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A REVIEW ON STUDY OF ANTHOCYANINS AND THEIR DIFFERENT HEALTH BENEFITS

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ABSTRACT

Anthocyanins are natural occurring pigment. Anthocyanins belong to category of flavonoids which are water – soluble found in a variety of fruits and vegetables. In fruits, vegetables, and cereals, anthocyanins are the pigments which give them their red, violet, and blue colours for example purple and red berries, plums, grapes, cabbage, apples, etc., and other food. Because of high level of anthocyanins, it used as natural colorants. Anthocyanins are flavonoid compounds produced by the phenylpropanoid route known as anthocyanidin glucosides. The six most prevalent anthocyanidins are cyanidin, delphinidin, malvidin, peonidin, petunidin, and pelargonidin. Plants are shielded from oxidizers by several phenolic hydroxyl groups present in the structure anthocyanins. This review paper shows the different activity and properties shown by the anthocyanins which are used to cure the diseases. they done many antioxidants activity by using DPPH (2,2-diphenyl-1-picrylhydrazy), antimicrobial activity done by gram-positive bacterial test cultures, TNF-stimulated expression of the endothelial adhesion molecules VCAM-1 and ICAM-1 was used to assess the anti-inflammatory effects of various PASs.

Keywords:- Anthocyanins, Anti-oxidant activity, DPPH assay, Anti-microbial activity, Anti-inflammatory.

INTRODUCTION

Anthocyanins word derived from Greek word "antos" meaning flower and "kyanos" meaning blue. Anthocyanins are a kind of plant element that has the same diphenyl propane skeleton collectively known as flavonoids. The blue, purple, and red colours of various plant sections (flowers, fruits, and other plant tissues) are often caused by anthocyanins, which are water-soluble and have certain spectral features. They are notably prevalent in many different fruits, particularly in practically all berry varieties. Due to their widespread presence in fruits, anthocyanin consumption is relatively substantial on a daily basis. (Cisowska *et al*., 2011) (Mazza., 2007). Anthocyanins are major constituents of the secondary plant metabolite class of flavonoid chemicals that are part of the antioxidant superfamily known as phenolics or polyphenolics (Bueno *et al.*, 2012). Anthocyanins occur naturally in plants as glycosides that include glucose, galactose, arabinose, rhamnose, and xylose. Many fruits and vegetables, such as berries, red-skinned grapes, apples, and pears, as well as radishes and red/purple cabbage, are examples of the anthocyanins (Burton-Freeman *et al.*, 2016). They are a collection of bioactive chemicals with high efficacy that are found in large quantities in plant food. (Bueno *et al.*,2012)

Plants use minerals from the ground, water, and sunshine to produce colour in a variety of intricate ways. These colours are created for a variety of reasons; some are simply the outcome of the biological processes of plants, while others exist to discourage or attract animals. Plants can produce colours like carotenoid (for red, orange, and brown), anthocyanin (for magenta, blue, and purple), anthoxanthins (bright yellow through to cream), and chlorophylls thanks to some ingenious chemistry (all greens). They are preserved in the plant's protoplasm, cell walls, or cell sap. In some cases, a plant may also have two or more pigments, generating a greater variety of different shades such as mauves and purples. Such patterns can appear in some plants because of a combination of damaged chloroplasts and additional blue or red anthocyanin pigments (Bailey.,2018). Anthocyanins are essential to pollination in plants and, by absorbing light, protecting them from harm from UV rays and cold stress. (Qiu *et al*., 2016)

Anthocyanins are anthocyanidin glucosides, which are flavonoid derivatives generated through the phenylpropanoid pathway. The fundamental components of anthocyanins are known as anthocyanidins. (Alhamed *et al*.,2012). The six main anthocyanidins which can be found in food are cyanidin, delphinidin, pelargonidin, peonidin, petunidin, and malvidin. (Khoo *et al*., 2017; Jian and Giusti, 2010). Pelargonidin varies from the majority of anthocyanidins in nature and shows as a red pigment (Nurraihana and Norfarizan-Hanoon., 2013). Delphinidin is chemically related to the majority of anthocyanidins. It shows in the plant as a blue -reddish or purple colour. The delphinidin pigment is responsible for the blue colour of flowers. (Liza *et al*., 2010). Cyanidin is a reddish-purple pigment that is mostly present in berries (Chua *et al*., 2019) and other red

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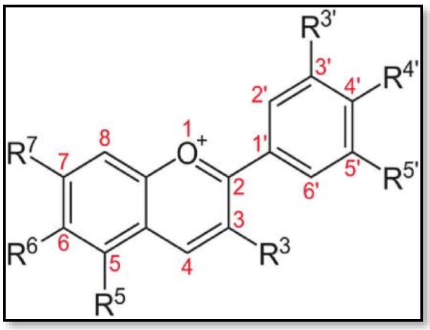
vegetables like purple maize and red sweet potatoes. (Kumarmath *et al.*, 2022). The glycosylated versions of anthocyanidins are known as anthocyanins (aglycones). These substances are created when a flavylium cation backbone is hydroxylated in various locations (often on carbons C3, C5, C6, C7 and C3', C4', C5'). This results in the formation of various anthocyanidins (Mattioli *et al.*, 2020). Although though these compounds include an oxonium group, the flavonoid skeleton (Nurraihana and Norfarizan-Hanoon., 2013), preserves its ring nomenclature with the charged oxygen atom on the C ring (Castañeda-Ovando *et al*.,2009). Anthocyanidins may be glycosylated to make anthocyanins on various hydroxyl moieties of the molecule, with 3-OH being the most prevalent glycosylation site in nature to produce 3-O-β glucosides. (He and Giusti., 2010)



Structure of Anthocyanins
(https://www.researchgate.net/figure/Basic-anthocyanin-structure_fig1_319107732)

Several phenolic hydroxyl groups included in the structure of anthocyanins protect plants against oxidizable substances. It is utilised to eliminate free radicals, prevent tumours, cancer, and inflammation, inhibit lipid peroxidation and platelet coagulation, prevent diabetes, reduce body fat, safeguard vision, and other things because of its special functionality. (Ma *et al*., 2019).

In the last few decades, plant cell cultures have produced second metabolites with enormous success. Sue L. Smit and colleagues in 1981 conducted a preliminary investigation on *Strobilanthes dyeriana* Mast (Acanthaceae) to further the research. They discovered that in the presence of indole-3-acetic acid (IAA) as a medium growth factor, a callus line of Strobilanthes dyeriana Mast could synthesise anthocyanins. These anthocyanins are identical to those generated through the entire plant. (Zhu *et al*., 2022). The effects of plant growth regulators on the formation of anthocyanin in cultured cells appear to vary. Better growth and anthocyanin production were achieved in *Strobilanthes dyeriana* callus cultures and Vitis vinifera suspension cultures using 1-naphthaleneacetic acid (NAA) than 2,4-dichlorophenoxyacetic acid (2,4-D) (Mizukami., 2002). Plant cell suspension cultures were used by Noboru Hiraoka in 1981 to study the metabolism of certain phenyl-ethylamines and related compounds, and the *S. dyerianus* culture metabolised 2-(pmethoxyphenyl) ethylamine to 2-(p-methoxyphenyl) ethyl3-D-glucopyranoside. (Zhu *et al*., 2022)

Anthocyanins are natural pigments which are mostly employed as natural colourants (Ghann *et al*., 2017). Some of the anthocyanin-rich flowers and fruits are also used as natural colourants and have historically been employed as medicines to treat a variety of illnesses. Anthocyanin pigments are traditionally used as food colouring and dye and are derived from flowers, fruits, and vegetables. A lot of research has been done on plant anthocyanins' potential medicinal value. (Khoo *et al*., 2017) The concentration and makeup of the anthocyanin pigments present in fruits and vegetables are influenced by genetic and environmental variables (Lee and Collins., 2001). Being a natural water-soluble pigment, anthocyanins are known to be unstable under many environmental circumstances (Laleh *et al*., 2006). Many factors may influence the stability of anthocyanin. The structural alterations including hydroxyl, methoxyl, glycosyl, and acyl groups or environmental variables like anthocyanin structure, pH, temperature, light, oxygen, and a variety of other factors may impact anthocyanin's stability chemically or physically, leading to colour change and deterioration. (Roobha *et al*., 2011; Khan and Farooqui., 2011). The isolated anthocyanins are extremely susceptible to degradation and exceedingly unstable (Giusti and Wrolstad., 2003).

The stability and colour of anthocyanin pigments may be influenced by pH value. the colour change occurred in plant that caused by due to different PH gradient. Depending on the pH of the solution, anthocyanins could be found in a variety of chemical forms (Fleschhut *et al*., 2006). At pH levels below 3, anthocyanins occur mostly in the form of red flavylium cation, which carries the positive charge of oxygen. When the pH rises between 2 and 4, the quinonoidal blue species predominant, and rapid deprotonation occurs between groups of oxygen and skeletal hydroxyl to create quinonoidal bases. When the pH rises between 5 and 7, there are colourless species, a carbinol pseudo base, and a yellowish chalcone (Wahyuningsih *et al*., 2017)

The molecular structure of anthocyanins is affected by temperature because anthocyanins are thermally sensitive substances. When the temperature rises, the degree of anthocyanin degradation also increases. It's possible that hydrolysing the 3-glycoside structure, which acts as a shield for unstable anthocyanin at higher temperatures, is

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what causes the fast breakdown of anthocyanin at such temperatures (Devi *et al.*, 2012). An increase in storage temperature significantly speeds up the rate at which anthocyanin pigment degrades, according to research on the relationship between temperature and anthocyanin stability (Yusoff and Kumara., 2014).

The stability of anthocyanin pigments is also influenced by light (Contreras-Lopez *et al.*, 2014). Researchers investigated that light affected the stability of anthocyanin pigments in grape juice and found that this accelerated the pigments' decomposition. In their research, they found that after storing anthocyanin-containing juice samples in the dark at 20 °C for 135 days, about 30% of the pigments were lost, but storing the same samples with the exact temperature and duration in the presence of light lost over 50% of the pigments (Amogne *et al*., 2020).

Food plants contain an abundance of anthocyanins, which are found in 27 families. During the last two decades, a growing number of research have examined the numerous protective benefits evoked by polyphenolics contained in a variety of fruits and vegetables (Ghosh and Konishi., 2007). Antioxidant, anti-inflammatory, antiviral, anti-proliferative, mutagenic, anti-microbial, anti-carcinogenic, protection from allergy and cardiovascular damage, improvement of microcirculation, prevention of peripheral capillary fragility, prevention of diabetes, and improvement of vision are some of these effects (Lee *et al*., 2005)

ANTIOXIDANT ACTIVITY

The popularity of foods and plants with antioxidant properties has grown recently. Vitamins C and E, carotenoids, and flavonoids are the chemical substances found in vegetables and fruits that have these properties. The most significant class of plant flavonoids, anthocyanins, are pigments with a flavylium cation (AH+) structure that function as acids. Its antioxidant action is directly correlated with this structure. Most the anthocyanins' functional characteristics and sensory qualities can be attributed to their chemical reactivity (Tena *et al.*, 2020).

While conducting investigations on the antioxidant activity of these chemicals, it is important to keep in mind that the structures and characteristics of anthocyanins rely on a variety of variables, including pH, temperature, and solvents (Kay *et al*., 2017). Several antioxidant tests have been presented to assess anthocyanins' potential to inhibit the natural oxidation process. Most of the time, an extraction step is required prior to performing the antioxidant bioassay depending on the source of the anthocyanins and their type. Because of the poor stability of anthocyanins following extraction and their propensity to remain linked to the matrix of the sample, extraction is a crucial step in the evaluation of the antioxidant activity bioassay and presents a problem (Hong *et al*., 2020).

Many researchers have evaluated the anthocyanins' antioxidant capacity for DPPH assay (Martin *et al*., 2020) By using 2,2-diphenyl-1-picrylhydrazyl (DPPH) and ferric reducing antioxidant power assays, native Australian fruits, and berries, including the Tasmanian pepper berry, Illawarra plum, Burdekin plum, Cedar Bay cherry, Davidson's plum, and Molucca raspberry, were assessed as sources of antioxidants and compared to blueberries. The radical scavenging activities of muntries and Burdekin plum were 1.5 and 2.6 times higher, respectively, than those of blueberry, and the overall reduction capacity of five fruits was 3.5–5.4 times more than that of blueberry (Netzel *et al*., 2006)

ANTIMICROBIAL ACTIVITY

To describe and create novel nutritious food components as well as medicinal and pharmaceutical goods, there has been much research on the antimicrobial activity of crude extracts of plant phenolic compounds against human infections. Nevertheless, there is little evidence available on the pure anthocyanins' antimicrobial properties. (Cisowska *et al*., 2011) In order to assess the antimicrobial activities of their extracts, Burdulis measured the total anthocyanin concentrations in the fruits and skins of blueberry (*V. corymbosum*) and bilberry (*V. myrtillus*) fruits. (Burdulis *et al*., 2009)

The gram-positive bacterial test cultures were used are followed to determine the extracts' antimicrobial activity. *Staphylococcus aureus* (ATCC 25923), Listeria monocytogenes (ATCC 19117), *Bacillus subtilis* (ATCC 6633), *Enterococcus faecalis* (ATCC 29212), and as well as gram-negative bacteria. *Escherichia coli* (ATCC 25922) and *Salmonella typhimurium* (ATCC 14028) were also tested. The agar well diffusion technique was used to investigate the antimicrobial characteristics. An examination of the antimicrobial l capabilities revealed that European cranberry extracts prevented the growth of a variety of gram-negative and gram-positive human pathogenic bacteria. *Salmonella typhimurium* and *Staphylococcus aureus* were found to have considerable resistance, whereas *Escherichia coli* was the least sensitive. Average zones of inhibition for Listeria monocytogenes and Enterococcus faecalis were 20.35 mm and 19.71 mm, respectively. Numerous publications have observed that phenolic berry extracts suppressed the development of Salmonella, Escherichia, and Staphylococcus species. The growth of Salmonella, Escherichia, and Staphylococcus species was reported to be reduced by phenolic berry extracts in several papers. Antimicrobials generated from cranberries might be used as useful complements to traditional antimicrobial formulations and treatment methods. (Česonienė *et al*., 2009)

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ANTI – INFLAMMATORY ACTIVITY

In this model, the TNF-stimulated expression of the endothelial adhesion molecules VCAM-1 and ICAM-1 was used to assess the anti-inflammatory effects of various PASs. TNF-induced cell surface expression of VCAM-1 and ICAM-1 in endothelial cells. While their actions were scaled differently, we discovered that pre-exposure of endothelial cells to all the distinct PASs exhibited anti-inflammatory capabilities by suppressing the TNF-induced production of VCAM-1 and ICAM-1. The most efficient PASs was found to be those from blackcurrant and mahaleb cherry that contain non-acylated anthocyanins.

They all demonstrated antioxidant activity, with samples containing non-acylated anthocyanins having the greatest levels. In addition to decreasing the expression of endothelium inflammatory antigens, these pure anthocyanin samples may have favourable cardiovascular protective effects. According to their equivalent antioxidant activity, non-acylated anthocyanins had a stronger vascular anti-inflammatory capability than anthocyanins acylated with cinnamic acid derivatives did (Blando *et al*., 2018).

ANTI-VIRAL ACTIVITY

According to antiviral research, anthocyanin purified from plants high in anthocyanins may be useful in treating viral infections (Jassim and Naji., 2003). Using molecular docking and mass spectrometry, Swaminathan evaluated the activity of cyanidin, delphinidin, and pelargonidin as three anthocyanins against 430-cavity of InfV neuraminidase and their binding site. While having similar structures, these compounds differed in terms of both the number and position of the OH groups in the benzyl substituent that was attached to the chromenylium ring. Molecular docking and mass spectrometry demonstrated the clear difference between the binding site characteristics. With the most OH substituents, delphinidin and cyanidin bonded tightly and had greater inhibitory capabilities than pelargonidin, which only had one OH substituent at the 4' position. Eventually, it was discovered that the anthocyanins' antiviral activity was influenced by the location and quantity of their OH groups (Swaminathan *et al*., 2014).

From ancient times, plants like elderberry (*Sambucus nigra* L.) have been used in traditional medicine to treat viral illnesses including colds and the flu (Roxas and Jurenka., 2007). Furthermore, given the significance of purified antiviral anthocyanin in the treatment of viral infections, elucidating the precise pharmacological mechanisms of action may help to advance the development of new viral infection therapies (Mohammadi *et al*., 2019).

ANTI-ALLERGIC PROPERTIES

One of the best sources of anthocyanins, which are known to have anticancer, wound-healing, and anti-allergic properties, is the bilberry (*Vaccinium myrtillus* L.). In this investigation, it was determined if bilberry extract (Bilberon-25), which is used to treat chronic allergic contact dermatitis in mice, reduces pruritus. After sensitization with 2,4,6-trinitro-1-chlorobenzene (TNCB) for 3 weeks in BALB/c mice, which resulted in chronic allergic contact dermatitis, Bilberon-25 was given for 3 weeks. By measuring scratching behaviour and ear swelling, respectively, the effects of Bilberon-25 on pruritus and inflammation were assessed. The effects of Bilberon-25 on pruritus and inflammation were evaluated by measuring scratching behaviour and, separately, ear inflammation. Dexamethasone therapy, however, reduced ear swelling greatly, and Bilberon-25 medication improved it. Repeated application of TNCB caused a change from a Th1 to a Th2 profile in the cutaneous cytokine milieu; this Th2 predominance of the lesional skin was relieved by bilberon-25 and dexamethasone. Patients with inflammatory skin conditions like atopic dermatitis may have chronic pruritus, which may be alleviated by bilberry anthocyanins. (Yamaura *et al.*, 2011)

ANTI- CANCER PROPERTIES

Anthocyanins, which act as antioxidants, can inhibit oxidative stress from causing genomic damage in the early stages of tumour growth. Moreover, anthocyanins can stop the growth of cancer cells by reducing the levels of pro-inflammatory cytokines. (Lu *et al*., 2017). Cancer cells may spread by invasion, proliferation, and migration in bloodstream. The prevention of cancer cells' migration and proliferation may be the cause of anthocyanins' potentially anti-cancer effects. (Wang and Stoner., 2008). The original in vitro inquiry proved to be where most of the research on anthocyanins' ability to treat various cancers was conducted. Natural pigments called anthocyanins have been shown to be helpful in the great majority of cancer cases. According to a research, anthocyanins' primary method for preventing cancer is through anti-oxidation and anti-inflammation. By giving an electron, activating Nrf2, and increasing hydroxylation, a daily intake of foods high in anthocyanins can successfully prevent cancer. By blocking pro-inflammatory cytokines and lowering pro-inflammatory gut bacteria, anthocyanins therapies may help prevent cancer. The two primary methods used by anthocyanins to treat cancer were chemotherapy and immunotherapy. The control of cancer by anthocyanins is mostly linked to

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anti-proliferation, anti-migration, and pro-apoptosis processes through down-regulation of PI3/Akt/mTOR, Wnt, Notch, or NF-B signalling pathways, according to emerging data (Chen *et al*., 2022).

CONCLUSION

As previously stated, anthocyanin-rich goods may have a protective effect on human health. More research is needed to determine the true implications of anthocyanins in these health-promoting characteristics, because most studies have employed fruit extract, and thus other components may be entirely or partially responsible for the listed biological activities. Because berries and other anthocyanin-containing fruits contain a variety of chemicals, including anthocyanins, weak organic acids, phenolic acids, and combinations of their different chemical forms, their antimicrobial action is believed to be generated by several processes and synergies. As a result, the antibacterial impact of chemically complicated substances must be scrutinised.

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