Suryoprabowo S, et al., J Food Sci Nutr 2024, 10: 180
DOI: 10.24966/FSN-1076/100180

HSOA Journal of Food Science and Nutrition

Review Article

Black Tea Manufacturing Process, Health Benefit, and Application in Food Industry: A Review

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Abstract

Tea (*Camellia sinensis*) is one of the most consumed beverages with its long history and was first consumed in China. People in ancient East Asia ate tea for centuries, perhaps even millennia, before ever consuming it as beverage. Based on the processing method, tea could be classified into six types, post-fermented (dark) tea, black tea, green tea, yellow tea, oolong tea, and white tea. Tea is being diverse by their fermentation process. Black tea is the most consumed type of tea which is a fully fermented tea with malty, fruity, or smoky flavor depends on the region it grown and the manufacturing process. Manufacturing black tea can be differentiated into orthodox and non-orthodox method. Chemical components of black tea are mainly antioxidants which gives many health benefits. Health benefit of black tea is abundant which being associated with lower risk of diabetes type 2, helping focus and mental state, and reducing risk of several types of cancer. Antioxidants in the black tea is being used to several applications in food industry such as improving gluten network, beef meat tenderizer, food colorant, and suitable for making probiotic beverage.

Keywords: Antioxidant; Black tea; *Camellia sinensis*; Health benefit; Orthodox; Tea

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Citation: Suryoprabowo S, Laywith B, Zhongxing W, Hendriko A, Wenbin W (2024) Black Tea Manufacturing Process, Health Benefit, and Application in Food Industry: A Review. J Food Sci Nutr 10: 180.

Received: April 04, 2024; **Accepted:** April 17, 2024; **Published:** April 24, 2024

Introduction

The making of tea as beverage is from boiling tea leaves (*Camellia sinensis*). This definition is being the reference for this literature review due to there are tea that being made from boiling flower or mixed herbs which being called flower or herbal tea [1]. This beverage is already well known long ago, the source of this beverage is still a matter of debate however general consensus agree that is known to be from China. The oldest record would be from Chinese legends which Emperor Shen Nong (2737-2697 B.C.) or known as the Divine Healer decreed the water to be boiled before drinking with the purpose of preserving health for his subjects, accidentally some leaves fell into the pot and the color of the drink turn into brown color which then being drank. After that, the emperor discovers many health benefit in tea and taught people to drink tea [2,3].

From all around the world, Tea is known as one of the popular beverages which being consumed. Tea leaves have specific species known as *Camellia sinensis*. All types come from *Camellia sinensis* which have 2 popular subspecies consist of Assam (*Camellia sinensis*. var. *assamica*) and China (*Camellia sinensis* var. *sinensis*). Different varieties have their own distinguish characteristics. Although, all types of tea came from 1 source of plant, tea characteristics are being affected by many factors such as, temperature, soil, rainfall, ground level, and processing methods [4].

India, China, Kenya, and Sri Lanka are countries that mostly grown tea, it also being cultivated in other places such as Indonesia, Nepal, Taiwan, Japan, and South Korea [5]. Tea needs to be grown in a warm, humid climate, with rainfall measuring minimum of 100 centimeters a year, it typically suitable with light, deep, acidic, and well-rained soil. Tea needs to be grown in the area from sea level up to altitudes as high as 2,100 meters above the sea [6].

There are several types of tea which can be differentiated from their processing methods. It is known there are six types of tea consists of white tea, green tea, black tea, oolong tea, yellow tea, and *Pu-erh* tea. White and green tea are the teas that being unfermented. White tea only undergoes withering and drying process [7]. Green tea itself also have many types, the color, aroma, and taste will be differed depend on how they are being processed. In China, green tea is using panning method and then being rolled. Different in Japan, green tea leaves being sweated using steam and it being dried. Normally in Japan, green tea leaves would be chopped into tiny pieces and being ground turning the leaves to fine powder and being called *matcha*. *Matcha* is being a staple product in Japan and being consumed also in several tea ceremony [8].

Oolong tea is the type of tea that undergo semi-fermentation process. The semi-fermentation process means that the fermentation process being stopped early. This process will lead to producing tea with the combine taste and aroma of green tea and fermented black tea [9]. Yellow tea or known as huángchá is known to be lightly fermented tea in China. It has pleasant mellow taste and being similar to green tea, however in the production of yellow tea have reduce the oxidation

level and removing the characteristic of grassy smell by the process called "sealed yellowing" [10]. *Pu erh* tea is a type of tea that are being fermented by microbes. The process is using sun-dried green tea which will be fermented by microbes and then being compressed into many types of shape but the most common is the cake shape [11]. Black tea is one of the most popular types of tea, it is known as fermented tea. This tea is being made due to back in the days when tea was being heavily trade using ships, tea was losing its aroma and flavor. The solution was the tea leaves then being withered, bruised by rolling, and leave it in the air and allowing it to be fermented [12].

With many interests of tea industry everywhere, there are already numerous research about health benefit and chemical components of tea. However, the focus of this studies is green tea specifically, there are no review especially health benefit and the application of black tea in the food industry, due to this problem, and this review will focus on the black tea itself which will cover the definition, manufacture, chemical components, health benefits, and application in food industry.

Black Tea

Definition and Types

Black tea is one of the variety teas created from the *Camellia sinensis*. The difference between black tea and other types of tea such as white, yellow, green, oolong, and *Pu-erh* are black tea is completely oxidized and tend to have stronger flavor and aroma than other tea types. Black tea origins are still not being verified but it considered to be originated from China. Eastern society tend to drink green tea rather than black tea as the base tea of the culture today. Until the 17th century, the teas that are known and being consumed were green and oolong [2]. Black tea is believed and being discovered due to the Chinese fermenting tea leaves in order to extend the storage life of tea and that is also the reason why the Western tend to like black tea, due to black tea have longer shelf life, when being brought to the British it is still tasty rather than green tea. Most of the black tea that China produced is being exported [13].

Camellia sinensis is the type of the smaller-leafed variety from China that is usually being produced to make green and white teas. It is usually grown in the sunny regions that is drier, cooler climates and in mountain regions. *Camellia sinensis assamica* is the type which is the larger leafed type of the tea plant and it is typically being used to produce black tea. The name comes from its region in the Assam district of India, it is being grown in warm, moist, and sub-tropical forests. There are hundreds of species and hybrid plants that already evolved from *Camellia sinensis*, but any type of tea unless herbal or flower is come from *Camellia sinensis* plant [14].

Black tea uniqueness is that before heat-processed and dried, it is fully oxidized. When oxidation happen, the tea plants cell walls turn the leaves to dark brown or black color that makes the black tea leaves color. Oxidation changes the flavor and aroma depends on the tea, which make it usually more malty, fruity, or smoky [15,16]. Black tea itself have many types and usually the name depends on the region the tea is being produced. The flavor and aroma of the tea is unique and mainly dependent on the region they are being grown. Several popular black tea types known are Assam, Darjeeling, Ceylon, and Kenyan [17].

Manufacture

Manufacturing typically is using orthodox or non-orthodox [18]. Orthodox process (Figure 1) is more time-consuming method, tea leaves remain whole or only partially broken during processing. The orthodox process consists of withering, rolling, oxidation, drying, and grading. In the orthodox process, it begins with the fresh green leaves and buds were being plucked and being softened by withering. Racks of the tea leaves within a large, heated room, or withered in the open air by sunshine. Whitering process taking place in making biochemical reaction occurs where the starch in the leaf will begins to convert to sugar and to dry the leaves which reducing the moisture content by 50-80%. The result of withering process is the leaf will become soft and pliable that can be rolled without breaking it. The process of whitering needs about 10-24 hours depends on the type of the tea. Without withering process, tea leaves will produce unpleasant and bitter taste. The desired moisture content depends on the growing region of the tea and the characteristics of the tea [19,20]. After next process after whitering is the leaves being rolled by machine or by hand. The aim of the rolling step is to release sap and oxygen which stimulate a fermentation and will take about 2 hours.

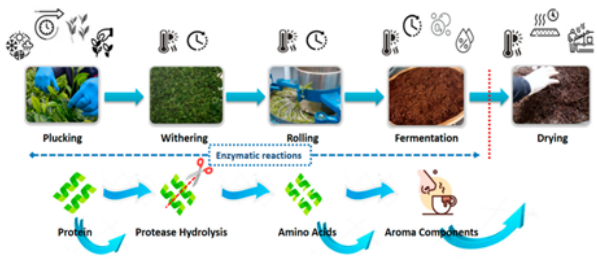

Figure 1: An overview of processing and preparation of orthodox tea [21].

Oxidation process is the most important processing procedure for tea due to in this stage the flavor and the value of the tea are being determined. The oxidation stage also separated the different categories of the tea. After the leaves being rolled then it's being placed on trays and spread it to a thickness of about 3-6 centimeters, then keep in the cool damp place for about 1-3 hours. Chemical reactions will happen in the leaf which will cause it to heat. In this process it is very crucial to stop the oxidation to obtain the best flavor. If the temperature is too high the leaves will have burned taste but if it is too low the leaves will have metallic aftertaste. Oxidation process will lead to changes in color, aroma, flavor of the tea [22,23].

The oxidizing will be stopped by exposing it to drying process which the leaves will be dried using hot air in a large dried on a conveyer belt, the temperature would be around 85-88ºC. The copper-colored leaves from the oxidation process will turn to dark brown or black. This process is also critical due to if the leaves have too many moistures, they could have mold but if the leaves dry out too much the tea will be flavorless or have burned taste [24,25]. The last step in orthodox process would be grading or sorting. The tea leaves that already being dried then would be separated based on the size of the tea leaves. The different categories consist of whole leaf, broken leaf, fannings, and dust. Whole leaf will produce loose leaf tea which considered to be the best quality of tea, while the fanning and dust are usually being used to make the quick brewing teas that often being saw in the tea bags [26].

Other tea processing is called unorthodox or also known as Crush, Tear, and Curl (CTC) which is the less time-consuming process which have cheap and uniform result, however have inferior quality. The process would be withering, cutting/tearing/curling, oxidizing, and drying at 130-190ºC. This method resulting in tea leaves in fine pieces and makes it easier to be oxidized. The tea that being produced by this process are usually being used in tea bags and it brew quickly for about 2-3 minutes. CTC market is very strong due to its cheap price and practicality [27,28]. The composition and percentage of each major component in the tea could be seen in table 1.

Compound	Concentration (% wt/wt Solids)
Catechin	9
Theaflavins	4
Simple polyphenols	3
Flavonols	1
Other polyphenols	23
Theanine	3
Amino acids	3
Proteins	6
Organic acids	2
Sugars	7
Other carbohydrates	4
Lipis	3
Caffeine	3
Other methylxanthines	<1
Potassium	5
Ash	5

Table 1: Chemical components of black tea [29].

Chemical Components

There are several major chemical components of black tea, it consists of amino acids, alkaloids, catechins, theaflavins, isomers of theaflavins, benzotropolone derivatives, and thearubigins [30].

Health Benefit

Tea have been one of drinks that seen as healthy drink even being regards as panacea when the Chinese kingdom still exist. This beverage has been consumed for many millenniums and there are no significant cases which have negative health impact. Numerous research has been done to explain health benefit of tea while it is still on progress to have concrete evidence by randomized control trials, the progress of the health benefit of tea is in positive light. Although, black tea consumption is the highest than any other type of tea (78%), there are more research about green tea rather than black tea including about health benefits [31]. There are association between drinking black tea and coffee with lower risk of type 2 diabetes [32]. Another research shown that there are significant association between consuming black and oolong teas with lower prevalence of cognitive impairment in Chinese adults. It is also known that drinking tea have mental relaxation effect [33,34].

Oral intake of L-theanine that is present in the black tea could cause anti-stress effects via the inhibition of cortical neuron excitation which will reducing psychological and physiological stress responses. It's shown that the activity of black tea and its polyphenols could inhibit tumor initiation and chemical carcinogens in mice [35]. Black tea chemical composition also contains theaflavin gallate have been researched that it can inhibit the formation of heterocyclic amines from cooked fish and meat which are genotoxic carcinogenic that have been associated with cancer of colon, breast, and pancreas [36,37]. Adults rinsing with black tea 10 times a day for 7 days have a significantly less pronounced pH fall result, lower plaque, and fewer *S. mutans* and total oral *Streptococci* in plaque. It is already being evident that black tea and the polyphenols it has also benefit human oral health [38]. Black tea polyphenols have been suggested inhibiting lipid and saccharide digestion, absorption and intake, promote lipid metabolism and block pathological processes of obesity and comorbidities that happen from obesity by reducing oxidative stress [39].

Application in Food Industry

There are quite many applications in food industry for black tea. The simplest and first application would be instant tea. Ready To Drink (RTD) of instant tea was made because of a high demand since it is practical and convenient and in addition using tea [40], there could be specific bacterial culture inoculation and the tea could be made into probiotic beverage using beneficial bacteria. There is other alternative to commercialized tea as a concentrated form. The concentrated form would have better quality and have many more bioactive compounds, but the concern would be preservation of the bioactive compounds [41]. Another application in food industry would be using tea waste for source of bioactive compounds and making it into food colorant [42].

Natural inhibitors of Polyphenol Oxidase (PPO) in the food industry have been replace from synthetic additives into tea. Tea have been successful to be used as an inhibitor of PPO in the pacific white shrimp This could happened maybe due to catechin which act as PPO competitive inhibitor due to similar structure of PPO substrate and catechin is the constitute of around 90% of the phenolic content in the tea [43]. Other food industry application would be catechins in the tea being used as a natural antimicrobial due to their ability to inhibit *Staphylococcus aureus* methicillin-resistant along with beta-lactams and also the growth of *Escherichia coli* and *Helicobacter pylori*. Depends on the dose and time of exposure of tea, catechin could inhibits the foodborne pathogens by reducing the antioxidant capacity [44,45].

Catechins also can used to increase of number of probiotics such as *Bifidobacteria* that is mainly used in the yogurt manufacture [46]. Other application is catechin is being made into a film which can preserve the quality of packed mushroom [47]. Other research has found that tea powder, soluble tea, and tea polyphenols were used to increase the dough strength of noodles which only been found that tea polyphenols is the best in develop a better gluten network and the most effective dough stabilizer [48].

Conclusion

Black tea is a type of tea that was being made with full oxidation process which can be differentiate in the processing method into orthodox and non-orthodox method. Black tea contains antioxidants and compounds that lead to many health benefit such as removing free radicals and decrease cell damages in the body, improving mental state and focus, inhibits tumor initiation and promotion, reducing risk of diabetes type 2 and many more. Other than its antioxidant effect in health benefit, there are also several in food industry such as producing RTD tea, food colorant, improving gluten network, beef meat tenderizer, and its antioxidant and antimicrobial activity is suitable for making edible coating.

Acknowledgement

The authors would like to thank Bina Nusantara University, Banten, Indonesia for providing access to the resources needed to prepare this review article.

Author Contributions

Steven Suryoprabowo: Resources, writing-review & editing.

Bryan Laywith: Conceptualization, investigation, and writing.

Albert Hendriko: Conceptualization.

Wang zhongxing: Editing and supervision.

Wang wenbin: Editing and investigation.

The authors have accepted responsibility for the entire content of this manuscript and approved its submission.

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