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Purple Tea, a Rich source of anthocyanin and polyphenol: A Review

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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Review Article

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ABSTRACT

Tea (*Camellia sinensis*) is a famous drink after water which is burned-through everywhere on the world because of its medical advantages. Anthocyanin-rich purple tea shoots (PL) has higher measure of polyphenol, when contrasted with standard green leaf shoot (GL). Likewise tea items produced using PL have more significant levels of catechin profile, and cell reinforcement exercises than that of GL. Notwithstanding, purple tea has a less measure of caffeine content and a high measure of anthocyanin which is useful in human wellbeing. Fundamentally anthocyanins are polyphenol. In-plant, anthocyanins accept a critical part in augmentation, seed dissipating, getting against abiotic and biotic pressing factor. Epidemiological examinations show that every day imtake of purple tea lessens the danger of cardiovascular sickness, neurological issues, and malignant growth moreover. As a result of higher measure of anthocyanin and polyphenol, purple tea displays more cell reinforcement, militating against stoutness, hostile to microbial, hostile to hyperglycemic properties as contrast with GL. In the central tangible framework, anthocyanin and cyaniding-3-O-glucoside (C3G) show insurance just as therapeutic properties against various genuine afflictions like Parkinson's, Alzheimer's disease, etc. Hindrance of neuroinflammation and oxidative pressing factor are two guideline pathways by which anthocyanin and C3G make guarded or possibly healing effects in CNS issue. In this study, we summarize various properties of purple tea and give an audit of the piece of purple tea, concerning polyphenols and anthocyanin in the evasion of cardiovascular ailment, harmful development, and central tangible framework (CNS) tangle prevalently Alzheimer's ailment and Parkinson's infection.

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1. INTRODUCTION

After water tea (*Camellia sinensis*) has been generally utilized as a sweet-smelling and non-mixed beverage all through the world (Hodson and croft., 2010). Tea is a lasting evergreen woody bush of family called Theaceae. Lately, the utilization of tea has been picked up a lot of consideration as far as both healthful and remedial advantages. Tea contains different sorts of polyphenol like flavan-3-ols or tea catechin including epicatechin (EC), epigallocatechin (EGC), epigallocatechin 3-gallate (EGCG) and epicatechin-3-gallate (ECG). Among the above mentioned, EGCG and gallic corrosive is generally plentiful in green tea. These polyphenols help to secure different illnesses including cardiovascular infection, atherosclerosis, and oxidant movement [1].

Presently in the tea business, purple tea, another assortment of *C. sinensis*, is turning into the focal point of fascination as a result of its excellent tone, special flavor, and its numerous medical advantages. Purple tea has been viably using in specific countries like Kenya, China, and India. In purple tea, there is a high measure of anthocyanin and phenolic mixes [2-5]. Additionally, it contains less proportion of caffeine and zero calories. In purple tea the shade of the leaves changes continually for instance in a juvenile stage the leaves are green which consistently changes into light green finally, it gets dull purple at the improvement stage [6,7]. Flavonoids are the significant auxiliary plant metabolites. In flavonoids, there are numerous subgroups present, one of which is anthocyanin. In anthocyanins, glycosylated anthocyanin is additionally included, which play a significant job in the improvement of the red, purple, or blue shade of the vegetables, organic products, leaves, and blossoms [*8*].

The biosynthetic pathway of flavonoids has been illustrated in various plant species like *Camellia sinensis*, *Medicago truncatula*, tobacco, etc. [*9*]. The malonyl coA and phenylalanine is the antecedent for the biosynthesis of the flavonoids. The chalcone synthase helps with get-together the forerunner and to shape chalcone moderate which experiences a couple of reactions by the help of various synthetic compounds like leucoanthocyanidin dioxygenase, flavanone-3-hydroxylase and dihydroflavonol-4-reductase to convey anthocyanin. Anthocyanin is the eventual outcome of flavonoids biosynthesis. Another significant finished result of flavonoids biosynthesis is catechins [10-13]. It is likewise detailed the inhibitory impact of polyphenols on colitis in dextran sodium sulfate treated mice [1*4*]. Purple shaded tea is additionally read for its enemy of proliferative impact colorectal carcinoma cells and its association in the cleavage of PARP initiation of caspase-3 [1*5*].

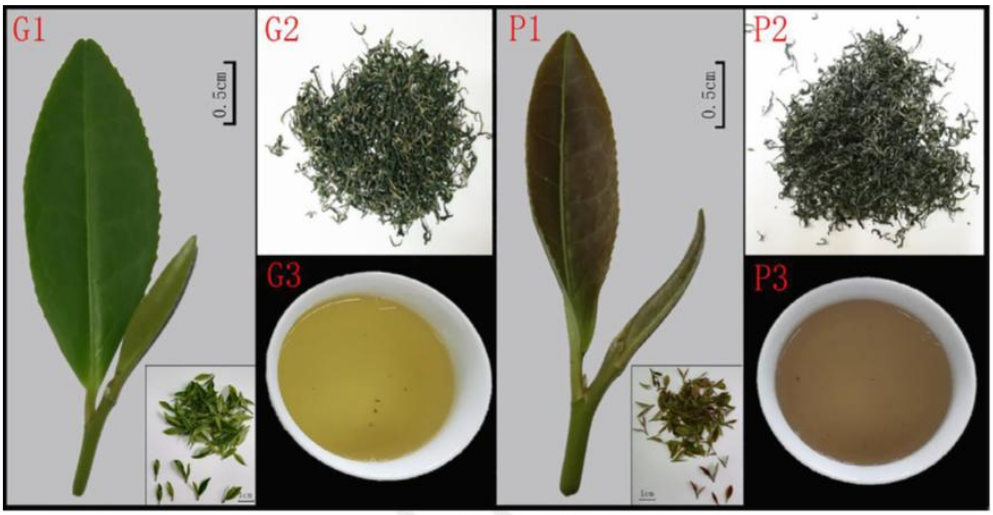

Fig. 1. Phenotype of purple and green young shoots [Source: DOI: 10.1002/jsfa.10158]

2. ANTHOCYANIN

Anthocyanins are the biggest gathering of phenolic colors (fig beneath) which is bounteously accessible in purple tea. They are glycosides of aglycon, which are water dissolvable in nature, called as anthocyanidins and it is compelling givers of hydrogen. Various types of anthocyanins are biosynthesized by plant by means of change of the normal 6 anthocyanin aglycon.

2.1 Biosynthetic Mechanism of Anthocyanin

The overall portrayed biosynthetic pathway of anthocyanin (fig. coming up next) is a puzzled cycle in different plant species (Holton et al., 1995), [16]. It is the sweeping pattern of the general flavonoid biosynthetic pathway. It starts from the advancement of naringenin chalcone from 4-coummaroyl-CoA and malonyl co A, with the help of chalcone synthase (CHS) compound. This naringenin chalcone is isomerized to naringenin with the help of the chalcone isomerase compound. From that point forward, flavanone-3-hydroxylase (F3H) helps in transformation of naringenin to dihydrokaempferol which can be further hydroxylated into two dihydroflavonol, dihydroquercetin or dihydromyricetin by the activity of flavonoid 3', 5' – hydroxylase (F3'5'H) or flavonoid-3'- hydroxylase (F3'H) separately. Then, these three dihydroflavenol structures dull leucoanthocyanidins by the movement of dihydroflavonol 4-reductase. By then, this grim leucoanthocyanin is changed into the concealed anthocyanidin by the help of anthocyanidin synthase compound (ANS). Finally, the sugar particle is attached to the anthocyanidins by the movement of various kinds of mixtures like flavonoid 3-O-glucosyltransferase which might be acylated with sweet-smelling acyl bundle by acyltransferases. CHS is the fundamental unique compound for the biosynthesis of flavonoids [17].

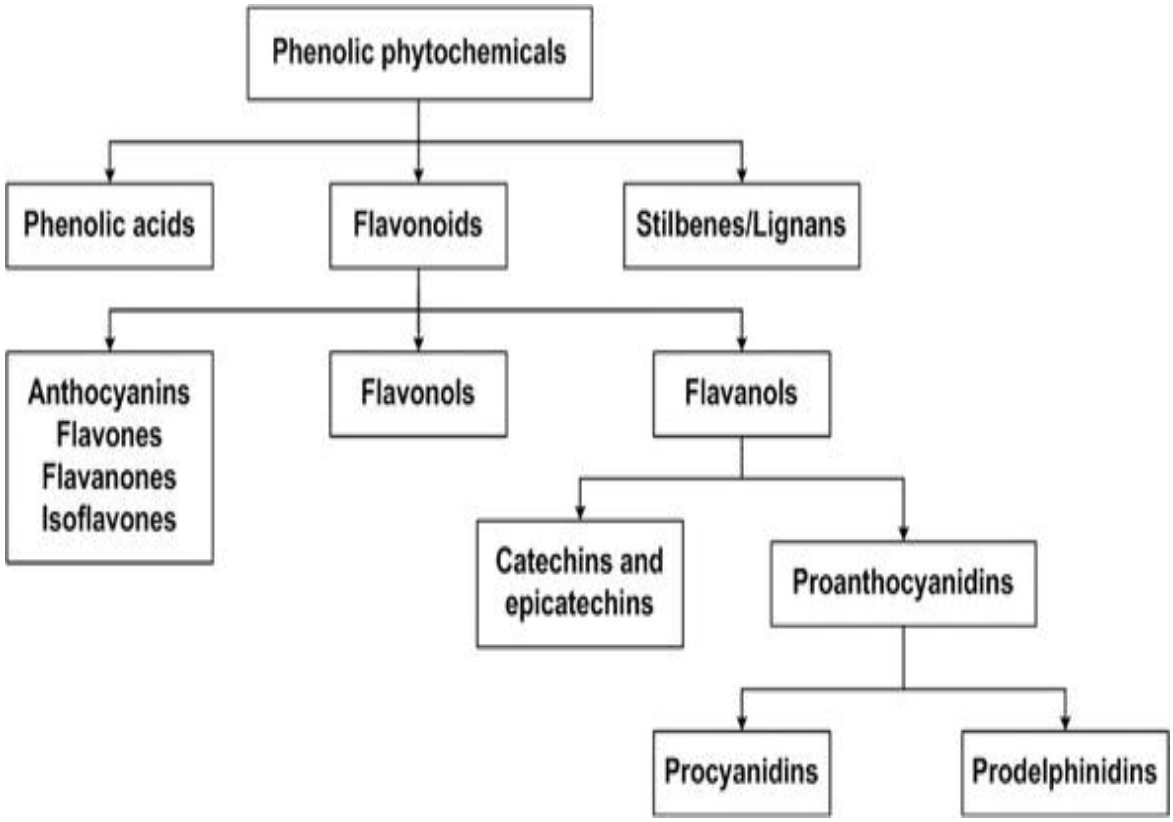

Fig:2- anthocyanin [Source: https://www.intechopen.com/books/flavonoids-from-biosynthesis-to-human-health/antioxidant-capacity-of-anthocyanin-pigments]

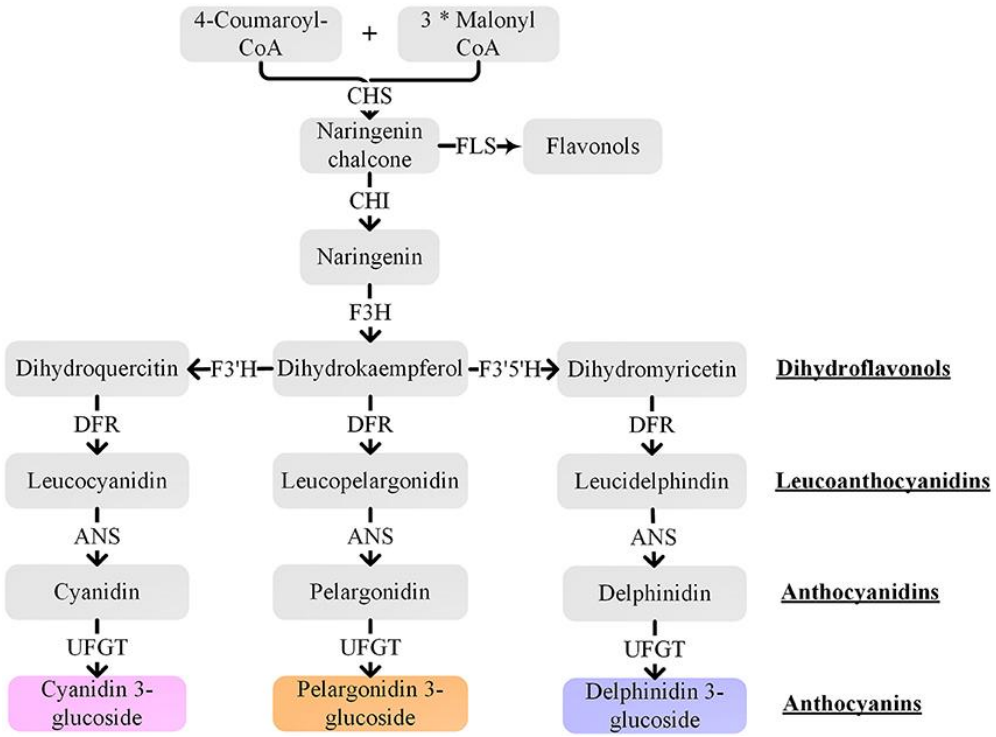

Fig: 3 Biosynthesis of anthocyanin [Source: https://www.frontiersin.org/files/Articles/308869/fchem-06-00052-HTML/image_m/fchem-06-00052-g004.jpg]

3. TOTAL POLYPHENOL CONTENT

Polyphenols are the micronutrients that go about as the counter oxidant, which kill the hurtful free radicle that is unsafe for the cells and increment the possibility of malignancy, coronary illness, and diabetes. Purple tea has more and special polyphenol as contrast with other tea (16.5% in purple tea, 10.1% in dark tea, and 9.1% in green tea as indicated by Omni vista Health learning). Information on the TP substance of purple tea is introduced in the accompanying table. As per the table, the un-circulated air through tea item contains more TP as contrast with the circulated air through tea item.

3.1 Individual Catechin

3.1.1 General

The following catechins are mostly found in the purple tea

3.2 a EGCG

EGCG is the main cell reinforcement catechin found in the purple tea. It is framed by the esterification response among epigallocatechin and gallic corrosive. EGCG demonstrated the most powerful antiproliferative impacts and decrease cell capture in the G1 period of cell circle and cell apoptosis. It is essentially higher on account of un-circulated air through purple tea from the green leaf hued cultivars.

3.3 b ECG

Epicatechin-3-gallate (ECG) is a polyphenol same as EGCG. Unlike EGCG, ECG content in purple tea shows different trends.

3.4 c Gallic Acid

The substance name of gallic corrosive is 3, 4, 5-trihydroxy benzoic corrosive which is a trihydroxy benzoic corrosive. It is the most well-known common cell reinforcement found in purple tea. It forestalls oxidative harm that happens in biomolecule by searching the free radicle. Un-circulated air through tea has a lower substance of gallic corrosive when contrasted with the circulated air through purple tea.

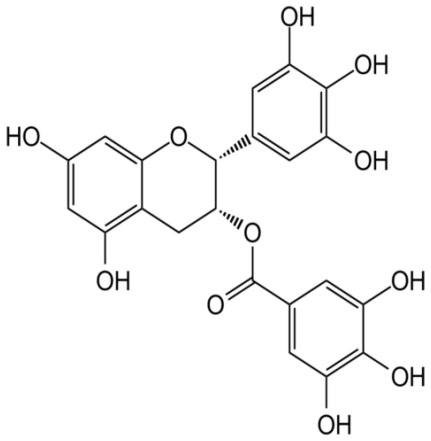

Fig. 4. chemical structure of ECGC [source: https://5.imimg.com/data5/RG/NJ/MY-8206856/egcg-epigallocatechin-gallate-500x500.png]

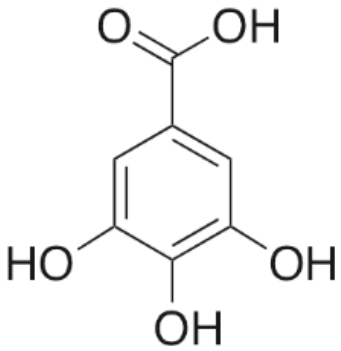

Fig. 5. gallic acid. [source: https://lktlabs.com/product/gallic-acid/]

Table 1. Content of polyphenol (%) in aerated and unaerated processed green leaf and purple leaf colored tea cultivar. [source: https://doi.org/10.1016/j.foodchem.2012.09.066]

Cultivars	Un-aerated (green tea)	Aerated (black tea)
Green leaf color		
GW Ejulu- L	32.0	26.3
AHP S15/10	21.4	17.9
TRFK31/8	25.0	21.0
TRFK 6/8	24.0	23.9
TRFK303/216	19.7	16.8
TRFK 301/1	20.9	16.6
EPK 14-3	22.0	18.7
Yabukita	19.1	14.8
Yutakamidori	16.8	12.9
Purple leaf color		
TRFK 306/1	22.8	20.0
TRFK 306/2	22.2	19.6
TRFK 306/3	23.2	19.6
TRFK 306/4	24.2	20.0
TRFK 73/1	21.7	17.6
TRFK 73/2	21.3	17.5
TRFK 73/3	21.3	18.5
TRFK 73/4	22.2	18.8

Table 2. Catechin (%), caffeine (%), gallic acid (%) in unaerated tea from purple colored leaf cultivar [source: https://doi.org/10.1016/j.foodchem.2012.09.066]

Cloned	ECG	EGCG	Caffeine	Gallic acid
Purple colored leaf				
TRFK 306/1	3.06	2.15	1.95	0.89
TRFK 306/2	3.76	1.58	1.75	0.68
TRFK 306/3	5.14	2.23	2.26	1.05
TRFK K Purple	3.65	3.13	2.99	0.79
TRFK 73/1	1.94	5.80	2.56	0.64

3.5 d Caffeine Content

Caffeine helps in stimulation which is found in tea, coffee, and cacao plants. The caffeine content in purple tea is less than green tea or black tea. Purple tea extract contains 4.5% caffeine (alluvia purple tea overview 2014).

4. CARDIOVASCULAR DISEASE

The most well-known explanation for the cardiovascular infection (CVD) is the aggravation of veins named atherosclerosis [18].Infiltration of low-thickness lipoprotein through the endothelium is the explanation for CVD. When the low-thickness lipoprotein (LDL) is caught in the sub-endothelium layer then it is more inclined to frame the oxidized LDL. Additionally, the oxLDL focuses on the T cells, monocytes, and endothelial cell initiation. When the endothelium cells in endothelium instigate grip atoms, porousness changes which help in the invasion of macrophage and T-cells and furthermore helps in diminishing the declaration of Nitrous oxide (NO) [19]. Therefore, vascular tension is expanded. This aggravation cycle involves the gathering of different cells including smooth muscle cells, living and dead froth cells, and endothelial cells which structure atherosclerotic plaques. Therefore, vessel thickness increases and decrease the lumen and results in fierce blood stream. Additionally, froth cells in the plaques can deliver proteases that can burst the plaque and making an embolic cycle. The blood stream in little vessels can be decreased by the plaque or its embolus which prompts cause the ischemia in the organ. This is the primary driver of different CVD, for example, coronary illness (CHD), stroke, and fringe blood vessel sickness.

In CHD ischemia in the coronary corridor, supplies oxygen to the heart. This condition may happen in view of developing of atherosclerotic plaques or embolic relocation in the coronary conduit which diminishes the blood stream and solidify the veins. This cycle prompts lessen oxygen flood to the heart, diminishes cardiovascular yield, or driving cell demise. Stroke, which harms the cerebrum work, may happen through ischemia because of a lessening in the blood stream brought about by apoplexy or embolus. Another stroke may shape through hemorrhagic cycles which include cracking of the veins because of hypertension [20-22].

The significant danger factor which can create cardiovascular sickness incorporates smoking, liquor utilization, hereditary inclination, actual inertia, unfortunate eating regimen, elevated cholesterol, hypertension, and diabetics. As indicated by clinical investigations, it is demonstrated that oxidative pressure is related with cardiovascular illness. With the expansion of oxidative pressure in the body the harm of macromolecule may happen which prompts cardiovascular infection. In the expansion, the heart is the kind of organ that builds the ROS creation the bringing down the convergence of the cancer prevention agent substance in the body. Thus, bringing down the centralization of cancer prevention agent substances, cells and tissues may harm which prompts influence the macromolecule like protein, DNA, and cell lipids.

4.1 Anthocyanin Mechanisms of Action

These days, different sorts of polyphenolic compounds including anthocyanin are utilized to treat cardiovascular illness. A few investigations show the helpful impact of anthocyanin on CVD, by repressing the incendiary cycle, endothelial brokenness, and NO creation. The major process of action mechanisms are as follow:

4.2 Antioxidant Properties of Anthocyanin

The cell reinforcement properties of anthocyanin rely upon its compound structure which further relies upon the number and position of the hydroxyl gathering, the level of glycosylation, formation gatherings and the presence of benefactor electron in the ring structure.

Oxidative pressure causes tissue injury which prompts the CVD. It happens in light of the fact that awkwardness between the age of RNS and ROS and cancer prevention agent guard framework in the body. These responsive species are setting off cell demise by assaulting the macromolecule like lipids, DNA, and protein. ROS is the group of exceptionally responding species that structure either enzymatically or non-enzymatically and causes cell harm either straightforwardly or through goes about as a moderate. Free extremists are delivered as a side-effect of different systems like nicotinamide adenine dinucleotide phosphate (NADPH), oxidase electron transport chain, digestion systems of arachidonic corrosive, and so forth There are additionally different wellsprings of ROS like xanthin oxidase, peroxisomal oxidase, and so forth Nonetheless, the significant wellsprings of ROS in CVD are mitochondrial, OX, and NADPH oxidase pathways.

4.3 The Antioxidant Action of Anthocyanin in ROS Production

The cancer prevention agent capability of anthocyanin relies upon the free OH radicle around the pyrone gathering and the OH bunch quantity is dispersed all through the atom structure. The cancer prevention agent movement of anthocyanin incorporates the concealment of receptive species arrangement through compound restraint and the sequestration of minor components that are engaged with the creation of free radicles. By the activity of flavonoids, the chain response of free radicles is broken on the grounds that the flavonoids give the hydrogen particle to the peroxyl radicle and structure a flavonoid radicle. Furthermore, anthocyanin is against peroxidative. In certain investigations shows that different flavonoids repress the lipid peroxidation of Rat liver cell layer actuate both by the ascorbic corrosive Fe2+ framework and arachidonic corrosive.

Anthocyanin shows various components for cell reinforcement properties like catching free radicles/anions, repressing XO, chelating metal particles, focusing on arachidonic corrosive, and attachment of atom.

4.4 Capturing Free Radicles/ Anions

The phenolic structure of anthocyanin permits it to give a proton to the free radicles which recover the acyl glycerol particle and forestalls the oxidation by free radicles. In this manner phenolic mixes settle the free radicles and spread without advancing oxidation responses [23]. Anthocyanin assists with eliminating the atomic types of dynamic oxygen like hydrogen peroxide, superoxide, OH, singlet, and peroxyl radicles.

4.5 Inhibition of Xanthine Oxidase

Different investigations show that the anthocyanin hinders the activity of xanthine oxidase. One of the significant strategies for this hindrance is expanding the convergence of uric corrosive. The .OH bunch in the C-5 and C-7 position initiates the XO inhibitory activity [24]. Then again, the .OH in C-3 and C-6 diminish the XO inhibitory activity.

4.6 Chelating Metal Ions Like Iron and Copper

Oxidative pressure associated with the iron stockpiling as heme protein or ferritin which starts the lipid peroxidation. Anthocyanin can go about as a chelating specialist and structure anthocyanin metal complex particles with their 3', 4'- dihydroxy gathering (*Buldas, S. et al., 2006*). They likewise restrain the oxidation of LDL which is incited by copper particles and peroxyl radicles [*25*].

4.7 Arachidonic Acid Targeting

Anthocyanin goes about as a biomarker of irritation in different fiery illnesses. In this view, the significant focuses of anthocyanin are the prostaglandin delivered by means of cyclooxygenase-2 (COX) and leukotrienes through lipoxygenase (LOX) [*26*]. The most intense inhibitor of secretary phospholipaseA2 (PLA2) is cyanidin, malvidin, peonidin, delphinidin, and so on [*27*]. PLA2 is the group of esterases. It is discharged by a cell layer that catalyzes the hydrolysis of glycerophospholipids and creates arachidonic corrosive just as other free unsaturated fats which are the antecedent of prostaglandin and leukotrienes. Different examinations show that anthocyanin gives an alternate level of hindrance against COX-1 and COX-2, despite the fact that the level of restraint relies upon the presence of free .OH bunch in anthocyanin structure. COX is the chemicals that assume a significant job in the change of n-6 unsaturated fat primarily arachidonic corrosive to prostanoids. This prostanoid assumes a

significant job in irritation. Cyanidin restrains the activity of COX proteins [*28*].

Anthocyanin hinders the activity of LOX which is a significant protein. LOX Influences aggravation, hypertension, and atherogenesis [*29*]. Dp-3-O-glucoside and Dp-3-O-galactoside are the particular anthocyanins that show the better outcome in LOX restraint because of a mix of free radicle searching, authoritative to the hydrophobic site of the LOX, or potentially association of hydrophobic unsaturated fats substrate [*30*].

4. 8 Polyphenol against CVD

Different human, creature, and cell examines have recommended that polyphenols have a helpful part against cardiovascular sickness by means of bringing down pulse, cancer prevention agent protections, improving endothelial capacities, repressing platelet accumulation, and low-thickness lipoprotein oxidation, and lessening fiery reactions. A day by day admission of flavanol containing purple tea can diminish the opportunity of hypertension CVD occurrence.

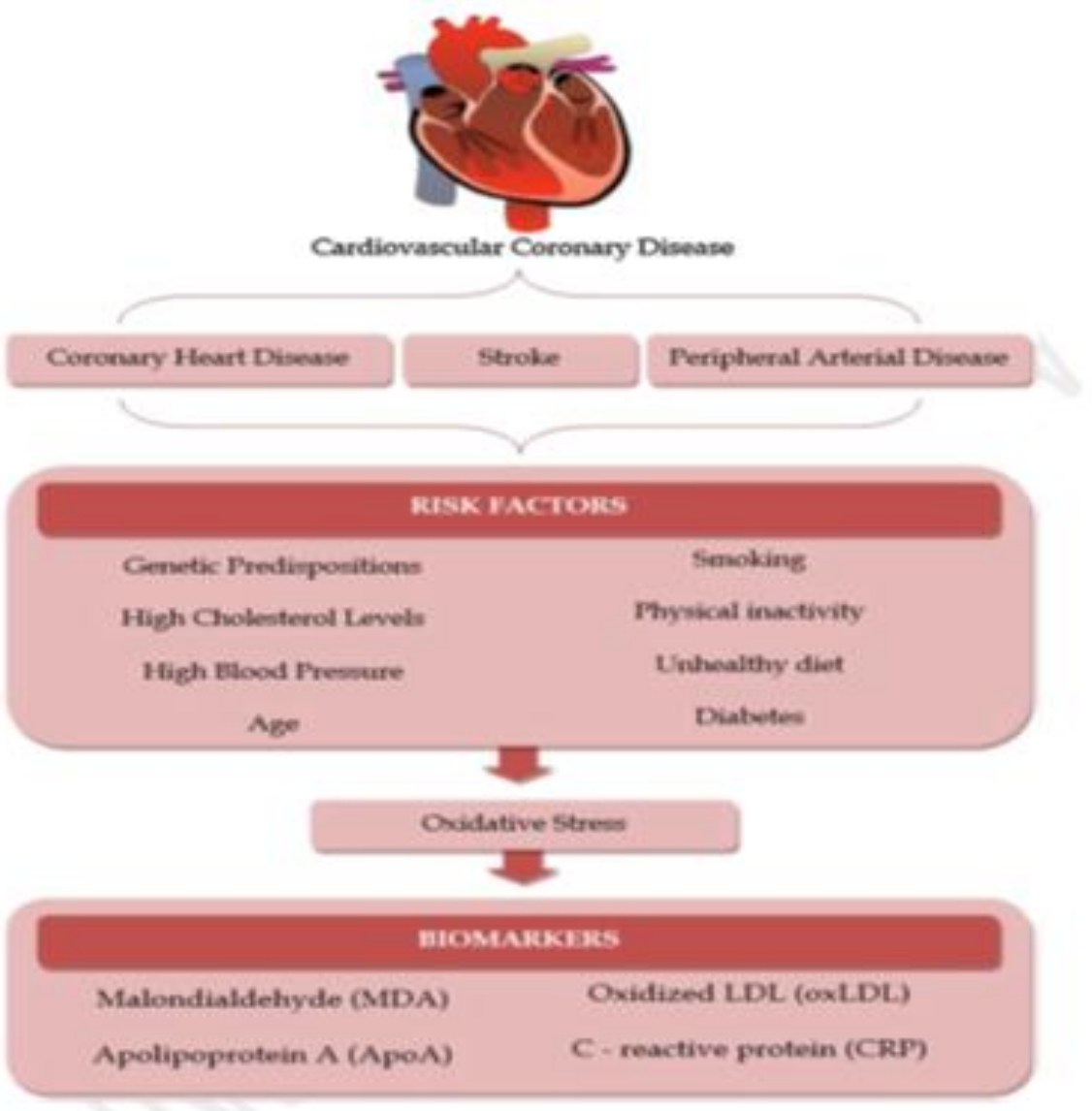

Fig. 6. CVD. risk factor and molecular marker. Source: Reis et al, 2016. doi: 10.1186/s12967-016-1076-5

One of the significant components of polyphenol against CVD is to adjust the level and action of nitric oxide synthase (eNOS) and control the bioavailability of nitric oxide to the endothelium. Aortic ring tests utilizing the physiological grouping of polyphenol have indicated that the polyphenol prompts endothelium-subordinate unwinding. This demonstrates that the capacity of polyphenols to include in kinase flagging pathways like the PI3-Akt pathway. Polyphenols additionally include in NO creation. It builds the eNOS articulation to incite prostacyclin creation to repress endothelin-1 and endothelial NADPH oxidase. In this way, it hinders angiogenesis and movement and expansion of vascular cells and lattice metalloproteinase (MMP) initiation. Additionally, flavanol and flavonols restrain AGE related vascular injury by directing MAPK motioning through RAGE.

4.9 Neuro-protective Properties of Purple Tea

A neurodegenerative issue prefers Parkinson's (PD) and Alzheimer's (AD), is an expanding issue in our maturing society [*31,32*]. There is an expanded commonness of both Parkinson's and Alzheimer's with the age. The neurodegenerative issue causes neuroinflammation, glutamatergic excitotoxicity, increments in oxidative pressure, iron, as well as exhaustion of endogenous cancer prevention agents. So hostile to AD or against PD medication would be gainful for improving the restorative status of AD and PD.

In vitro examines show that the menadione-actuate creation of receptive oxygen species in human cells can be diminished by utilizing anthocyanin [*33*]. Likewise, cyaniding-3-O-glucoside (C3G) represses the arrangement of Aβ1-40 and Aβ1-42 amyloid fibrils in mouse neuroblastoma Neuro2a cells [34,35]. A significant level of oxidative pressure is basic for AD commencement [*36,*37]. Restraint of oxidative pressure is a significant procedure for controlling AD. In vitro examines shows that the hindrance of arrangement of Aβ fiber and Aβ25-35 incited MMP interruption, cell apoptosis and oxidative pressure is profoundly identified with against AD properties of anthocyanin [*33*]. Anthocyanin represses the development of APP C-terminal in the ventral back cortex which improves the learning and memory in AD patients [33].

Parkinson's sickness is a neurodegenerative illness of the CNS that doesn't have any successful restorative procedure [*38*]. In the previous quite a long while, different bioactive specialists like anthocyanin separated from different sources, influence the PD pathogenesis [39,40]. Diet rich in anthocyanin containing products of the soil can decrease the danger of PD [41]. In late investigations shows that anthocyanin rotenone-incited dopaminergic cell demise by saving the mitochondrial breath [42]. On account of PD patients, anthocyanin builds the centralization of cyclic glycin-proline in cerebrospinal liquid (CSF) [43]. Consequently the proportion of CSF/plasma in cGP is altogether expanded. The anthocyanin is firmly connected with the plasma convergence of cGP and cGP/Insulin-like development factor 1 proportion [44]. The cGP rivals IGF-1 to tie with insulin-like development factor restricting protein-3 which prompts the measure of free IGF-1. It is better for the modification of IGF-1 interceded pathophysiological capacities like PD [45,46].

5. CANCER AND PURPLE TEA

Malignancy alludes to a gathering of infections that upsets command over cell development and digestion. Imbalanced authority over cell multiplication is an essential explanation behind malignancy in fact. The atoms which can handle disease cell multiplication might be additionally valuable as a chemo-preventive specialist. There are numerous sorts of disease like cellular breakdown in the lungs, colon malignant growth, bone disease, prostate malignancy for male and bosom disease overwhelmingly in ladies, and so forth

It is seen that EGCG is a strong enemy of cancer-causing and chemo-preventive specialist. In vitro and in vivo considers have demonstrated that tea polyphenols are engaged with cell apoptosis, cell multiplication, and cell cycle in tumor development. Accordingly they have a hostile impact against a particular sort of disease like bosom, prostate, colorectal, skin malignancy. In the beginning phase of malignant growth, DNA mutagenesis is instigated by lipid peroxidation in the cell which may build the malonaldehyde (MDA) [*46*]. These MDA builds the danger of disease. When contrasted with the sound human, in bosom malignant growth patients the degree of malonaldehyde-DNA adduct 3-(2-deoxy-β-D-erythro-pento-furanosyl) and pyrimido (1,2-α) purin-10 (3H)- one (M1dG) were a lot higher. The utilization of tea polyphenol shows that the degree of M1dG is decreased.

Likewise, tea polyphenols are powerful for their enemy of proliferative properties on account of colorectal malignancy. EGCG actuates cell apoptosis in both early and late-stage which captures the cell cycle and causes the passing of the malignant growth cells [47]. In ongoing examinations, it is demonstrated that the therapy of colorectal cell (CRC) with EGCG and radiation increment the affectability to the radiation by hindrance of cell multiplication. The declaration of LC3 and caspase-9 mRNA are likewise prompted by the therapy of EGCG and radiation.

6. CONCLUSION

The phenolic, catechin profile and anthocyanin of purple tea pull in much consideration due to its high medical advantages. This audit work shows the anthocyanin and other polyphenolic mixes in purple tea and their medical advantages like security against CVD, malignancy, and CNS problem like Alzheimer's sickness, Parkinson's infection. The all out cancer prevention agent exercises are firmly identified with the EGCG, ECG, TC, and CC. Anthocyanin of purple tea accepts a huge part in the restriction of oxidative pressing factor, NO creation, and neuroinflammatory response. Further examination of the remedial properties of anthocyanin and other polyphenols in purple tea may help in the formation of a novel neuroprotective trained professional. Catechins and anthocyanins are water-solvent. Subsequently it is right away removed into the mixers making the tea alcohol more astringent with preferred mouthfeel and sweet taste over green tea and dark tea. Anthocyanins are a gathering of flavonoids glucosides. In any case, it is disputably said that flavonoid glucosides are not consumed proficiently after oral ingestion. In any case, ongoing examinations show that because of positive charge anthocyanins are retained effectively after oral utilization. Being tea is the most favored non-mixed drink, this purple tea contains more polyphenolic mixes and anthocyanin normally which fills in as a substitute for the manufactured cancer prevention agent. Tea cell reinforcements in particular catechin and anthocyanin are non-harmful and water-solvent. Therefore, it isn't hurtful when purple tea burns-through in more focus. Subsequently the anthocyanins and catechins are more bioavailable through the utilization of tea alcohol.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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