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A review on purple tomato used in cancer disease

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ABSTRACT
A rich source of different nutrients, secondary metabolite various pigment are found in a different type of fruits and vegetable. Some fruits and vegetable are containgusuful nutritional ingredient used in various treatment of diseases. Tomato (solanum lycopersicum) is a vegetable commonly used to produced a new varieties of anthocyanin rich fruit. New variety of purple tomato are containing high in nutrition value. The plant secondary metabolite anthocyanins are a class of polyphenols which are useful in various disease. Anthocyanin are generally high rich in purple tomato. Purple tomato are high in antioxidant. purple tomato possess anti-cancerous, anti-inflammatory, Neuroprotective, antimicrobial, cardio-protective, high protective effect due to high properties of anthocyanin and antioxidant the regular intake of purple tomato has a effective in certain in chronic disease of human like cancer. The uncontrolled growth of cell is known as cancer. Cancer is complex disease. The purple color of tomato is due to presence of anthocyanin pigment. Anthocyanin pigment are responsible for the color red, blue, and purple are vegetable and fruits anthocyanin are color water soluble pigment belonging to the phenolic group. It is traditionally used as natural food colorant. The color and stability pigment are influenced by temperature, light, structure and pH. The tomato antioxidant is high as compared to non-anthocyanin tomatoes. Purple tomatoes is beneficially for human health. Therefore these is review focuses on the used of purple tomato in anticancer disease.

Keywords: purple tomato, anthocyanin, antioxidant

I. INTRODUCTION

Cancer is the second most reason of mortality in the world [1]. In case of male the mostly high percentage of cancer disease arise in the lungs, prostate, bronches, urinary bladder etc. In case of women breast, rectum, uterine, corpus, lungs and bronches, thyroids glands etc [2]. Cancer arise by a sequence of continues mutation in gene therefore the cell function are change due to mutation. Some chemical of substance like carcinogenic chemical compound that tends to produce lungs cancer in body [3]. The environment also conatin chemical compound with carcinogenic properties and effect the cytoplasm and nucleus of cell. It also tends to cause a genetic disorder and gene muatation [4,5]. Due to genetic mutation unhealthy eating, inflammation, work stress, exposure to radiation, intake to toxic substance are found to be case of cancer. 7% of cancer are comprasing the carcinogenic factor like bacteria, viruses and rays radiation [6]. Treatment are also available in on the basis of stage of cancer and severity of cancer disease. the treatment may be therapy like chemotherapy , hormonal therapy, radio therapy, targated therapy etc. patient have side effect of each treatment without harming new cell to destroyed or inhibit the growth of cancer cell it is the aim to anticancer treatment [7].

PURPLE TOMATO

In across the world the tomato is one of the most important vegetable which is taken after cooking as in raw from [8,9]. Tomato fruits contaning mineral, cartenoids, vitamin E, vitamin C, flavonoids, phenolic, dietary fibers and some phytochemical with the beneficial effect on the health of human it is the source of energy [10,11,12]. Tomato fruit become purple due presence of anthocyanin pigment so they are know purple tomato (**Fig.1**). In early past the more awareness and much attention get by purple tomato. The purple tomato as a dietary factor with the multiple beneficial effect on the human being and play safeguarding role due to presence anthocyanin

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pigment in tomato. The scientist all over the world are trying to improve the content of anthocyanin in tomato fruit. Purple tomato have high contain of phenolic, rutin, chlorogenic acid, and total flavonoids. As compare to valid tomato the proportion of beta carotene, alpha carotene, lutein, similar;y the content of cartonoids are high in purple tomato. The pigment lycophene are low in purple tomato.

Fig.1: Purple tomatoes

APPROCHES FOR OBTANING THE PURPLE FRUIT

1) TRADITIONAL BREEDING APPROCHES

In the past, by crossing different interfertile wild species with the tomato (solaniumlycopersicum) they obtained various genetic combination. Atroviolacea (atv) and anthocyanin fruit (aft) the homozygous for both the alleles and are the most stable anthocyanin rich fruit [13]. In the interspecific crosses the wild type tomato and convectional tomato species are involved and in some of the cultivated species have allowed in cooperating anthocyanin pigment [14,15,16,17]. In the year 2012 the "indigo rose" the first purple colurtomato variety was produced by the convectional breeding and it is due to release cultivation) (**Fig.2**).

Fig.2: A purple tomato fruit of variety "Indigo Rose".

II) TRANSGENIC APPROCHES

In 2008 the first modified tomato was developed by exposure transcription factor Delila fruit specific E8 promoter it wholly produce the fruit Del/Ros1 purple tomato line [18]. An intense color to the peel and to the flesh of fruit I due to high level of anthocyanin present in the genetically modified purple tomato fruit **(Fig.3)**.

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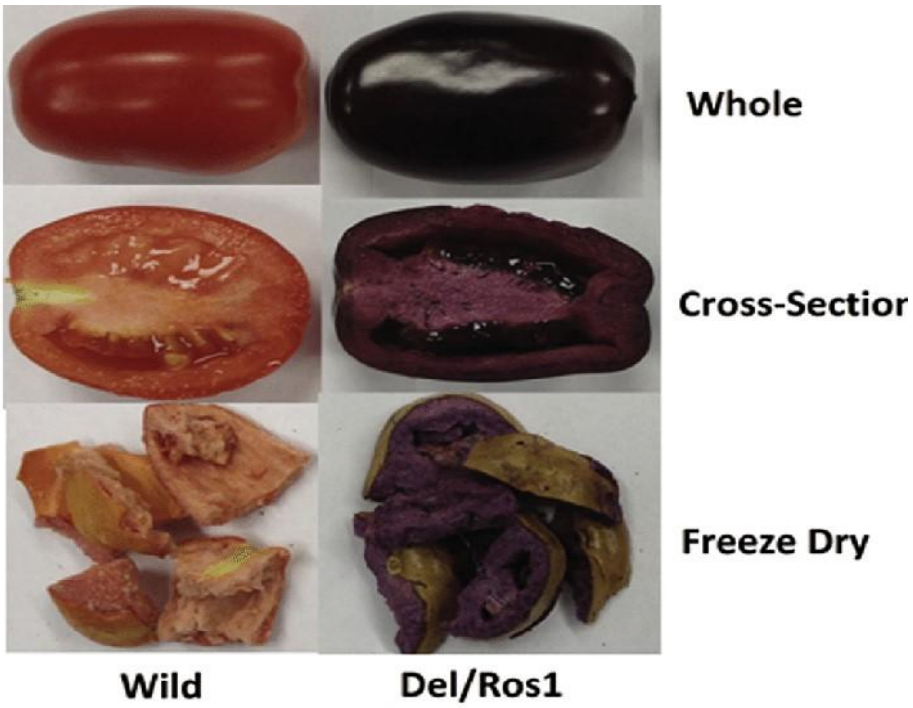

Fig.3: Representative image of whole, cross section and freeze-dry of the transgenic del/ros1 tomato fruit

The biosynthesis of anthocyaninis controlled by the expression of genes that exihibited by both the traditionally breed and the modified varieties. Anthocyanin in peel are slow in the traditional breed and in the modified verity are generated in the flesh and peel of tomato fruit. Both of the approach are tends to synthesis the new tomato line of anthocyanin rich fruit.

CHEMICAL CONSTITUENT OF PURPLE TOMATO

I) ANTHOCYANIN

Anthocyanin are pigment obtanined from natural are responsible for the wild verity in color like orange to blue in many vegetable, fruits and flower. It play role in plant life for maintain physiology, it use to protect against biotic and abiotic stresses, seed disperser and attraction of pollinators [19]. Plant, flowers and fruits containing anthocyanin pigment like red, purple and blue in color. Anthocyanin appers as a pigment in acidic condition and while in alkaline condition blue pigment. The general molecular structure of is in (**Fig.4**) anthocyanin are used in flowers red hibiscus, red rose, red pineapple sage, etc. plant anthocyanin found in a high range of uses. Anthocyanin rich plant traditionally used in treatment of different disease [20]. anthocyanin stability depend on the solution of pH these is due to molecular structure of anthocyanin have an ionic nature [21]. According to the pH the anthocyanin can assume four moleculer structure in the aqueous solution. Generally dark, red and purple fruit or vegetable are rich source of anthocyanin eg. Cherries, grapes, black beans, red onions, eggplant, purple sweet potato, berries, anthocyanin are taken with diet [22]. Jucies, red wine

and yogurt these food beverage also contain anthocyanin which is take in body with human diet [23]. In japan, A blue tomato are same like indigo tomato the breed are high anthocyain [24]. The glycosylate derivatives pf anthocyanin molecules are anthocyanin. Chemical structure of anthocyanin is based on polymethoxylated aromatic ring formed by C15 skeleton or attached by C3 benzene ring. Arbinose, rutinose, glucose, galactose, rhamnose and xylose are the most commn sugers. On a C ring at 3^{rd} or 7^{th} position mono, di, or tri sacchrides, aromatic acid and aliphatic group are acetylise by sugermoietics. Pelargondin, cynidin, delphnidin, peonidin, petunidin and malvidin the six which is produced by some anthocyanindin or it is subsituents groups on structural ring [25]. The most common anthocyanin found in nature is 3-o glucose derivatives. The glycosylating agent is main representing in glucose [26,27]. Anthocyanin it give many health benefit like anti-obesity effect, antimicrobial, anti-carcinogenic, anti-

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inflammtoryetc [28]. The beneficial effect of anthocyanin containg fruit are depend on the compound bioavliabilty the extent and the rate to which their metabolite become available in the body at site of action. The crucial role in the digestion posses in these case many study carried out [29]. The anthocyanin are enter into the systemic circulation in minute and absorbed from the stomach rapidly. They fact decline after reaching to the maximum concentration after the few hours [30]. The concentration of anthocyanin are note same in the various compartment in the intestinal tissue they can achieve the value of micro molar, plasma level are maximum at non-molar range [31]. In previous study, anthocyanin are found in animal and it is present in liver or kidney and brain [32,33]. They can decomposed partially by the micro-biota and reach to the large intestine [34,35]. Anthocyanin also have therapeutic effect in addition with antioxidant .the anthocyanin pigment like delphindin posses some therapeutic effect and an active pharmaceutical ingredient. Delphindin it has immunospprssive active ingreadient and a source of antiphlogestic[36]. It is also indicate that the delphindin and delphindin-3-glucoside it dhow inhibitors effect on O2 scavenging activity and on the lipid peroxidation. In their specific biosynthesis pathway of the mutation of regulatory genes due to that the tomato fruit are not synthesize the pigment anthocyanin [37].

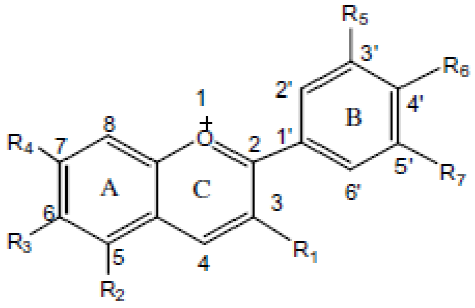

Fig.4: Basic anthocyanin structure

II) ANTIOXIDANT

Due to the presence of high content of anthocyanin, carotenoids and phenolic compound in the purple tomato posses the antioxidant activity. the activites of antioxidant inpurple tomato are either indirect or direct efffrect. In decreased production of nitric aicd (NO) and malondialdehyde (MDA) is a direct antioxidant effect and increased a gluthathione peroxidase (Gps) and superoxide dismutase (SOD) activity in edematous tissue. The anthocyanin show the health and therapeutic effect and it is given by many antioxidative activities. The quinodal and calcones anthocyanin are bases with a conjugated double bond attached to the keto group are scaveng free radical and efficiency antioxidant it is reported in literature [38]. For high antioxidant activity are increase by methoxylation and orthohydroxylation [39]. As compare to anthocyanin the anthocyanin has a high ORAC value. The reasone is aglocane anthocyanin are very unstable and highly reactive [40]. The anthocyanidin with single suger molecules than the addition of extra suger at position C-3 in the hetrocyclic C-ring the anthocyanin has a lower antioxidant the activity of malvidin-3-glucoside that was determined by metalcatlyzedlipid peroxidation model [41].

APPLICATION OF PURPLE TOMATO

I) Anti-inflammatory

The animal body any fight injuries toxins or other stress, infection due to complex response of inflammation to the immune system. The activation of imflammation pathway characterized by the released of inflammation markerfromed the injured cell surface receptor recognized the detrimental stimuli, with the activation of inflammatory pathway from the injuried cell they realese the inflammatory markers. It is the process of acute inflammation, tumour necrosis, interleukins, interferon gamma, factor alpha, prostaglandins are the markers. Inflmmatory cell like leukocytes are recruited from the venus system to the injured tissue [42].

II) Anticancer

In a cancer prevention antiangiogenesis is the process that are use to prevent new blood vessels formation that are used to transfer oxygen to the tumor cell anthocyanin include flavonids and other phytochemical are the antiangiogenesis based in vitro and cell culture studies and cell culture studied and animal model. The key for cancer disease is angiogensis where it is an important step in the transfer of tumour from a been extracted and isolate for their cheaking anticancer capacity on colon, breast, liver, esophagus, hematologival and prostate cancer. The extract of anthocyanin pyruic and blueberry anthocyanin demonstrated anti invasive potentionalin MDA MP 231 and MCF7 in both breast cancer line [43]. By acting as chemo-inhibitor the extract inhibited proliferation of cancer cell. The extract of the anthocyanin pyruvic acid show better effect in MDA MB-231, at it suggest thatestrogen receptors as a effect independent. In a studies bilberry, chocokeberry,

and grapes the supplmentaion of extract of rich anthocyanin. In a cancer study the human heptoma hep3b cell have anti-invansive property due to less common anthocyanin source from wine [44].

III) Cardio vascular health

The studies of epidermiology show the relation between cardio system and anthocyanin rich food. As an relationship of total anthocyanin intake and risk developing these cardiovascular system related disease in vitro it also demonstrate anthocyanin an anti-thromabotic effect [45]. In a studies that anthocyanin containing maized seed fet rat of eight week are less susceptible to ischemia reperfusion injury and relation of infract size with increased myocardial antioxidant enzyme it is supported by antithrobotic effect [46]. The anthocyanin rich extract bilberry and chokeberry but not elder berry it possess vasorelaxation properties it is reveled by bell and gochenaw. The consumption of anthocyanin rich strawberries for one month it improve lipid profile and platelates function in healthy volunteers it is suggest by research in clinical trials [47]. The consumption of 500 mg/day of elder berry extract for 12 week it indicate that the ineffective in reducing the risk of cardiovascular in health postmenopausal women.

IV) Antimicrobial

Anthocyanin containing polyphenolic compound possess antimicrobial activity against a microorganisum with wide range. It is also to inhibit the growth of food bron pathogen [48]. Antimicrobial activity exihibited by anthocyanin by several mechanisum such as in it is induced cell damge by destroying cell membrane , cell wall and intra cellular matrix [50]. In the previous study, the maquiberryexract had antibacterial activity with the highest sensitivity to listemiainnocua and aeromanos hydrophilia [49].

II. CONCLUSION

Due to the advanced social media platform the people are aware towards the health related information on food and Nutrition level of food. The continuous increase in demand for providing food security and nutritional security particular in poor and developing nations has made researchers all around the globe think in a direction of providing cost effective source of better nutrition source and nutrient through the qualitative improvement.

REFERANCES

[1]. Siegel R, Naishadham D, Jemal A. Cancer statistics, 2013. CA Cancer J Clin. 2013;63(1):11-30. doi:10.3322/caac.21166
[2]. Siegel RL, Miller KD, Jemal A. Cancer statistics, 2016. CA Cancer J Clin. 2016;66(1):7-30. doi:10.3322/caac.21332
[3]. Aizawa K, Liu C, Tang S, et al. Tobacco carcinogen induces both lung cancer and non-alcoholic steatohepatitis and hepatocellular carcinomas in ferrets which can be attenuated by lycopene supplementation. Int J Cancer. 2016;139(5):1171-1181. doi:10.1002/ijc.30161
[4]. Poon SL, McPherson JR, Tan P, Teh BT, Rozen SG. Mutation signatures of carcinogen exposure: genome-wide detection and new opportunities for cancer prevention. Genome Med. 2014;6(3):24. Published 2014 Mar 31. doi:10.1186/gm541
[5]. Antwi SO, Eckert EC, Sabaque CV, et al. Exposure to environmental chemicals and heavy metals, and risk of pancreatic cancer. Cancer Causes Control. 2015;26(11):1583-1591. doi:10.1007/s10552-015-0652-y
[6]. Parkin DM. The global health burden of infection-associated cancers in the year 2002. Int J Cancer. 2006;118(12):3030-3044. doi:10.1002/ijc.21731
[7]. Wang JJ, Lei KF, Han F. Tumor microenvironment: recent advances in various cancer treatments. Eur Rev Med Pharmacol Sci. 2018;22(12):3855-3864. doi:10.26355/eurrev_201806_15270
[8]. Paul, V. and Pandey, R., 2013. Delaying tomato fruit ripening by using 1-methylcyclopropene (1-MCP) for better postharvest management: current status and prospects in India. Indian Journal of Plant Physiology, 18(3), pp.195-207.
[9]. Jangid, K.K. and Dwivedi, P., 2016. Physiological responses of drought stress in tomato: a review. International Journal of Agriculture, Environment and Biotechnology, 9(1), p.53.
[10]. Rao, A.V. and Rao, L.G., 2007. Carotenoids and human health. Pharmacological research, 55(3), pp.207-216.
[11]. Olaniyi, J.O., Akanbi, W.B., Adejumo, T.A. and Akande, O.G., 2010. Growth, fruit yield and nutritional quality of tomato varieties. African Journal of Food Science, 4(6), pp.398-402.

[12]. Ramesh, K.V., Paul, V. and Pandey, R., 2021. Dynamics of mineral nutrients in tomato (Solanum lycopersicum L.) fruits during ripening: Part I—On the plant. Plant Physiology Reports, 26(1), pp.23-37.
[13]. Georgiev, C., 1972. Anthocyanin fruit (Af). Rep Tomato Genet Coop, 22(10), p.10.
[14]. Mes, P.J., Boches, P., Myers, J.R. and Durst, R., 2008. Characterization of tomatoes expressing anthocyanin in the fruit. Journal of the American Society for Horticultural Science, 133(2), pp.262-269.
[15]. Gonzali, S., Mazzucato, A. and Perata, P., 2009. Purple as a tomato: towards high anthocyanin tomatoes. Trends in plant science, 14(5), pp.237-241.
[16]. Myers, J., 2012. Breeding tomatoes for increased flavonoids. In Strengthening Community Seed Systems. Proceedings of the 6th Organic Seed Growers Conference, Port Townsend, Washington, USA, 19-21 January, 2012 (pp. 50-51). Organic Seed Alliance.
[17]. Colanero, S., Perata, P. and Gonzali, S., 2020. What's behind purple tomatoes? Insight into the mechanisms of anthocyanin synthesis in tomato fruits. Plant physiology, 182(4), pp.1841-1853.
[18]. Butelli, E., Titta, L., Giorgio, M., Mock, H.P., Matros, A., Peterek, S., Schijlen, E.G., Hall, R.D., Bovy, A.G., Luo, J. and Martin, C., 2008. Enrichment of tomato fruit with health-promoting anthocyanins by expression of select transcription factors. Nature biotechnology, 26(11), pp.1301-1308.
[19]. Winkel-Shirley, B., 2002. Biosynthesis of flavonoids and effects of stress. Current opinion in plant biology, 5(3), pp.218-223.
[20]. Laleh, G.H., Frydoonfar, H., Heidary, R., Jameei, R. and Zare, S., 2006. The effect of light, temperature, pH and species on stability of anthocyanin pigments in four Berberis species. Pakistan Journal of Nutrition, 5(1), pp.90-92.
[21]. Turturică, M., Oancea, A.M., Râpeanu, G. and Bahrim, G., 2015. Anthocyanins: Naturally occuring fruit pigments with functional properties. The Annals of the University Dunarea de Jos of Galati. Fascicle VI-Food Technology, 39(1), pp.9-24.
[22]. Wu, X., Beecher, G.R., Holden, J.M., Haytowitz, D.B., Gebhardt, S.E. and Prior, R.L., 2006. Concentrations of anthocyanins in common foods in the United States and estimation of normal consumption. Journal of agricultural and food chemistry, 54(11), pp.4069-4075.
[23]. Zamora-Ros, R., Knaze, V., Lujan-Barroso, L., Slimani, N., Romieu, I., Touillaud, M., Kaaks, R., Teucher, B., Mattiello, A., Grioni, S. and Crowe, F., 2011. Estimation of the intake of anthocyanidins and their food sources in the European Prospective Investigation into Cancer and Nutrition (EPIC) study. British Journal of Nutrition, 106(7), pp.1090-1099.
[24]. Ooe, E., Ogawa, K., Horiuchi, T., Tada, H., Murase, H., Tsuruma, K., Shimazawa, M. and Hara, H., 2016. Analysis and characterization of anthocyanins and carotenoids in Japanese blue tomato. Bioscience, biotechnology, and biochemistry, 80(2), pp.341-349.
[25]. Wallace, T.C. and Giusti, M.M., 2015. Anthocyanins. Advances in Nutrition, 6(5), pp.620-622.
[26]. Andersen, O.M. and Markham, K.R., 2005. Flavonoids: chemistry, biochemistry and applications. CRC press.
[27]. Kong, J.M., Chia, L.S., Goh, N.K., Chia, T.F. and Brouillard, R., 2003. Analysis and biological activities of anthocyanins. Phytochemistry, 64(5), pp.923-933.
[28]. Smeriglio, A., Barreca, D., Bellocco, E. and Trombetta, D., 2016. Chemistry, pharmacology and health benefits of anthocyanins. Phytotherapy Research, 30(8), pp.1265-1286.
[29]. Fang, J., 2014. Bioavailability of anthocyanins. Drug metabolism reviews, 46(4), pp.508-520.
[30]. Milbury, P.E., Cao, G., Prior, R.L. and Blumberg, J., 2002. Bioavailablility of elderberry anthocyanins. Mechanisms of ageing and development, 123(8), pp.997-1006.
[31]. Milbury, P.E., Vita, J.A. and Blumberg, J.B., 2010. Anthocyanins are bioavailable in humans following an acute dose of cranberry juice. The Journal of nutrition, 140(6), pp.1099-1104.
[32]. Passamonti, S., Vrhovsek, U., Vanzo, A. and Mattivi, F., 2005. Fast access of some grape pigments to the brain. Journal of agricultural and food chemistry, 53(18), pp.7029-7034.
[33]. Talavéra, S., Felgines, C., Texier, O., Besson, C., Gil-Izquierdo, A., Lamaison,

J.L. and Rémésy, C., 2005. Anthocyanin metabolism in rats and their distribution to digestive area, kidney, and brain. Journal of agricultural and food chemistry, 53(10), pp.3902-3908.

[34]. González-Barrio, R., Edwards, C.A. and Crozier, A., 2011. Colonic catabolism of ellagitannins, ellagic acid, and raspberry anthocyanins: in vivo and in vitro studies. Drug Metabolism and Disposition, 39(9), pp.1680-1688.

[35]. Stalmach, A., Edwards, C.A., Wightman, J.D. and Crozier, A., 2012. Gastrointestinal stability and bioavailability of (poly) phenolic compounds following ingestion of Concord grape juice by humans. Molecular nutrition & food research, 56(3), pp.497-509.

[36]. Roewer, N. and Broscheit, J., Sapiotec GmbH, 2018. Delphinidin complex as an antiphlogistic or immunosuppressive active ingredient. U.S. Patent 9,925,274.

[37]. Colanero, S., Perata, P. and Gonzali, S., 2020. What's behind purple tomatoes? Insight into the mechanisms of anthocyanin synthesis in tomato fruits. Plant physiology, 182(4), pp.1841-1853.

[38]. Bors, W., Heller, W., Michel, C. and Saran, M., 1990. [36] Flavonoids as antioxidants: Determination of radical-scavenging efficiencies. In Methods in enzymology (Vol. 186, pp. 343-355). Academic Press.

[39]. Wang, H., Cao, G. and Prior, R.L., 1997. Oxygen radical absorbing capacity of anthocyanins. Journal of agricultural and Food Chemistry, 45(2), pp.304-309.

[40]. Stintzing, F.C., Stintzing, A.S., Carle, R., Frei, B. and Wrolstad, R.E., 2002. Color and antioxidant properties of cyanidin-based anthocyanin pigments. Journal of agricultural and food chemistry, 50(21), pp.6172-6181.

[41]. Terahara, N., Callebaut, A., Ohba, R., Nagata, T., Ohnishi-Kameyama, M. and Suzuki, M., 2001. Acylated anthocyanidin 3-sophoroside-5-glucosides from Ajuga reptans flowers and the corresponding cell cultures. Phytochemistry, 58(3), pp.493-500.

[42]. Chen, L., Deng, H., Cui, H., Fang, J., Zuo, Z., Deng, J., Li, Y., Wang, X. and Zhao, L., 2018. Inflammatory responses and inflammation-associated diseases in organs. Oncotarget, 9(6), p.7204.

[43]. Faria, A., Pestana, D., Teixeira, D., de Freitas, V., Mateus, N. and Calhau, C., 2010. Blueberry anthocyanins and pyruvic acid adducts: anticancer properties in breast cancer cell lines. Phytotherapy research, 24(12), pp.1862-1869.

[44]. Lala, G., Malik, M., Zhao, C., He, J., Kwon, Y., Giusti, M.M. and Magnuson, B.A., 2006. Anthocyanin-rich extracts inhibit multiple biomarkers of colon cancer in rats. Nutrition and cancer, 54(1), pp.84-93.

[45]. Rechner, A.R. and Kroner, C., 2005. Anthocyanins and colonic metabolites of dietary polyphenols inhibit platelet function. Thrombosis research, 116(4), pp.327-334.

[46]. Toufektsian, M.C., De Lorgeril, M., Nagy, N., Salen, P., Donati, M.B., Giordano, L., Mock, H.P., Peterek, S., Matros, A., Petroni, K. and Pilu, R., 2008. Chronic dietary intake of plant-derived anthocyanins protects the rat heart against ischemia-reperfusion injury. The Journal of nutrition, 138(4), pp.747-752.

[47]. .Bell, D.R. and Gochenaur, K., 2006. Direct vasoactive and vasoprotective properties of anthocyanin-rich extracts. Journal of applied physiology, 100(4), pp.1164-1170.

[48]. Cushnie, T.T. and Lamb, A.J., 2005. Antimicrobial activity of flavonoids. International journal of antimicrobial agents, 26(5), pp.343-356.

[49]. Genskowsky, E., Puente, L.A., Pérez- Álvarez, J.A., Fernández- López, J., Muñoz, L.A. and Viuda- Martos, M., 2016. Determination of polyphenolic profile, antioxidant activity and antibacterial properties of maqui [Aristoteliachilensi s (Molina) Stuntz] a Chilean blackberry. Journal of the Science of Food and Agriculture, 96(12), pp.4235-4242.

[50]. Pojer, E., Mattivi, F., Johnson, D. and Stockley, C.S., 2013. The case for anthocyanin consumption to promote human health: a review. Comprehensive reviews in food science and food safety, 12(5), pp.483-508.