4th International Conference Eco-Innovation in Science, Engineering, and Technology
Volume 2023
http://dx.doi.org/10.11594/nstp.2023.3617

NST Proceedings
OPEN ACCESS

Conference Paper

Black Tea: A Comprehensive Review

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ABSTRACT

Tea is one of the most popular refreshing drinks due to its strong and delicious flavor, it is also known to have many health benefits. Tea comes from the tops (shoots) of the leaves of the *Camellia sinensis* plant which are processed and then dried. Black tea is the most widely produced tea in Indonesia, which is about 78% of the total tea production. Black tea can be divided into two categories based on the process, namely orthodox and CTC black tea, which are known to contain many chemical compounds that are good for the body. The content of chemical compounds in tea is generally contained in its leaves which are classified into four major groups, namely phenol groups, non-phenol groups, aromatic compound groups, and enzymes. The content of chemical compounds present in tea will form the physical characteristics of tea, namely appearance, liquor, and infused leaf. Many research found that black tea could reducing the accumulation of dental plaque, preventing obesity, preventing cardiovascular disease, as an antibacterial and anticancer, and preventing osteoporosis. The compound epigallocatechin gallate which is the main component in tea has been shown to have insulin-potentiating activity. In addition, theaflavin compound in tea is also known to inhibit the entry of HIV-1 in the body.

Keywords: Black tea, characteristics, benefits, functional properties, review

Introduction

Tea is one of the most popular revitalizing beverages in the world due to its strong and delicious flavor, as well as its many health benefits. Tea is made from the leafy peaks of the Camellia sinensis plant. The annual production and consumption of tea is known to be as much as three billion kilograms which is divided into three types of tea, namely black tea which is commonly consumed in western countries, green tea which is commonly consumed in Asia, and oolong tea which is produced by a partial enzymatic oxidation process, mainly in Southern China (Hayat et al., 2015).

Tea is a popular beverage in the world because of its flavor, aroma, and health benefits (Mondal & De, 2018). Camellia sinensis is a plant that can grow and is widely distributed in several regions of Indonesia, such as West Sumatra, South Sumatra, North Sumatra, Bengkulu, Jambi, West Java, Central Java, Banten, East Java, and Yogyakarta. The potential of tea commodities has good prospects in Indonesia because the weather and climate are very suitable for tea cultivation (Directorate General of Plantations, 2021).

Black tea is the most widely produced tea in Indonesia. Around 78% of the total tea production, green tea at 20%, oolong tea and white tea at 2% (Robbani, 2019). Based on research by Nugraha et al. (2017), about 69.5% of more than the number of Indonesians choose to consume black tea because it has become a family habit. In the process of making black tea, tea leaf shoots will be subjected to grinding, enzymatic oxidation or fermentation, and drying, so that the colour of the tea powder becomes blackish brown and produces a distinctive taste and aroma.

How to cite:
Sanjaya, Y. A., Apriliani, A. P., & Rohmah, M. N. (2023 Black Tea: A Comprehensive Review. *4th International Conference Eco-Innovation in Science, Engineering, and Technology*. NST Proceedings. pages 109-117. doi: 10.11594/ nstp.2023.3617

Black tea

According to Rohdiana (2015), there are several types of tea based on the processing method, one of which is black tea which is the most widely produced tea with a complicated processing process. Black tea can be divided into two categories based on the process, namely orthodox black tea and CTC (crushing, tearing, curling) black tea. Orthodox black tea is a black tea that goes through a 14-18 hours withering process. The withered tea leaves will then go through a rolling, crushing, and oxidation process for about an hour. CTC black tea is a black tea that undergoes a shorter withering process of 8-11 hours followed by a grinding procedure that aims to extract as much cellular liquid as possible. The milled tea leaves will then enter the drying process, which aims to stop the oxidation process and reduce the moisture content. Afterward, the dried tea is sorted and graded to produce various grades of tea.

According to Tanui et al. (2012), CTC black tea is one of the most widely produced black teas, accounting for 65% of global black tea production. The process of making CTC black tea is also different from other types of tea, in CTC black tea the tea leaves will undergo a scouring process and then will be twisted so that it will make the shape of the tea curling. The core process or stage of CTC black tea production is during milling which uses machines such as rotorvane and CTC roll. This grinding stage can be divided into three to four times (starting from the rotorvane to three CTC machines) which aims to reduce the particle size of tea leaves (Zhang et al., 2018).

According to Panda et al. (2017), the processing of orthodox black tea is done manually by rolling the leaves by hand or using a machine that mimics rolling by hand. Orthodox tea is known to be of higher quality with a milder flavor and can be reused in several infusions when compared to CTC black tea. According to Aulia et al. (2022), the production process of orthodox black tea starts with the process of exposing or flattening the wet shoots on the Withering Trough to continue withering the wet shoots until the wet shoots have decreased in moisture content to 55-60%. In the grinding section, the withered shoots are crushed to remove the remaining liquid still contained in the leaves. After that, the rolled shoots are chopped to reduce the size of the shoots into wet powder which is divided into 4 grades. The wet powder will then undergo enzymatic oxidation, this process is known to take approximately 1 to 2 hours depending on the type of powder. The wet tea powder is dried in the drying room and then proceeds to the sorting process. The sorting process is the process of separating the dried tea powder according to its type, then proceeding with the packing and storage process so that the quality of black tea powder can be maintained.

Appearance

CTC black tea grades have different particle sizes according to the type of grade. The largest particle sizes of black tea are Broken Pekoe 1, Pekoe Fanning 1, Fanning, Pekoe Dust, Dust 1, and Dust 2. Each type of quality has a different color, size, and shape. According to Anggraini (2018), the type of quality BP (Broken Pekoe) consists of tea leaf particles that are short, and straight, have stalks and young leaf bones that are not peeled off, and have a blackish color.PF (Pekoe Fanning) consists of tea leaf particles that are short, black in color, slightly curly, and have a larger size than Fann. Fann (Fanning) consists of tea leaf particles that are short, black in color, small in size, and flat in shape. Dust 1 consists of small, granular, black-colored tea leaf particles. Dust II consists of tea leaf particles that are very small, contain a lot of fiber, and have a reddish color. BM (Broken Mixed) consists of tea leaf particles that are a mixture of two or more broken grades and contain a lot of fiber.

According to Kunarto (2005), there are several orthodox black tea qualities, including Broken Orange Pekoe A (BOP A), Broken Orange Pekoe (BOP), Broken Orange Pekoe Fannings (BOP F), Pekoe Fannings (PF), Pekoe Fannings II (PF II), Dust, Dust II, Dust III, Bohea, and Kawul. Broken Orange Pekoe A (BOP A) is known to be pitch black and contains many tea shoots with perfectly rolled, curly, pedicled, and small shoots. Broken Orange Pekoe (BOP) is known to have a less black color and less shoot content when compared to BOP A grade, while Broken Orange Pekoe Fannings (BOP F) has a smaller particle

size compared to BOP A grade. Another grade, Pekoe Fannings (PF) is known to have black tea powder with a curly shape, while Pekoe Fannings II (PF II) has a reddish color with the same particle size as PF grade. Dust quality is known to be black with a smaller particle size (like dust), while the difference in appearance between Dust II and Dust III tea quality is in the color of the powder, where Dust II is reddish while Dust III is grey. Bohea quality tea powder is known to have a yellow to brownish color while Kawul quality can be seen from the yellowish-brown tea powder with small unrolled leaves.

Liquor

The color, taste, and aroma of black tea brewing are influenced by various chemical compounds present in black tea, namely flavonoids, catechins, theaflavins, and thearubigins. In addition, the color, taste, and aroma of steeping tea are also influenced by the fermentation process (enzymatic oxidation) in black tea processing. Flavonoids in tea will give a yellow-brown color to the tea brew and will turn dark brown if further oxidation occurs (Lagawa et al., 2020). The astringent and bitter flavor in tea is due to the presence of catechin compounds in tea (Anjarsari, 2016). The higher the catechin content in black tea, the more astringent and bitter the flavor of black tea will be. The aroma of black tea has a normal aroma, not smoky, or burnt. The aroma of black tea brewing is influenced by compounds consisting of volatile and reducible essential oils (Rohdiana, 1999). Theaflavin and thearubigin greatly affect the quality of tea. This is because theaflavin influences astringency, brightness, and briskness. Thearubigin will provide color, strength, and mouthfeel (Sud & Baru, 2000).

These various chemical compounds are caused by the fermentation process or enzymatic oxidation in the black tea processing process by utilizing the enzyme polyphenol oxidase. The polyphenol oxidase enzyme with the help of oxygen in the air will make polyphenolic compounds contained in tea oxidized to orthoquinone (Widyawati et al., 2018). This causes condensation that forms black tea pigments, namely teaflavin and thearubigin, which have less active hydroxyl groups which will result in reduced polyphenol content in black tea (Martinus et al., 2015).

Infused leaf

According to the Indonesian National Standards Agency (BSN), the quality assessment of black tea dregs is seen from the color and evenness of the dregs produced after black tea is brewed. According to ISO 9001:2008, the appearance of good black tea steeping dregs is tea dregs that have a very bright and coppery color.

Nutrition content

The content of chemical compounds in tea is generally contained in the leaves. Therefore, tea processing with good quality is also obtained based on the quality of the processed tea leaves. The chemical composition of tea leaves is classified into four major groups, namely phenol groups, non-phenol groups, aromatic compound groups, and enzymes (Juniaty, 2013).

Phenol

Phenol compounds are one of the sources of antioxidants found in tea. There are two groups of phenols found in tea leaves, namely catechin and flavanol compounds. Catechins are known as the largest substance that contains phenol compounds (Juniaty, 2013).

Catechins

Catechins are chemical compounds that belong to the flavonoid class. Catechins have antioxidant properties because there are two phenol groups and one dihydropyran group. This compound is also often called polyphenol because it has more than one phenol group in its structure. Catechins in tea

leaves are arranged as catechin compounds (C), epicatechin (EC), epicatechin gallate (ECG), epigalocatechin (EGC), epigalocatechin gallate (EGCG), and galocatechin (GC) (Widyaningrum, 2013). In the process of enzymatic oxidation, catechins will break down into theaflavins and thearubigins. Catechins in fresh tea leaves range from 13.5-31% Catechin compounds are the most important compounds in tea leaves that function as antioxidants. In addition, catechin compounds also play a role in determining the properties of tea products such as taste, color, and aroma (Juniaty, 2013).

Flavanols

Flavanols in tea leaves include kaemferol, quercetin, and mirisetin compounds with a content of 3-4% of dry weight (Wiyarti, 2013). About 2-3% of water-soluble tea is a flavonol compound. There are about 14 glycosides of mirisetin, quercetin, and kaemferol in fresh tea, green tea, and black tea (Ma'rifah, 2020).

Non-phenols

All non-phenol substances in tea leaves enrich the tea content and give the tea its unique flavor (Ma'rifah, 2020). There are nine types of non-phenol groups present in tea leaves. The content of non-phenols in tea leaves, namely carbohydrates, pectin, alkaloids, proteins and amino acids, chlorophyll, organic acids, resins, vitamins, and minerals (Juniaty, 2013).

Carbohydrates

Carbohydrates play a role in its reaction with amino acids and catechins in tea processing. The reaction of carbohydrates with other compounds in tea will form aldehyde compounds that give the aroma of caramel, flowers, honey, and so on at high temperatures (Wiyarti, 2013). Fresh tea leaves contain carbohydrates of 3-5% of the dry weight of tea leaves (Juniaty, 2013). Carbohydrates contained in tea leaves range from simple to complex sugars (Rossi & Maria, 2010). Carbohydrates in tea include cellulose, polysaccharides, oligosaccharides, glucose, and fructose (Ma'rifah, 2020).

Pectin

Pectic acid will form a gel that serves to maintain the shape of the tea leaf roll after grinding and control the enzymatic oxidation process. Pectin contained in tea leaves ranges from 4.9-7.6% of the dry weight of the leaves consisting of pectin and pectic acid. Pectin mainly consists of pectin and pectic acid with contents ranging from 4.9-7.6% of leaf dry weight. Pectin will break down into pectic acid and methyl alcohol during tea processing, some of the methyl alcohol will evaporate into the air and some will react with organic acids into esters that play a role in composing the aroma (Juniaty, 2013).

Alkaloids

The main alkaloid in tea leaves is caffeine. Alkaloid compounds in tea leaves contain about 3-4% of the dry weight of tea leaves. Alkaloid compounds in tea leaves include caffeine, theobromine, and theopholine compounds (Juniaty, 2013). Caffeine compounds will react with catechins and form compounds that determine the freshness (briskness) of tea brewing (Rossi & Maria, 2010). Alkaloids can be retained in tea products until the final processing stage during storage (Ma'rifah, 2020).

Proteins and amino acids

Proteins will break down into amino acids in the withering process, then amino acids together with carbohydrates and catechins form aromatic compounds in the form of hydrocarbons, alcohols, aldehydes, ketones, and esters. The protein component in tea leaves plays a role in the formation of aroma

in black tea. Some amino acids that play a role in the formation of aromatic compounds include alanine, phenylalanine, valine, leucine, and isoleucine. The content of protein and free amino acids in tea leaves ranges from 1.4-5% of the dry weight of tea leaves (Juniaty, 2013).

Chlorophyll and other colors

Green chlorophyll breaks down into pheophytin, which is black and forms the color of black tea in the process of enzymatic oxidation. In addition, some carotenoid dyes will be oxidized into volatile substances consisting of unsaturated aldehydes and ketones that play a role in the aroma of tea brewing, while other carotenoids will play a role in giving orange-yellow color (Juniaty, 2013). The dye content in tea leaves is about 0.019% of the dry weight of the leaves (Rossi & Maria, 2010).

Organic acids

Organic acids will react with methyl alcohol to form ester compounds that have a distinctive aroma in the tea processing process. Some types of organic acids contained in tea leaves include malic acid, citric acid, succinic acid, and oxalic acid. The content of organic acids in tea leaves ranges from 0.5-2% of the dry weight of tea (Juniaty, 2013).

Resin

Resin is a carbon chain polymer compound with a content of about 3% of the dry weight of tea leaves. Resins in tea processing will contribute to the aroma of tea. The aroma of tea will greatly affect the quality of the tea produced (Juniaty, 2013).

Vitamins

Tea also has various vitamin contents in it. Some types of vitamins in tea leaves include vitamins A, B1, B2, B3, B5, C, E, and K. Vitamins are very sensitive to enzymatic oxidation processes and high temperatures. Therefore, the vitamin content in green tea is higher than in black tea (Juniaty, 2013).

Minerals

Tea has various mineral contents in it. Some types of minerals contained in tea leaves include K, Na, Mg, Ca, F, Zn, Mn, Cu, and Se. The mineral content in tea ranges from 4-5% of the dry weight of tea leaves. The highest mineral contained is mineral F (Juniaty, 2013).

Aromatic compounds

The aroma found in tea is related to the aromatic substances naturally contained in tea as well as those formed as a result of biochemical reactions in the tea processing process. Aromatic substances contained in tea are volatile compounds. The aromatic compounds naturally contained in tea include linalool, linalool oxide, pfhenuetanol, geraniol, benzyl alcohol, methyl salicylate, n-hexanal, and cis-3-hexenol (Lee et al., 2013).

Enzymes

Several enzymes are present in tea leaves, including the enzymes invertase, amylase, β-glucosidase, oxymethylase, protease, and peroxidase (Nisa' et al., 2021). These enzymes act as biocatalysts in every biochemical reaction that occurs during tea processing. One of the important enzymes in the tea processing process is the enzyme polyphenol oxidase which will initiate the oxidation reaction of catechins in the enzymatic oxidation process. Polyphenol enzymes are stored in the cytoplasm, while catechins

are contained in the vacuole. Cells will be destroyed in the grinding process so that catechins can come out and meet with polyphenol enzymes. Polyphenol oxidase activity is greatest in young tea leaves. Other enzymes contained in tea leaves that determine the specific properties of black tea are pectase and chlorophyllase enzymes. Pectase enzymes play an active role in pectin alteration reactions, while chlorophyllase enzymes play an important role in the biochemical changes of chlorophyll during enzymatic oxidation reactions (Rossi & Maria, 2010).

Benefits

Tea is known to have many benefits for the body, in addition to refreshing tea is also known to restore body health without causing negative impacts on the body. The content of bioactive compounds in tea is known to be the basis for the many benefits contained in tea. Bioactive components that are widely contained in tea are polyphenols which can be divided into two major groups, namely flavonoids and phenolic acids (Sudaryat et al., 2015). Polyphenol compounds are one type of compound that can provide hydroxyl atoms to free radicals. Polyphenolic compounds are known to contain aromatic rings with one or more hydroxyl (OH) groups which cause these compounds to be polar. The term polyphenol itself refers to phenol compounds with several hydroxyl groups (Baihakki et al., 2015). Phenol compounds are one type of antioxidant that is known to be found in many plants. The content of phenol compounds is known as a free radical destroyer and is positively related to antioxidant activity (Febriana et al., 2019).

Table 1. Benefits of black tea for the body

Benefits	Result	References
Reduces the build-up of dental plaque	From this study, it was found that gargling using black tea brewed water was effective in preventing plaque formation on teeth	Halid et al., 2021
Prevent obesity	Black tea brew juice is known to prevent the process of cell division and can convert preadipocyte tissue into adipocytes to avoid an increase in fat mass that can cause obesity.	Susanto et al., 2014
Antibacterial	The content of theaflavins in black tea can inhibit the growth of *Streptococcus mutans* bacteria	Chen et al., 2019
	Black tea extract and ethanol were shown to reduce the number of *Pseudomonas aeruginosa* bacteria within 24 hours and reduce bacterial resistance.	Flayyih et al., 2013
Anticancer	Apoptotic cell death was found in HT-29 (human colon carcinoma cells) after 72 hours of incubation with repeated administration of black tea extract. Black tea extract is also known to induce DNA strand breaks and DNA oxidative damage in HT-29 (human colon carcinoma cells) and MCF-7 (human breast carcinoma cells) carcinoma cells.	Koňariková et al., 2015
Prevent cardiovascular diseases	Theaflavin extract obtained from black tea can significantly reduce the aortic wall thickness of Wistar rats fed with atherogenic diet.	Krisna et al., 2015

	Regular, long-term consumption of black tea can result in significantly lower blood pressure in individuals with normal to high blood pressure.	Hodgson et al., 2012
Prevent osteoporosis	Black tea extract and thearubigin are known to increase bone strength and thickness. In addition, black tea extract and thearubigin are also known to inhibit osteoclastogenesis.	Liang et al., 2018

Functional Properties

Catechins are one of the compound components contained in black tea and belong to the category of secondary metabolites. Secondary metabolites are compound components that are produced or synthesized by certain cells and taxonomic groups when facing certain levels of growth or pressure. These compounds are known to have more complex structures and are difficult to synthesize. Secondary metabolite compounds are also rarely found in the market because only about 15% of these compounds are successfully isolated, so they have high economic value and are expensive (Anjarsari, 2016). Catechins that belong to the tannin compound class are known to have an impact on the level of 'astringency' and bitter or astringent taste. There are several catechin compounds contained in tea, such as epicatechin (EC), epigalocatechin (EGC), epicatechin gallate (ECG), and epigalocatechin gallate (EGCG). Epicatechin (EC) and epigalocatechin (EGC) give a slightly bitter taste with a touch of sweetness after drinking, while their gallate forms (ECG and EGCG) give a very bitter taste with strong 'astringency' properties (Martono & Setiyono, 2014).

Research conducted by Anderson and Polansky (2002) proved that one of the catechin components, epigallocatechin gallate (EGCG) found in black tea can increase insulin activity. In addition, other components in tea such as epicatechin gallate (ECG), tannins, and theaflavins have also been shown to increase insulin activity. This study also stated that caffeine had no significant effect on increasing insulin activity, which has previously been shown to increase blood glucose without relying on insulin. Both caffeinated tea and decaffeinated tea have the same effect in increasing insulin activity.

Theaflavins are one of the compounds also contained in black tea and are formed through the oxidation of certain catechins, such as epicatechin and epigallocatechin-3-gallate, with the help of polyphenol oxidase and peroxidase enzymes. During the fermentation process, catechins change into various types of TFs, which mainly include theaflavin (TF1), theaflavin-3-gallate (TF2A), theaflavin-3’-gallate (TF2B), theaflavin-3,3’-digallate (TF3), and certain arubigin polymers (Shan et al., 2021). Based on research conducted by Liu et al. (2005), it was found that these theaflavin compounds can prevent HIV-1 virus entry into target cells by blocking membrane fusion induced by HIV-1 envelope glycoproteins. These results demonstrate the potential of using tea, particularly black tea, as a source of anti-HIV agents, and derived compounds such as TF3 can be further used as candidates for the development of HIV-1 entry inhibitors targeting gp41.

Conclusion

The appearance of good black tea is black, granular, and does not contain much fiber. Black tea liquor will produce a distinctive tea color, taste, and aroma that is influenced by various chemical compounds present in black tea, namely flavonoids, catechins, theaflavins, and thearubigins. Good black tea-infused leaf has a very bright and coppery color. The chemical composition in tea leaves is classified into four major groups, namely phenol groups, non-phenol groups, aromatic compound groups, and enzymes. According to some studies, black tea has benefits for reducing dental plaque

build-up, preventing obesity, preventing cardiovascular disease, and as an antibacterial, and anticancer. Epigallocatechin gallate is a major component present in tea and tea has been shown to have insulin-potentiating activity. Epigallocatechin gallate is a major component present in tea and tea has been shown to have insulin-potentiating activity.

Acknowledgment

This work was financially supported by the Department of Food Technology, Faculty of Engineering, Universitas Pembangunan Nasional "Veteran" Jawa Timur, Surabaya, Indonesia.

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