatment of differentiated 3T3-L1 fat cells with potato extract. Sweet purple for 24 hours (40).

A study was conducted on anthocyanin extracts of plants such as berries and acai fruits, where their role in inhibiting the production of TNF-α was observed after treatment of BV-2 mice microglia cells with these anthocyanin-rich extracts (41) as well as human colon epithelial cells stimulated with the roinflammatory cytokine TNF- α, IL-1β, and interferon γ (IFN-γ) (42).

The effect of grapevine extract on LPS-activated macrophages was observed, with female fractions downregulating the expression of the inflammatory cytokines IL-1β and TNF-α. (43). Black rice extract and anthocyanin-rich polyphenol fraction of Lonicera caerulea fruits reduced the production of TNF-α and IL-1β LPS (44). And human gingival fibroblasts treated with LPS result in downregulation of IL-1β, IL-6, and TNF-α. (45). It resulted in dose-induced production of C-reactive protein IL-6, IL-1β and IL-6 (46,79,80).

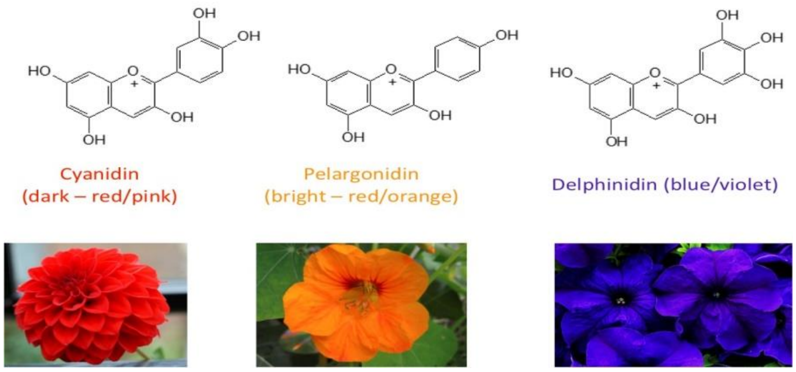
4-Antimicrobial

Current studies are directed to how to inhibit the activity of human pathogenic microbes through the use of safe and highly effective compounds such as the use of raw extracts from new food ingredients for their application in medical fields (47). These compounds include anthocyanins of the class of plant flavonoids with antimicrobial activity (48, 49). However, the explanation for this incomplete efficacy is that bacteria must adhere to and form biofilms for reproduction and colonization (50,51). Therefore, when selecting effective compounds, they have the ability to penetrate microbial membranes to stop their flowering and colonization (52). Among those isolated from plants such as raspberries against Vancomycin-resistant Enterococcus faecium, Pseudomonas aeruginosa, Staphylococcus aureus, and Escherichia coli, known diseases in the case of plankton complemented by evaluation of their ability to inhibit adhesion and influence biofilm formation. But the extracts of anthocyanins isolated from black currant and strawberry found that they inhibit Gram-negative bacteria and do not affect Gram-positive bacteria. The reason is due to the different composition of the cell wall between Gram-negative bacteria and Gram-positive bacteria, and the outer membrane of Gram-negative bacteria acts as a protective barrier against hydrophobic compounds but not on hydrophilic compounds(53,54,55, 56).

5- As food colorants

Anthocyanin dyes are strong, water-soluble, and have been used to color food and textiles since ancient times. Where red grapes and blackberries were used to color drinks, pastries and foods(57). And red cabbage was used after improving its color by adding acid to it due to the effect of anthocyanin colors on changing the acid function (58).

The colors of the anthocyanins are distinguished by their gradation from yellow to purple, in addition to being healthy and low in price, encouraging their use as coloring materials for foods and pharmaceutical drugs(59). But its colors are affected by temperature, oxygen, ultraviolet rays, and the acidic function, all of which destroy the flavilium ion and cause color loss. Therefore, treatment methods were used to stabilize the color, including keeping foods in cold temperatures, interacting with the elements, or storing them in vacuum packages of oxygen(60,61,62).

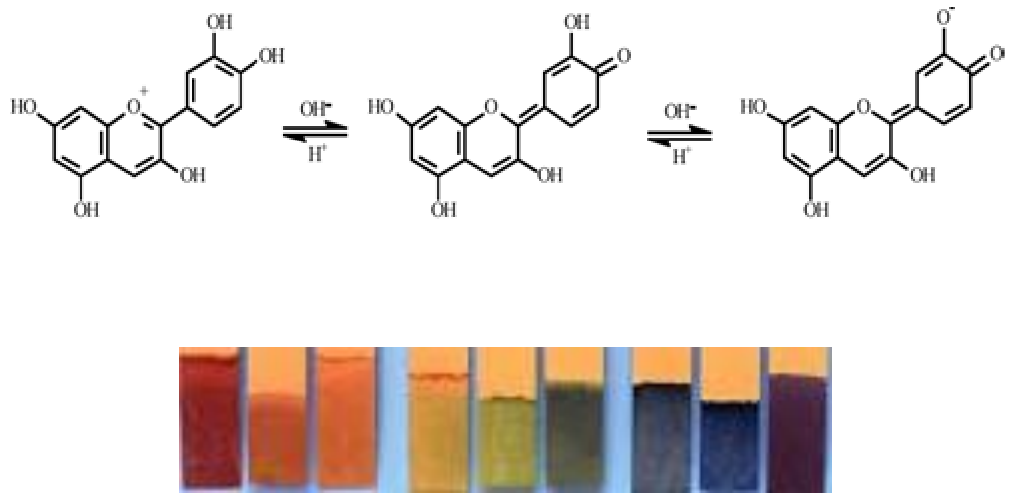


.63)(Fig(3) The colors of the anthocyanins in plants

5-Anthocyanins as indicators:-

Defines the indicator as weak organic acids or weak organic bases that change color or flash at a certain pH by adding an acid or base and the color change results from adding or deleting an H+ proton(64). Most of the signs have two or more contrasting colors, one of which appears in the acidic medium and the other in the basic medium, then you know that the indicators are dichotomous and some of the signs are monochromatic such as phenolphthalein, they are colorless in the acidic medium and purple in the base medium volumetric analysis is one of the quantitative analysis techniques where the equivalent point called the end point is determined in a conventional titration with some additions to the analyte solution, which changes color when the equivalent point is reached(65). These substances are generally referred to as pointers. Several types of indicators are available for different types of titration analyses. Most pH indicators are either weak organic acids or weak organic acids that accept or donate electrons (66,67). Although an automated titrant is available that determines the equivalence point between reactants, evidence is still needed for education and research laboratories to perform simple titration(68,69, 70).

It was found that the known evidence used in laboratory volumetric analysis possesses hazardous effects on the human body and environmental pollution. It is also a bit expensive and unavailable, so natural guides have been prepared from the parts of the plant. Over the past few years, compounds have been isolated from colorful plants that act as markers and are a source of multifunctional green chemistry. These high-color pigments obtained from plants are characterized by showing color changes with changing pH. These natural dyes are environmentally friendly(71, 72, 73,75,77).



Fig(4): The chemical structure forms and colors of an anthocyanin at different pH(21)

References

1-Delgado-Vargas F, Jimenez AR, Paredes-Lopez O,(2000) Natural Pigments: Carotenoids, Anthocyanins, and Betalains — Characteristics, Biosynthesis, Processing, and Stability, Critical Reviews in Food Science and Nutrition, 40 (3), 173 – 289.

2-Chemler JA, Leonard E, Koffas MAG, (2009) Flavonoid Bio transformations in Microorganisms, In Anthocyanins: Biosynthesis, Functions, and Applications, Gould K, Davies K, Winefield C, Springer, 191 – 238.

3-Martin J, Navas MJ, Jimenez-Moreno AM, Asuero AG, (2017)Anthocyanin Pigments: Importance, Sample Preparation and Extraction, In Phenolic Compounds - Natural Sources, Importance and Applications, Soto- Hernandez M, PalmaTenango M, Garcia-Mateos R, Books on Demand, 117 – 152.

4-Deroles S.(2009), Anthocyanin Biosynthesis in Plant Cell Cultures: A Potential Source of Natural Colourants, In Anthocyanins: Biosynthesis, Functions, and Applications, Gould K, Davies K, Winefield C, Springer, 107 – 167.

5-Bueno MJ, Saez-Plaza P, Ramos-Escudero F, Jímenez AM, Fett R, Asuero AG, (2012)Analysis and antioxidant capacity of anthocyanin pigments, Part II: chemical structure, color and intake of anthocyanins, Critical Reviews in Analytical Chemistry, 42, 126 – 151.

6-Fang J, (2015)Classification of fruits based on anthocyanin types and relevance to their health effects, Nutrition, 31, 1301 – 1306.

7-Usenik V, Stampar F, Veberic R,(2009) Anthocyanins and fruit colour in plums (*Prunus domestica* L.) during ripening, Food Chemistry, 114, 529–534.

8-Khoo HE, Azlan A, Tang ST, Lim SM,(2017) Anthocyanidins and anthocyanins: coloured pigments as food, pharmaceutical ingredients, and the potential health benefits, Food & Nutrition Research, 61 (1), 1361779.

9-Chu WK, Cheung SCM, Lau RAW, Benzie IFF,(2011)Bilberry (*Vaccinium myrtillus* L.), In Herbal Medicine: Bio molecular and Clinical Aspects, 2nd edition, Benzie, I. F. F. and Wachtel-Galor, S, CRC Press, 55 -72.

10-Winkel, B.S. (2004) Metabolic channeling in plants. Annu. Rev. Plant Biol. 55, 85–107.

11-Tanaka, Y. and Brugliera, F. (2006) Flower colour. In Flowering and its Manipulation (Ainsworth, C., ed.). Annual Plant Reviews, vol. 20. Oxford: Blackwell Publishing, pp. 201–239.

12-Cao G, Russell RM, Lischner N, Prior RL.(1998) Serum antioxidant capacity is increased by consumption of strawberries, spinach, red wine or vitamin C in elderly women. J Nutr; 128: 2383-2390.

13-Mazza G, Kay CD, Cottrell T, Holub B.(2002) Absorption of anthocyanins from blueberries and serum antioxidant status in human subjects. J Agric Food Chem; 50: 7731-7737.

14-Youdim KA, Shukitt-Hale B, MacKinnon S, Kalt W, Joseph JA.(2000) Polyphenolics enhance red blood cell resistance to oxidative stress: in vitro and in vivo. Biochimica et Biophysica Acta; 1523: 117-122.

15-Dudonne, S. et al.,(2009). Comparative study of antioxidant properties and total phenolic content of 30 plant extracts of industrial interest using DPPH, ABTS, FRAP, SOD, and ORAC assays. **Journal of gricultural and Food Chemistry** 57(5):1768-1774.

16-Krikorian, R. et al.(2012) Concord grape juice supplementation and neurocognitive function in human aging, **Journal of Agricultural and Food Chemistry** 60(23):5736-5742,

17-Evans, M.; Wilson, D.; Guthrie, N. (2014) Randomized, double-blind, placebo controlled,pilot study to evaluate the effect of whole grape extract on antioxidant status and lipid profile. **Journal of Functional Foods** 7(1):680-691.

18-Tenore, G.C. et al.(2012) Antioxidant profile and in vitro cardiac radical-scavenging versus pro-oxidant effects of commercial red grape juices (*Vitis vinifera* L. cv. Aglianico N.) **Journal of Agricultural and Food Chemistry** 60(38):9680-9687.

19-Wang SY, Jiao H.(2000) Scavenging capacity of berry crops on superoxide radicals, hydrogen peroxide, hydroxyl radicals, and singlet oxygen. J Agric Food Chem. 2000;48:5677–5684

20-Renis M, Calandra L, Scifo C, Tomasello B, Cardile V, Vanella L, Bei R, Fauci LL, Galvano F. (2007) Response of cell cycle/stress-related protein expression and DNA damage upon treatment of CaCo2 cells with anthocyanins. Br J Nutr. p1–9.

21-Bagchi D, Sen CK, Bagchi M, Atalay M. Anti-angiogenic, antioxidant, and anti-carcinogenic properties of a novel anthocyanin-rich berry extract formula. Biochemistry (Mosc) 2004;69:75–80.

22-Parry J, Su L, Moore J, Cheng Z, Luther M, Rao JN, Wang JY, Yu LL.(2006) Chemical compositions, antioxidant capacities, and antiproliferative activities of selected fruit seed flours. J Agric Food Chem. 2006;54:3773–3778.

23-Bagchi A.(2012) Extraction of curcumin, Journal of Environmental Science, Toxicology and Food Technology. 2012; 3: 1-16.

24-Shih PH, Yeh CT, Yen GC.(2007)Anthocyanins induce the activation of phase II enzymes through the antioxidant response element pathway against oxidative stress induced apoptosis. J Agric Food Chem. ;55:9427–9435.

25- Meyers KJ, Watkins CB, Pritts MP, Liu RH(2003)Antioxidant and antiproliferative activities of strawberries. J Agric Food Chem. ;51:6887–6892.

26- Singletary KW, Jung KJ, Giusti M. (2007)Anthocyanin-rich grape extract blocks breast cell DNA damage. J Med Food. ;10:244–251

27- Olsson ME, Gustavsson KE, Andersson S, Nilsson A, Duan RD. (2004)Inhibition of cancer cell proliferation *in vitro* by fruit and berry extracts and correlations with antioxidant levels. J Agric Food Chem. ;52:7264–7271.

28-Feng R, Ni HM, Wang SY, Tourkova IL, Shurin MR, Harada H, Yin XM.(2007) Cyanidin-3-rutinoside, a natural polyphenol antioxidant, selectively kills leukemic cells by induction of oxidative stress. J Biol Chem;282:13468–13476.

29-Afaq F, Syed DN, Malik A, Hadi N, Sarfaraz S, Kweon MH, Khan N, Zaid MA, Mukhtar H. (2007)Delphinidin, an anthocyanidin in pigmented fruits and vegetables, protects human HaCaT keratinocytes and mouse skin against UVB-mediated oxidative stress and apoptosis. J Invest Dermatol;127:222–232.

30- Kong JM, Chia LS, Goh NK, Chia TF, Brouillard R. (2003)Analysis and biological activities of anthocyanins. Phytochemistry. ;64:923–933.

31-Weisel T, Baum M, Eisenbrand G, Dietrich H, Will F, Stockis JP, Kulling S, Rüfer C, Johannes C, Janzowski C.(2006) An anthocyanin/polyphenolic-rich fruit juice reduces oxidative DNA damage and increases glutathione level in healthy probands. Biotechnol J.;1:388–397.

32-Duthie SJ, Jenkinson AM, Crozier A, Mullen W, Pirie L, Kyle J, Yap LS, Christen P, Duthie GG.(2006) The effects of cranberry juice consumption on antioxidant status and biomarkers relating to heart disease and cancer in healthy human volunteers. Eur J Nutr.;45:113–122.

33-Charepalli V, Reddivari L, Radhakrishnan S, Vadde R, Agarwal R, Vanamala JK (2015). Anthocyanin-containing purple-fleshed potatoes suppress colon tumorigenesis via elimination of colon cancer stem cells. J Nutr Biochem 26: 1641–1649.

34-Thwe A, Valan Arasu M, Li X, Park CH, Kim SJ, Al-Dhabi NA *et al.* (2016). Effect of different agrobacterium rhizogenes strains on hairy root induction and phenylpropanoid biosynthesis in tartary buckwheat (Fagopyrum tataricum Gaertn). Front Microbiol 7: 1–10.

35-Klabusay M, Kohutova V, Coupek P, et al. (2006) Simultaneous analysis of cytokines concentrations occurring in plasma of healthy blood donors. Med Inflamm. 2006(2006);1–7. doi:10.1155;65237.

36-Ng PC, Li K, Wong RPO, et al.(2003) Proinflammatory and anti-inflammatory cytokine responses in preterm infants with systemic infections. Arch Dis Child Fet Neonat.;88:209–213.

37-Van de Voorde J, Pauwels B, Boydens C, et al.(2013) Adipocytokines in relation to cardiovascular disease. Metabolism;62:1513–1521.

38- Kim SM, Chung MJ, Ha TJ, et al. (2012) Neuroprotective effects of black soybean anthocyanins via inactivation of ASK1-JNK/p38 pathways and mobilization of cellular sialic acids. Life Sci.;90:874–882.

39-Paixa˜o J, Dinis TC, Almeida LM.(2012) Malvidin-3-glucoside protects endothelial cells upregulating endothelial NO synthase and inhibiting peroxynitrite-induced NF-kB activation. Chem Biol Interact;199:192–200.

40- Ju JH, Yoon HS, Park HJ, et al.(2011) Anti-obesity and antioxidative effects of purple sweet potato extract in 3T3-L1 adipocytes in vitro. J Med Food.;14: 1097–1106.

41-Poulose SM, Fisher DR, Larson J, et al. Anthocyanin-rich ac¸ai (Euterpe oleracea Mart.) fruit pulp fractions attenuate inflammatory stress signaling in mouse brain BV-2 microglial cells. J Agric Food Chem. 2012;60:1084–1093.

42-Triebel S, Trieu HL, Richling E.(2012) Modulation of inflammatory gene expression by a bilberry (Vaccinium myrtillus L.) extract and single anthocyanins considering their limited stability under cell culture conditions. J Agric Food Chem.;60: 8902–8910.

43-Lee SG, Kim B, Yang Y, et al. Berry anthocyanins suppress the expression and secretin of proinflammatory mediators in macrophages by inhibiting nuclear translocation of NF-jB independent of NRF2-mediated mechanism. J Nutr Biochem. 2014;25:404–411.

44-Min SW, Ryu SN, Kim DH. Anti-inflammatory effects of black rice, cyanidin-3-Obeta-D-glycoside, and its metabolites, cyanidin and protocatechuic acid. Int Immunopharmacol. 2010;10:959–966.

45-Zdarilova´ A, Rajnochova´ Svobodova´ A, Chytilova´ K, et al.(2010)Polyphenolic fraction of Lonicera caerulea L. fruits reduces oxidative stress and inflammatory markers induced by lipopolysaccharide in gingival fibroblasts. Food Chem Toxicol;48: 1555–1561.

46-Tsuda T, Ueno Y, Yoshikawa T, et al.(2006) Microarray profiling of gene expression in human adipocytes in response to anthocyanins. Biochem Pharmacol.;71: 1184–1197.

47-Cisowska, A., Wojnicz, D. and Hendrich, A.B. (2011) Anthocyanins as antimicrobial agents of natural plant origin. Nat Prod Commun 6, 149–156.

48-Cowan, M.M. (1999) Plant products as antimicrobial agents. Clin Microbiol Rev 12, 564–582.

49-Puupponen-Pimi€a, R., Nohynek, L., Meier, C., K€ahkonen, M., € Heinonen, M., Hopia, A. and Oksman-Caldentey, K.M. (2001) Antimicrobial properties of phenolic compounds from berries. J Appl Microbiol 90, 494–507.

50-Donlan, R.M. (2001) Biofilm formation: a clinically relevant microbiological process. Clin Infect Dis 33, 1387–1392.

51-Shi, X. and Zhu, X. (2009) Biofilm formation and food safety in food industries. Trends Food Sci Technol 20, 407–413.

52- Bakkiyaraj, D. and Karutha Pandian, S.T. (2010) In vitro and in vivo antibiofilm activity of a coral associated actinomycete against drug resistant Staphylococcus aureus biofilms. Biofouling 26, 711–717.

53-Bridle P, Timberlake CF. (1997)Anthocyanins as natural food colours—selected aspects. Food Chem;58(1):103–109.

54-Lapidot T, Harel S, Akiri B, et al.(1999) pH-dependent forms of red wine anthocyanins as antioxidants. J Agric Food Chem.;47(1):67–70.

55-Pérez-Gregorio RM, García-Falcón MS, Simal-Gándara J, et al. (2010) Identification and quantification of flavonoids in traditional cultivars of red and white onions at harvest. J Food Compos Anal. ;23(6):592–598.

56-Kumoro AC, Retnowati DS. Budiyati CS.(2010)Solubility of delphinidin in water and various organic solvents between (298.15 and 343.15) K. J Chem Eng Data ;55(7):2603–2606.

57-Lauro, G.J. and Francis, F. J. (2000) Natural Food colours, Science and technology. IFT Basic Symposium Series 14, Marcel Dekker.

58-Hendry, G.A.F. and Houghton, J.D. (1996) Natural food colorants, 2 nd edition, Blackie Academic Press.

59-Delgado-Vargas, F. and Paredes-López, O. (Eds)(2003) Natural colorants for food and nutraceutical uses. CRC Press.

60-Ahmadiani N Anthocyanin based blue colorants [dissertation]. Ohio: Ohio State University; 2012.

61-Mori K, Goto-Yamamoto N, Kitayama M, et al.(2007) Loss of anthocyanins in red-wine grape under high temperature. J Exp Bot.;58(8):1935–1945.

62-West ME and Mauer LJ. (2013)Color and chemical stability of a variety of anthocyanins and ascorbic acid in solution and powder forms. J Agric Food Chem.;61 (17):4169–4179.

63-Patras A, Brunton NP, O'Donnell C, et al.(2010) Effect of thermal processing on anthocyanin stability in foods; mechanisms and kinetics of degradation. Trends Food Sci Technol.;21(1):3–11.

64-Nwosu FO, Adekola FA, Ihedioha KC.(2004) Titrimetric colourindicators from some natural flower petals. Centrepoint (Science Edition); 12: 74-89.

65-Abugri DA, Ohene BA, Pritchett G.(2012)Investigation of a simple and cheap source of a natural indicator for acid-base titration: effects of system conditions on natural indicators. J Green and Sustainable Chemistry. ; 2: 117-122.

66-Pradeep DJ, Dave K.(2013) A novel, inexpensive and less hazardous acid-base indicator. Journal of Laboratory Chemical Education; 1: 34-38.

67-Akpuaka MU, Chukwuneke C, Agbo G. (1998)The dyeing of textile fabrics with natural dyes from some local trees. J Chem Soc Nig ; 23: 47-52.

68-Osabohien E, Ukpumwan DO. (2002)Extraction of natural dyes from some local plants. J Chem Soc Nig; 27: 2, 139-142.

69-Ekandem JE, Owor AU. (1997)Local flower extracts as simple acid-base indicators. J Chem Soc Nig ; 22: 98-103.

70-Eze SO, Okereafo A.(2002) Industrial and analytic potentials of dye extracts from Telfairaoccidentalis (Fluted pumpkin). J Chem Soc Nig. 2002; 27: 143-146.

71-Patil SB, Konda-war MS, Naik-wade NS, Magdum CS(2009) Use of Flower Extracts as an Indicator in Acid-Base Titrations. Research Journal of Pharmacy and Technology; 2: 421- 422.

72-Dossett M, Lee J, Finn CE.(2011) Characterization of a novel anthocyanin profile in wild black raspberry mutants: An opportunity for studying the genetic control of pigment and color. J of Functional Foods ; 3: 207-214.

73-Moldovan B, David L.(2014) Influence of temperature and preserving agents on the stability of cornelian cherries anthocyanins. Molecules. 2014; 19: 8177-8188.

74-Abdel-Aal E-S, Abou-Arab AA, Gamel TH, Hucl P, Young JC, Rabalski I. (2008)Fractionation of blue wheat anthocyanin compounds and their contribution to antioxidant properties. J Agric Food Chem; 56: 11171-11177.

75-Burungale SH, Mali AV. (2014)Natural indicator as an eco-friendly in acid base titration. Journal of Chemical and Pharmaceutical Research; 6: 901- 903.

76-Grotewold, E. (2006) The genetics and biochemistry of floral pigments.
Annu. Rev. Plant Biol. 57, 761–780.

77-Izonfuo WAL, Fekarurhobo GK, Obomanu FG, Daworiye LT. (2006) Acid-base indicator properties of dyes from local plants I: Dyes from Basellaalba (Indian spinach) and Hibiscus sabdariffa (Zobo). J Appl Sci Environ Mgt.; 10: 5-8.

78-Kresty LA, Frankel WL, Hammond CD, Baird ME, Mele JM, Stoner GD, Fromkes JJ. Transitioning from preclinical to clinical chemopreventive assessments of lyophilized black raspberries: interim results show berries modulate markers of oxidative stress in Barrett's esophagus patients. Nutr Cancer. 2006;54:148–156.

79-Zhu Y, Ling W, Guo H, et al. Anti-inflammatory effect of purified dietary anthocyanin in adults with hypercholesterolemia: a randomized controlled trial. Nutr Metab Cardiovasc Dis. 2013;23:843–849.

80- Zhang Y, Lian F, Zhu Y, et al. Cyanidin-3-O-beta-glucoside inhibits LPS-induced expression of inflammatory mediators through decreasing IjBa phosphorylation in THP-1 cells. Inflamm Res. 2010;59:723–730.

أصناف أصباغ الأنثوسيانين المستخلصة من النباتات الملونة وتطبيقاتها

فاطمة صيوان صباح

جامعة البصرة /كلية العلوم/قسم الكيمياء

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الخلاصة

الأنثوسيانين هي فئة من مركبات الفلافونويد ، تتميز بأصباغ ملونة قابلة للذوبان في الماء توجد في شكل جليكوسيدات. ترتبط بواحد أو أكثر من شقوق السكر. تم العثور على الأنثوسيانين داخل أعضاء النبات المختلفة. كالزهور والأوراق والفواكه والجذور والدرنات والحبوب. تظهر بألوان تتراوح من الأصفر إلى الأزرق ، اعتمادًا على هيكلها ودرجة الحموضة وعوامل أخرى. حظيت هذه المركبات باهتمام كبير حيث حلت محل الأصباغ الكيميائية مثل تلوين الطعام وصناعة الأدوية ، بالإضافة إلى دورها في تعزيز تحمل النبات للعديد من المؤثرات المناخية مثل الملوحة والجفاف والضوء الزائد والأشعة فوق البنفسجية والضغط البارد. إلى جانب ذلك ، أظهرت الدراسات السابقة أهمية الأنثوسيانين في صحة الإنسان وخصائصه الوقائية ضد الأمراض المزمنة. لقد كان أيضًا موضع اهتمام نظرًا لقدرته على تغيير اللون وفقًا لقيم الأس الهيدروجيني واستخداماته كمؤشر حمضي قاعدي في التحليل الكمي.