Deterioration of Tea Quality Caused by Tea White Scab Disease Disease

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Abstract

Tea is a popular daily beverage worldwide, especially in China. Tea white scab disease affects tea quality is poorly understood. In the current study, we aimed determine whether tea quality will variation. we collected green tea samples from five samples (with varying morbidity from CK to on Baiyun Mountain in Hunan Province. Results showed that tea quality are obviously decreased as infected by tea white scab disease . Results showed that an increase in incidence rate decreased total tea polyphenols (TP) , water extract and caffeine but increased amino acids (AA) , Nonetheless, the constituents of polyphenolic compounds were differentially altered. Additionally, the percentage of (−)-epicatechin (EC) and (−)-epicatechin-3-gallate (ECG) increased with increasing morbidity. (−)-epigallocatechin (EGC) and (−)-epigallocatechin-3-gallate(EGCG) just the opposite. The constituents of AA, especially Alanine, γ-aminobutyric acid, serine and phenylalanine increased with increasing elevational gradients. Proline, and theanine were reduce along with morbidity level. As a whole. This observation demands development of effective measures for sustaining green tea quality in the face of tea white scab disease.

1. Introduction

Tea, which made from the fresh leaves of tea plant (*Camellia sinensis*), is one of the mostly used daily beverage throughout the world, especially in China. It is estimated that more than 3 billion cups of tea are consumed every day (L. Chen & Zhou, 2005; Z. Chen, 1994). Tea also is associated with many physiological and pharmacological health benefits (Singh, Shankar, & Srivastava, 2011). Back to 2737 B.C., China is the earliest country for cultivation and utilization of tea plan, and South China are the main area (Hasimoto M, 1978; Yamanishi, 1995). As vital economic crop in South China,tea white scab could attach enough importance.

Tea white scab diseasse, which are important to susceptible tea cultivars are grown in humid areas, can cause tea leaves blemishes. This disease not only can reduce the quality of tea for the market, but also cause tea yield losses. Fungal pathogens *Elsinoe leucospila* are initiated when spores attach to host surfaces and germinate (Hématy, Cherk, & Somerville, 2009; Underwood, 2012;Zhou, et al., 2020). Then the spores breach external and internal barriers with altering host defence mechanisms and establish biotrophic interactions (Tucker & Talbot, 2001), and usually cause external blemishes, tea white scab disease. This organism can affects the leaves and twigs on many susceptible cultivars, such as lemons, grapefruit, and many tangerines (K. R. Chung, 2011; Paudyal, Hyun, & Hwang, 2017). For infecting tea leaves, there were no report in South China.

As health benefits drink, the basic components of tea like catechins, alkaloids, proteins and carbohydrate were potential health benefits (Banerjee & Chatterjee, 2015). At the same time, the function of the tea is also largely attributed to the abundant secondary metabolites (Hamiltonmiller, 2001; Lv, Zhu, et al., 2015). For example, flavonols, anthocyanins, saponin, and aroma precursors (Lv, Dai, et al., 2015; Wu, Xu, Héritier, & Andlauer, 2012). It is know that catechin, caffeine content and sensory attributes determines the quality of tea (Choung & Lee, 2011). Thus, evaluating variations in tea composition effect by Tea white scab disease is necessary.

2. Material And Methods

2.1 Sample Collection

From January 2015 to January 2019, Sampling was conducted from five levels with varying morbidity including CK (morbidity: 0), □ (morbidity: 11–40%), □ (morbidity: 41–50%), □ (morbidity: 51–80%), □ (morbidity: 81–100%),which were leaves of fuding white tea variety of 17 years With the same management from the cities of changde in Hunan in China.All the samples were split into two, one batch was Baked sample immediately and the other batch left to pan-fired for different durations.

2.2 Determination of sensory quality evaluation

According to the national standard (GB/T 23776 − 2009). the samples of pan-fired tea were put into 90℃ water with the proportion by tea and water is 1:50, appearance(a), aroma(b), Liquor color(c), taste(d) and Infused leaves(e). The scoring factors and coefficients are shown in Table 1.The total score of each factor is 100 points, Sensory evaluation = a×25%+b×10%+c×25%+d×30%+e×10%.

Table 1
Results of sensory quality evaluation on tea with white scab diseases

Level	Appearance		Aroma		Liquor color		Taste		Infused leaves		Total
CK	Tight, green, smooth	88	Clean and high aroma	90	Brilliant green	90	Sweet and mellow	90	Fat and tender	90	90
□	Tight, green, smooth	88	Clean and high, with little smell	88	Brilliant green, light yellow	89	Sweet and mellow, slight bitter	88	Fat and tender, little spots	88	88
□	Tight, yellowish green, smooth	88	Clean aroma, with smell	88	Brilliant green, deep yellow	89	Slight bitter	85	Fat and tender, clear spots	86	87
□	Coarse, yellowish green, flat and thin	85	Without aroma, with smell	86	Yellow green dull, deeply	88	Heavy bitter, astringency	80	Tender yellow, Spots	85	84
□	Coarse, yellowish green ,tea dust	80	Without aroma, with heavy smell	82	Yellow green, deeply	85	Heavy bitter, astringency	75	Tender yellow, Spotted densely	83	80
Note: CK (morbidity: 0), □ (morbidity: 11–40%), □ (morbidity: 41–50%), □ (morbidity: 51–80%), □ (morbidity: 81–100%)											

2.3 Determination of basic biochemical component test

We detected water extract of tea, free amino acids, caffeine, tea polyphenols, and flavonoids. Ethanol was used as a solvent to extract phenolic compounds from dried fresh tea samples. The extraction was performed at temperature of 40, 50, and 60℃ which was maintained using a water bath. Folin-Ciocalteu's reagent was used to detennine the total phenolic content spectrophotometrically and gallic acid was used as the calibrant(Komes, et al., 2010). Briefly, the diluted sample extract (1.0 ml) was transferred to tubes in duplicate, where each tube contained 5.0 ml of a 1/10 dilution of Folin–Ciocalteu's reagent in water.

2.4 Determination of catechin and monomer content

We carried out further phytochemical analysis to determine concentrations of individual catechins and free amino acid compounds from a sub-sample of tea samples. An HPLC method (GB/T 8313 – 2008) was used to quantify concen trations of catechins as described by (Wei, et al., 2011).The individual catechins we measured include: epigallocatechin-3-gallate (EGCG), epicatechin gallate (ECG), epigallocatechin (EGC) and epicatechin (EC).

2.5 Determination of Amino acids composition

An automatic amino acid analyzer (Hitachi L-8900, Japan) was used to measure individual amino acids including Proline, Alanine, Methionine, Tyrosine□β-alanine□Tryptophan□α-Aminobutyric acid□Arginine□Theanine□Glutamic acid□Phenylalanine□Phosphoserine□Taurine□Phosphoethanolamine□Urea□Aspartic acid□Threonine□Serine□Asparaginate□Glycine□Citrulline□Valine□Cystine□Isoleucine□Leucine□β-Aminoisobutyric acid□γ-Aminobutyric acid□Histidine□Ornithine□Lysine□α-Aminoadipicacid. Amino acids were measured by adding 5 ml of tea extract with 5 ml of sulfosalicylic acid and centrifuging the mixture at 13,000 rpm for 5 min to facilitate the reaction. The mixture was filtered through a 0.20-μm nylon filter membrane and run using the amino acid analyzer(Wang, et al., 2006).

3. Results

3.1 Effect of tea white scab disease on Sensory quality evaluation

Tea made from increasingly severe tea white scab disease infected tea leave recorded a markedly progressive decline in appearance, aroma), Liquor color, taste and Infused leaves (Table 1). Along with the increase of morbidity (from CK to □), the appearance were from tight, green, smooth to coarse, yellowish green, and tea dust were increased. The aroma also with heavy smell. For liquor color, the CK were brilliant green, but turn into deep yellow green. The taste were obvious difference which changed from sweet and mellow to heavy bitter. At last, we had found densest spots on leave □ tea infused leaves.

3.2 Effect of tea white scab disease on Basic biochemical component

As four conventional index, water extract, caffeine and tea polyphenols were markedly decreased when the tea quality change. Free amino acids and flavonoids were fluctuate (Table 2).

Table 2
Basic composition content of tea with white scab diseases (mg·g)

Level	Water extract	Free amino acids	Caffeine	Tea polyphenols	Flavonoids
CK	42.14 ± 5.51a	3.34 ± 0.87a	2.92 ± 1.23a	25.51 ± 4.09a	0.63 ± 0.06a
	40.56 ± 3.37a	3.27 ± 0.67a	2.25 ± 0.49a	24.83 ± 1.02a	1.23 ± 0.21b
	38.59 ± 3.44a	3.48 ± 0.59a	1.67 ± 0.47a	22.62 ± 2.66a	0.87 ± 0.06a
	37.62 ± 2.79a	3.72 ± 0.24a	1.49 ± 0.67a	21.99 ± 1.54a	1.30 ± 0.10b
	36.59 ± 1.67a	4.04 ± 0.43a	1.42 ± 0.65a	15.63 ± 1.05b	1.43 ± 0.12b
Letters mean significant level (P < 0.05); Minimum detectable: 0.01mg·g					

3.3 Effect of tea white scab disease on Catechin and monomer content

The variation of catechin and monomer content along with increase of tea morbidity (from CK to) were shown in Table 3. Catechin was the most important functional composition in tea. Obviously, it was on a declining curve, but some its monomer content (EC, ECG) were up.

Table 3
Catechin and monomer content of tea with white scab diseases (mg·g)

Level	Catechinic	EC	ECG	EGC	EGCG
CK	13.33 ± 0.32a	0.63 ± 0.35a	1.38 ± 0.34a	3.50 ± 0.24a	6.44 ± 1.70a
	12.93 ± 1.16a	0.73 ± 0.40a	1.48 ± 0.42a	3.07 ± 0.05ab	6.26 ± 0.94a
	11.87 ± 0.91a	0.86 ± 0.46a	1.62 ± 0.45a	2.65 ± 0.30bc	5.74 ± 1.19a
	11.63 ± 2.25a	1.11 ± 0.60a	1.74 ± 0.53a	2.61 ± 0.11bc	5.17 ± 1.50a
	10.80 ± 2.35a	1.69 ± 1.12a	1.90 ± 0.40a	2.12 ± 0.39c	3.59 ± 0.85a
(−)-epicatechin (EC), (−)-epigallocatechin (EGC), (−)-epicatechin-3-gallate (ECG),(−)-epigallocatechin-3-gallate(EGCG). Values are expressed as mg/g DW. Mean denoted by same letters are not significantly different according to Duncan's multiple range test (P < 0.05), Minimum detectable: 0.01mg·g					

3.4 Effect of tea white scab disease on amino acid composition

It is known that many amino acids on tea and some were important for human. Our study revaled most amino acids variation in samples (Table 4). Among those amino acid, proline and theanine were reduce along with morbidity level. Alanine, γ-aminobutyric acid, serine, and phenylalanine were increased with increasing elevational gradients. To our interesting, tryptophan, asparagine, glutamic acid, and glycine were

increased abruptly on level (morbidity: 51–80%). Some amino acids such as α-aminobutyric acid, cystine had not been found on the tea severe infected by *Elsinoe leucospila* (level ,). The other amino acids also have some changes.

Table 4
Amino acid composition content of tea with white scab diseases (mg·g)

Amino acid profile	CK				
Proline	0.021 ± 0.003a	0.020 ± 0.003a	0.005 ± 0.005b	0.000b	0.000b
Alanine	0.003 ± 0.003a	0.012 ± 0.011ab	0.014 ± 0.002ab	0.020 ± 0.004ab	0.022 ± 0.007b
Methionine	0.000a	0.001 ± 0.002a	0.008 ± 0.007ab	0.021 ± 0.013b	0.007 ± 0.002ab
Tyrosine	0.026 ± 0.009a	0.007 ± 0.006b	0.012 ± 0.001b	0.009 ± 0.001b	0.011 ± 0.002b
β-alanine	0.003 ± 0.005a	0.005 ± 0.009a	0.018 ± 0.007a	0.022 ± 0.002a	0.011 ± 0.007a
Tryptophan	0.102 ± 0.024a	0.081 ± 0.032ab	0.054 ± 0.009ab	0.066 ± 0.029ab	0.027 ± 0.015b
α-Aminobutyric acid	0.000a	0.005 ± 0.008a	0.009 ± 0.008a	0.000a	0.000a
Arginine	0.007 ± 0.005a	0.015 ± 0.014a	0.033 ± 0.003a	0.061 ± 0.043a	0.320 ± 3.791a
Theanine	1.334 ± 0.116a	1.030 ± 0.022a	1.017 ± 0.076a	0.796 ± 0.112a	0.527 ± 0.116a
Glutamic acid	0.222 ± 0.014a	0.193 ± 0.032a	0.165 ± 0.013a	0.298 ± 0.209a	0.194 ± 0.024a
Phenylalanine	0.006 ± 0.010a	0.000ab	0.001 ± 0.001ab	0.002 ± 0.001b	0.003 ± 0.001ab
Phosphoserine	0.009 ± 0.000a	0.011 ± 0.001a	0.010 ± 0.001a	0.028 ± 0.031a	0.012 ± 0.002a
Taurine	0.012 ± 0.002a	0.001 ± 0.000b	0.002 ± 0.002b	0.001 ± 0.001b	0.002 ± 0.001b
Phosphoethanolamine	0.027 ± 0.006a	0.029 ± 0.017a	0.010 ± 0.009a	0.010 ± 0.009a	0.013 ± 0.002a
Urea	0.250 ± 0.150a	0.061 ± 0.106a	0.204 ± 0.178a	0.259 ± 0.290a	0.249 ± 0.082a
Aspartic acid	0.143 ± 0.026a	0.110 ± 0.033a	0.09 ± 0.005a	0.172 ± 0.129a	0.028 ± 0.017a
Threonine	0.028 ± 0.008a	0.026 ± 0.011a	0.018 ± 0.004a	0.040 ± 0.034a	0.021 ± 0.002a
Serine	0.089 ± 0.027a	0.094 ± 0.050a	0.098 ± 0.017a	0.129 ± 0.141a	0147 ± 0.007a

Letters mean significant level ($P < 0.05$); Minimum detectable: 0.01mg·g

Amino acid profile	CK	□	□	□	□
Asparaginate	0.060 ± 0.026a	0.045 ± 0.037a	0.012 ± 0.004a	0.054 ± 0.077a	0.020 ± 0.019a
Glycine	0.005 ± 0.003a	0.005 ± 0.002a	0.007 ± 0.006a	0.002 ± 0.001a	0.001 ± 0.000a
Citrulline	0.000a	0.014 ± 0.024a	0.009 ± 0.011a	0.031 ± 0.016a	0.008 ± 0.007a
Valine	0.002 ± 0.002a	0.007 ± 0.046a	0.010 ± 0.007a	0.008 ± 0.011a	0.002 ± 0.001a
Cystine	0.039 ± 0.013a	0.039 ± 0.043a	0.000a	0.000a	0.000a
Isoleucine	0.022 ± 0.007a	0.022 ± 0.007a	0.015 ± 0.006a	0.018 ± 0.004a	0.006 ± 0.006a
Leucine	0.008 ± 0.002a	0.006 ± 0.001a	0.006 ± 0.002a	0.009 ± 0.006a	0.007 ± 0.005a
β-Aminoisobutyric acid	0.003 ± 0.002a	0.002 ± 0.001a	0.001 ± 0.002a	0.009 ± 0.002a	0.020 ± 0.022a
γ-Aminobutyric acid	0.009 ± 0.003a	0.020 ± 0.006a	0.021 ± 0.004a	0.039 ± 0.037a	0.036 ± 0.015a
Histidine	0.002a ± 0.001a	0.006 ± 0.002a	0.012 ± 0.001a	0.008 ± 0.007a	0.005 ± 0.002a
Ornithine	0.004 ± 0.002a	0.003 ± 0.001a	0.001 ± 0.001a	0.002 ± 0.001a	0.003 ± 0.005a
Lysine	0.026 ± 0.009a	0.017 ± 0.007a	0.012 ± 0.005a	0.073 ± 0.085a	0.018 ± 0.008a
α-Aminoadipicacid	0.000a	0.000a	0.004 ± 0.006a	0.020 ± 0.012a	0.033 ± 0.031a
Letters mean significant level (P < 0.05); Minimum detectable: 0.01mg·g					

4. Discussion

Tea is a significant aquaculture species in China (Y. F. Li, et al., 2017). Tea white scab disease were found to occur at varying levels in tea. Consumer acceptability of tea greatly depends upon its sensory quality evaluation. Tea quality depends upon spatiotemporal variability of geographical origin, manufacturing process, which in turn highly influence the chemical composition, and which are very critical in determining its quality. On the other hand, sensory quality evaluation factors like color, appearance, flavor and taste also determines its commercial value (Bhattacharyya, et al., 2012; Bhondekar, et al., 2010). Qin et al (2017) compared the difference on sensory quality evaluation by human panel test and spectroscopy system, and revealed the variation on tea from different areas and variety. As shown in Table 1, tea white scab seases can strongly effect on the tea in sensory quality evaluation. The characteristic of high quality tea (CK) were

green, smooth appearance; clean, high aroma; sweet, mellow taste, and fat, tender infused leaves. but the diseased one were quite another thing. Sensory quality evaluation, as first tea standard of National Food Safety Standards of China, is important for appraisaling tea quality. The effect of Tea white scab disease could be paied attention to.

Aqueous extract, caffeine, tea polyphenols, and flavonoids were the significant component in tea (P. Li, Wang, Ma, & Zhang, 2005). The tea polyphenols content in tea are about 28.4%, and be proved the more and more important functions, such as antimutagenic activity, antioxidant activity, depressor effect on renal hypertension, inhibitory effect on lipid peroxidation, and inhibitory effect on arteriosclerosis (L. Chen & Zhou, 2005; Z. Chen, 1989; Yamamoto, Juneja, Chu, & Kim, 1997). Caffeine makes a significant contribution to the briskness and creaming properties of tea brew, Its average content was about 4.2%. When on the low-caffeine tea, it will lose special tea aroma and taste (L. Chen & Zhou, 2005; Willson & Clifford, 1992). Flavonoids are the main regulators of plant growth and defense, and also contribute to the color, taste and aroma of tea (Jay-Allemand, Tattini, & Gould, 2015; Q, M, & J, 2017). Our result show caffeine, tea polyphenols and water extract were dramatic decline. It is agree with the previous report about the tea influence by Tea white scab disease (Zhou, Deng, & Deng, 2007). We believe that Tea white scab disease in tea can damage basic biochemical component on tea.

Tea polyphenols are mainly composed of five catechins and their derivatives. Epigallocatechin gallate (EGCG) is the largest portion, next epigallocatechin (EGC), epicatechin gallate (ECG), epicatechin (EC), gallocatechin (GC), respectively(L. Chen & Zhou, 2005). As a marker for superior quality in tea, catechins index is very important(Magoma, Wachira, Obanda, Imbuga, & Agong, 2000). Fan et al (2016) show difference thermal processing can cause variation in tea catechins. Our study also uncover the tea catechins content change along with tea white scab disease .Tea contain high levels of amino acids, the profile of which beneficial health effects have also been proposed (Bryan, 2008). Good quality teas require high concentrations of amino acids principally contributing to mellowness and freshness, and an optimum ratio of amino acids for a balance of astringent to mellow tastes (Wang, Cheng, Yuchen, & Liu, 1988). It consistent with our results that many amino acids varied along with the increase of morbidity (from CK to □).

In conclusion, the present study showed the new pathogen (*Elsinoe leucospila*) of Tea white scab disease in tea from south China and comprehensive analysis the tea quality along with the increase of morbidity (from CK to □). In our study, sensory quality evaluation, basic biochemical component, catechin and monomer content and amino acid composition of tea are obvious change after infected by tea white scab disease. Thus, the result will give advice to farm operators to understand and control Tea white scab disease in tea.

Declarations

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Compliance with ethical standards

Conflicts of interest All authors declare no conflicts of interest.

Compliance with ethics requirements This article does not contain any studies with human or animal subjects.

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