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Purple Tea: Prospects of Darjeeling Tea Plantation

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Abstract **– Purple tea is a variety of Camellia sinensis and it contains anthocyanidins and 1, 2-di-O-galloyl-4, 6-O-(S) -hexahydroxydiphenoyl-β-D-glucose(GHG),a hydrolysable tannin. Purple tea is a unique type of thirst quenching tea with excellent briskness and flavor in oxidized form with lots of health benefits. According to the Food and Agriculture Organization (FAO) of the United Nations (UN), the world market for aerated (black) tea is anticipated to shrink in future whereas that for un-aerated (green, purple tea, etc.) tea and other forms of specialty teas is expected to grow. The identification of anthocyanins in purple tea is a positive step towards the diversification of tea products and uses an anthocyanin rich health tea drink. Purple tea is reported to contain several bioactive ingredients which are mostly contributed by polyphenols which plays a key role in prevention of many diseases; apart from this adoption of purple tea plantation also act as a coping mechanism to climate change due to its leading characters in drought resistance to green variety of tea. India is very rich in this tea germplasm being a place of origin. Purple tea is also available in several tea estates of Darjeeling, India. Therefore, India has tremendous potential to produce purple tea, as it is the tea of the future as far as excellent briskness and flavour in oxidized form with lots of health benefits are concerned. It will be a turning point for Darjeeling tea planters to realize the advantage of purple tea cultivation as far as health, environment, economic and other spheres are concerned.**

Keywords **– Anthocyanin, Anti-oxidents, Darjeeling Tea, GHG, Polyphenols, Product Diversification, Purple Tea.**

I. INTRODUCTION

Purple tea is a rare variety of *Camellia sinensis*, which in addition to certain tea constituents found in green tea, also contains anthocyanins. The major constituents in the leaves of purple tea are caffeine, theobromine, epigallocatechin (ECG), epigallocatechin gallate (EGCG) and 1, 2-di-*O*-galloyl-4, 6-*O*-(*S*)-hexahydroxydi phenoyl-*β*-D-glucose (GHG); in addition, GHG which is found uniquely in purple tea leaves at approximately the same concentration as EGCG, may also contribute to the anti-obesity effect (Shimoda et all., 2015). The tea beverage yields many health benefits to humans due to the extensive secondary metabolites in tea leaves, including polyphenols, theanine, and volatile oils (Yamamoto et al 1998, Rogers et al 2008). The chemical composition of tea is complex but includes polyphenols, amino acids, carbohydrates, proteins, chlorophyll, volatile compounds, minerals, trace elements and alkaloids such as caffeine, theophylline and theobromine. Among these, polyphenols constitute the main bioactive molecules in tea (Rashid et al 2014, Cabrera et al., 2003).

Anthocyanins are the largest group of water- soluble pigments in the plant kingdom and belong to the family of compounds known as flavonoids. Anthocyanins display a wide range of biological functions such as

attracting pollinators and seed dispersers and protecting plants against various biotic and abiotic stresses (Sun et al 2016). Purple tea is a variety of *Camellia sinensis* and it contains anthocyanidins (malvidin, peralgonodin and cyaniding 3-O-galactoside) and 1, 2-di-O-galloyl-4, 6-O-(S)-hexahydroxydiphenoyl-β-D-glucose (GHG), a hydrolysable tannin. Purple tea also differs from other varieties of *Camellia sinensis* in its caffeine content, which is relatively lower in comparison to green and black tea (Shimoda et al, 2015).

Purple Tea is grown in cooler conditions, at extremely high elevations of between 4500-7500 feet, which result in strong antioxidant properties. The wild Purple Plant was first discovered in the gardens of Assam, India (https://purposetea.com/about-purple-tea/; http://purpleteaexperience.com/history-of-purple-tea/). India is very rich in this tea germplasm being a place of origin. Purple tea is also available in several tea estates of Darjeeling, India. Therefore, India has tremendous potential to produce purple tea, as it is the tea of the future as far as excellent briskness and flavour in oxidized form with lots of health benefits are concerned.

According to the Food and Agriculture Organization (FAO) of the United Nations (UN), the world market for aerated (black) tea is anticipated to shrink in future whereas that for un-aerated (green, purple etc.) tea and other forms of specialty teas is expected to grow. Kenya has therefore embarked on opportunities to diversify its tea products in order to access this market. Un-aerated purple tea is a relatively new product in the Kenyan market and the world market at large and for this reason it has lower market share compared to black and green tea. (Simon et al 2015). Product diversification is expected to lead to increased production and utilization of the tea crop through value addition (Monks, A. 2000, Anon 2010, Yilmaz, Y. 2006, Lelgo et at 2011). In order to access diversified tea market, Darjeeling Tea Research & Development Centre, Tea Board of India, Kurseong, India has also initiated experimentation since 2014 to release and develop planting materials of purple tea for Darjeeling Plantation.

The reported biological activities of purple tea include anti-trypanosome and cerebral antioxidant activities (Shimoda et al 2015). The taste un-aerated purple tea is as mild as black tea owing to the anthocyanin content in them (Yilmaz 2006). Blending with purple tea such as mixed with green jasmine, citrus, spices, multiple fruit mix with purple tea is a strategy to modify flavor and aroma making them more appealing to consumers which can be championed to sell the diversified tea product.

Manufacturing of Purple Tea:

Purple tea leaves are processed by the same method used to process green tea. Reproduction is by cuttings since the seeds display high genetic variability. Bushes take 3 to 6 years to mature. The high mountain grown tea tastes best when withered slightly, using processing methods like green tea (Dan Bolton 2017).

Fig. Purple Tea clone at Long Term Trial plot of DTRDC, Darjeeling; Tea Board of India.

Ingredients of Purple Tea:

The chemical composition of tea is complex but includes polyphenols, amino acids, carbohydrates, proteins, chlorophyll, volatile compounds, minerals, trace elements and alkaloids such as caffeine, theophylline and theobromine. Among these, polyphenols constitute the main bioactive molecules in tea (Cabrera *et al.*, 2003). In addition to the usual polyphenolic compounds found in green tea, such as epigallocatechin gallate (EGCG) and epicatechin gallate (ECG), purple tea is unique in that it also contains anthocyanidins (malvidin, peralgonodin and cyanidin 3-O-galactoside) and 1, 2-di-O-galloyl-4, 6-O(S)-hexahydroxydiphenoyl-β-D-glucose (GHG), a hydrolysable tannin (Yagi, Goto and Nanjo 2009). Upon comparison with common teas (dry leaves) such as green tea, black tea and oolong tea, Purple Tea has the highest content of variety of Polyphenols antioxidants which are 09.1%, 10.1%, 07.4% and 16.5% respectively. Purple Tea extract is rich in polyphenols GHG and theobromine which is unusually found in other common teas such as green tea, black tea and oolong tea. Content of functional components of Purple Tea extract are total polyphenol (50.4%), caffeine (4.5%), theobromine (1.6%), GHG (7.4%), EGCG (9.8%), ECG (5.8%), chlorogenic acids (0.9%), total anthocyanin (1.5%) (Oryza, Ver. 1.0 SJ). Purple tea also differs from other varieties of Camellia sinensis in its caffeine content, which is relatively lower in comparison to green and black tea (Cherotich et al 2013, Kilel et al 2013).

Various Effects and Prospects of Purple Tea:

In addition to polyphenolic compounds found in green tea, such as epigallocatechin gallate (EGCG) and epicatechin gallate (ECG), purple tea is unique in that it also contains anthocyanidins (malvidin, peralgonodin and cyanidin 3-O-galactoside) and 1, 2-di-O-galloyl-4,6-O(S)-hexahydroxydiphenoyl-β-D-glucose (GHG), a hydrolysable tannin (Yagi, Goto and Nanjo 2009). Oryza Oil and Fat Chemical Co. Ltd, discovered a specific polyphenol compound, (1, 2-di-galloyl-4, 6-hexahydroxydiphenoyl-β-D-glucose) (GHG) which is not found in green tea, oolong tea and black tea. GHG has been shown to demonstrate excellent anti-obesity and anti-ageing effects (Oryza, Ver. 1.0 SJ). The biological activities of purple tea include anti-trypanosome (Rashid et al 2014) and cerebral antioxidant (Rashid et al 2014) activities.

Tea catechins have been found to be pharmacologically active (Higdon & Frei, 2003; Karori, Wachira, Wanyoko, & Ngure, 2007; Rizvi, Zaid, Anis, & Mishra, 2005; Wachira & Kamunya, 2005). The major catechins in the tea leaf include: (+)-catechin (C), gallocatechin (GC), ()-epigallocatechin (EGC), ()-epicatechin

(EC), ()-epicatechin gallate (ECG) and ()-epigallocatechin gallate (EGCG) with the most abundant in green leaf being EGCG. Anthocyanins are the largest group of water soluble pigments found in the plant kingdom including purple tea. Recently interest in anthocyanins has increased owing to their potential health benefits (Kong, Chia, Goh, Chia, & Brouillard, 2003) and their use as an alternative source of synthetic colourants or dyes (Jackman, Yada, Tung, & Speers, 1987). Because of the sedentary nature of plants, they are prone to UVB irradiation which can cause oxidative stress. Anthocyanins protect plants against such irradiation. Their biosynthesis has been demonstrated to be upregulated when the plant is exposed to UV-B irradiation (Merzlyak, Chivkunova, Solovchenko, & Naqvi, 2008). Anthocyanins also aid to elevate the plants leaf temperature during winter or chilling (Hughes, Neufield, & Burkey, 2005), apart from providing protection against invasion from pests and herbivores (Chalker-Scott, 1999). Industrially, anthocyanins may be used as food colourants (in jams, juices and confectioneries) and preservatives, in the manufacture of cosmetics (soaps, shampoos, lotions) and in the pharmaceutical industry for tablet/ capsule coatings, syrups and as health concentrates. Because of their colour, they are also important in the making off red wine (Rivero-Perez et al., 2008). Recent research has shown that anthocyanins have numerous health beneficial properties, which include antioxidant (Bae & Suh, 2007), anticarcinogenic (Lee et al., 2009), anti-angiogenic (Bagchi, Sen, Bagchi, & Atalay, 2004), antimicrobial (Viskelis et al., 2009), antiapoptotic (Elisia & Kitts, 2008) and pro-apoptotic (Lo et al., 2007) properties. It was also expected that the presence of anthocyanins in addition to the catechins would contribute to new and unique tea products (Kerio et al ,2012). Apart from this purple tea is leading in drought resistance to green variety of tea (*Kimati* et al 2016). From above points it will be a turning point for Darjeeling tea planters to realize the advantage of purple tea cultivation as far as health, environment, economic and other spheres are concerned.

Why Should Drink Purple Tea:

Health Benefits:

It has been found to have a host of medicinal properties, is rich in anthocyanins and contains catechins. Purple tea has low caffeine content and is high in antioxidants that provide anti- oxidants to the body.

- Lowers cholesterol and blood sugar metabolism;
- Helps fight free radicals in the body hence reducing risks of hypertension and cardiac arrests;
- Reduce risks of certain types of cancer;
- Improves vision;
- Helps reduce constipation.
- Supports women reproductive health.
- Used as drug supplements, preservatives and other industrial uses.
- Used in the manufacture of fast moving consumer goods such as health care products, foods and confectionaries.

This is due to high levels of anthocyanins, the same antioxidants that give color to foods like blueberries, cranberries, grapes, and even red cabbage or eggplants (AFFA, 2015; Kenya).

II. CONCLUSION

The identification of anthocyanins in purple tea is a positive step towards the diversification of tea products and uses an anthocyanin rich health tea drink. Though anthcyanins have recently been identified in purple tea in addition to catechins, but it is one of the most researched plant based on remedy from ancient times whose possible benefits including cardio – vascular health, stops aging, skin protection and impaired immune system. Adoption of purple tea cultivation can also acts as a coping mechanism during climate change.

REFERENCES

[1] Anon (2010) Strategic Plan. Tea Research Foundation of Kenya Strategic Plan, 60.
[2] Bae, S.H., & Suh, H.J. (2007). Antioxidant activities of five different mulberry cultivars in Korea. Food Science and Technology, 40, 955–962.
[3] Bagchi, D., Sen, C. K., Bagchi, M., & Atalay, M. (2004). Anti-angiogenic, antioxidant and anti-carcinogenic properties of a novel anthocyanin-rich berry extract formula – A review. Biochemistry, 69, 75–80.
[4] Cabrera, C., Gimenez, R. and Lopez, C.M. 2003. Determination of tea components with antioxidant activity. Journal of Agricultural and Food Chemistry 51:4427-4435.
[5] Chalker-Scott, L. (1999). Environmental significance of anthocyanins in plant stress responses. Phytochemistry and Phytobiology, 70, 1–9.
[6] Cherotich L, Kamunya SM, Alakonya A, et al. Variation in catechin composition of popularly cultivated tea clones in East Africa (Kenya). Am. J. Plant Sci. 2013; 4 (3): 628.
[7] Dan Bolton, Purple Tea Ready for prime time, August 2017.
[8] Elisia, I., & Kitts, D.D. (2008). Anthocyanins inhibit peroxyl radical induced apoptosis in Caco-2 cells. Molecular and Cellular Biochemistry, 312, 139–145.
[9] Higdon, J.V., & Frei, B. (2003). Tea catechins and polyphenols: Health effects, metabolism and antioxidant functions. Critical Reviews in Food Science and Nutrition, 43, 89–143.
[10] Hughes, N.M., Neufield, H.S., & Burkey, K.O. (2005). Functional role of anthocyanins in high light winter leaves of the evergreen herb Galax urceolata. New Phytologist, 168, 575–578.
[11] Jackman, R., Yada, R., Tung, M., & Speers, R.A. (1987). Anthocyanins as food colorants – A review. Journal of Food Biochemistry, 11, 201–247.
[12] Karori, S. M., Wachira, F.N., Wanyoko, J.K., & Ngure, R.M. (2007). Antioxidant capacity of different types of tea products. African Journal of Biotechnology, 6, 2287–2296.
[13] Kerio L C,Wachira FN ,Wanyoko JK , Rotich MK, Characterization of anthocyanins in Kenyan teas: Extraction and identification, Food Chemistry 131 (2012) 31–38.
[14] Kilel EC, Faraj AK, Wanyoko JK, et al. Green tea from purple leaf coloured tea clones in Kenya- their quality characteristics. Food Chem. 2013; 41: 769.
[15] Kimat RKi, Karanja B, Karanja R, Adoption of Purple Tea Farming as a coping mechanism to Climate Change, Kericho County, Kenya, IJSR, Vol. 5, Issue -6, 2016.
[16] Kong, J.M., Chia, L.S., Goh, N.K., Chia, T.F., & Brouillard, R. (2003). Analysis and biological activities of anthocyanins. A review. Phytochemistry, 64, 923–933.
[17] Lelgo, S.K., Kamunya, S.M., Ochanda, S.O. and Wanyoko, J.K. (2011) The Effect of Processing Technique on Biochemical Composition of Adapted Kenyan and Introduced Japanese and Chinese Tea Germplasm. Tea Journal, 32, 22-23.
[18] Lee, S., Park, S., Park, J.H., Shin, D.Y., Kim, G.Y., Rya, C.H., et al. (2009). Induction of apoptosis in Human leukaemia U937 cells by anthocyanins through down regulation of Bcl-2 and activation of caspases. International Journal of Oncology, 34, 1077–1083.
[19] Lo, C., Huang, H., Lin, H., Chien, C., & Wang, C. (2007). Effect of Hibiscus anthocyanin rich extract induces apoptosis of proliferating smooth muscle cell via activation of P38 MAPK and p53 pathway. Molecular Nutrition and Food Research, 51, 1452–1460.
[20] Merzlyak, M.N., Chivkunova, O.B., Solovchenko, A.E., & Naqvi, R. (2008). Light absorption in juvenille stressed and senescing leaves. Journal of Experimental Botany, 59, 3093–3911.
[21] Monks, A. (2000) Market Alternatives for Japanese Green Tea: A Report for the Rural Industries Research and Development Corporation. RIRDC.
[22] Oryza, Purple tea extract, Oryza Oil & Fat Chemical Co. Ltd. Ver. 1.0 SJ zc Purple Tea : Delicious and has more antioxidants than black or green tea; https://purposetea.com/about-purple-tea/Purple Tea ; http://purpleteaexperience.com/history-of-purple-tea/
[23] Rizvi, I.S., Zaid, M.A., Anis, R., & Mishra, N. (2005). Protective role of tea catechins against oxidation-induced damage of type 2 diabetic erythrocytes. Clinical and Experimental Pharmacology and Physiology, 32, 70–75.
[24] Rashid K, Wachira FN, Ngure RM, Nyabuga JN, Wanyonyi B, Murilla G and Isaac AO(2014). Kenyan purple tea anthocyanins ability to cross the blood brain barrier reinforcing brain antioxidant capacity in mice; African Crop Science Journal, Vol. 22, pp 819-828.
[25] Rivero-Perez, M.D., Muniz, P., & Gonzalez-Sanjos, M.L. (2008). Contribution of anthocyanin fraction to the antioxidant properties of wine. Food and Chemical Toxicology, 46, 2815–2822.
[26] Rogers PJ, Smith JE, Heatherley SV, Pleydell-Pearce CW: Time for tea: mood, blood pressure and cognitive performance effects of caffeine and the anine administered alone and together. Psychopharmacology 2008, 195: 569-577.
[27] Shimoda H, Hitoe H, Nakamura S, Matsuda H, "Purple Tea and its Extract Suppress Diet-induced Fat Accumulation in Mice and Human Subjects by Inhibiting Fat Absorption and Enhancing Hepatic Carnitine Palmitoyltransferase Expression", Int J Biomed Sci. vol. 11 no. 2 June 2015.
[28] Shimoda H, Tanaka J, Kikuchi M, et al. Effect of polyphenol-rich extract from walnut on diet-induced hypertriglyceridemia in mice via enhancement of fatty acid oxidation in the liver. J. Agric. Food Chem. 2009; 57: 1786.
[29] Simon O. Ochanda, John K. Wanyoko, Henrik K. Ruto, Effect of Spices on Consumer Acceptability of Purple Tea (Camellia sinensis), Food and Nutrition Sciences, 2015, 6, 703-711.
[30] Sun B, Zhu Z, Cao P, Chen H,Chen C, Zhou X, Mao Y, Lei J, Jiang Y, Meng W, Wang Y & Liu S 'Purple foliage coloration in tea (Camellia sinensis L.) arises from activation of the R2R3-MYB transcription factor CsAN1'. www.nature.com/scientificreports 2016.

[31] Tea Industry: The Future is Purple; Agriculture, Fisheries and Food Authority (AFFA 7) Kenya; Issue No. 3; Oct- Dec., 2015.
[32] Viskelis, P., Rubiskiene, M., Jasutiene, I., Sarkinas, A., Daubaras, R., & Cesoniene, L. (2009). Anthocyanins, antioxidative and antimicrobial properties of American Cranberry (Vaccinium macrocarpon Ait) and their press cakes. Journal of Food Science, 74, 157–161.
[33] Yagi K, Goto K, Nanjo F. Identification of a major polyphenol and polyphenolic composition in leaves of Camellia irrawadiensis. Chem. Pharm. Bull. 2009; 57: 1284.
[34] Yamamoto T, Juneja LR, Chu DC, Kim M, (Eds): Chemistry and Application of Green Tea, CRC Press, New York; 1998.
[35] Yilmaz, Y. (2006) Novel Uses of Catechins in Foods. Trends in Food Science Technology, 17, 64-71.
[36] Wachira, F. N., & Kamunya, S. (2005). Kenyan teas are rich in antioxidants. Tea, 26, 81–89.

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