Morphological Classification of Tea Clones (Camellia sinensis, Theaceae) at the Mount Lawu Forest, East Java, Indonesia

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Abstract. This study aims to find out the morphological classification of tea clones and its utilization, which is established close to mount Lawu forest, East Java. One tea plantation managed by PT Candi Loka (Jamus tea plantation) was selected. It has an area of 478.20 hectares and improve the quality and productivity of tea by planting tea clones. Identification and determination based on morphological characteristics of tea clones and interviews were carried out in 2016-2018. Seven tea clones were recorded according to leaf thickness and length, lifespan and fine hairs on the tea buds. Those are Asamica, Yabokita, Chin, GMB 3, GMB 7, TRI 2024, and TRI 2025. Asamica is the oldest clone since 1866. The most commonly planted is GMB 7 because of high productivity and good shoot quality. Chin clone is not bred anymore. Even though the quality is pretty well, its productivity is less because leaf shape is narrow. TRI 2025 clones have the highest productivity due to its long and thick leaves. The tea is then processed into products such as white tea, green tea, black tea/fragrant tea, and coffee flavoured tea. White tea and green tea are increasingly popular as traditional medicines.

1. Introduction

Mountain forest play a significant role in conserving biodiversity, holding water capacity and keeping the water consumable [1]. The forest should be managed in wide range thus it can be beneficial for all people live in surrounding [2]. Tea is one of the mountain plantations. Jamus tea plantation in Ngawi Regency, East Java Province, Indonesia is one that has been established since the Dutch era. Tea (Camellia sinensis) in this area has grown since 1866. The 478.20 hectares of Jamus tea plantation was pioneered by a Dutch businessman named Van Rappard. At the beginning of the Jamus tea plantation opening, there was only one tea, Asamica. When World War II occurred, Jamus tea plantation was replaced with taro plants to meet the needs of the Japanese war. Then in 1973, the management of Jamus tea plantation was handed over to PT.Candi Loka. This tea company still conserve Asamica and strives to improve the quality and productivity of tea by planting tea clones until now.

The variety of Jamus tea products continues to grow along with the abundant tea production. Formerly Jamus tea was only produced as a product of tea drinks. Then nowadays has been developed tea product as a medicine. To get the benefits of tea as a medicine, Jamus tea plantation multiply the
tea clone. The clones of tea are selected based on the level of productivity [3], the levels of active substances contained in tea, and the efficacy of the active substances contained in the tea species [4]. In order to obtain good efficacy and production level, Jamus tea plantation also chose to plant new clones of tea from the crosses, both generative and vegetative. In addition to the season, tread, leaf age, and sunlight intensity, this tea clone also affect the caffeine, catechin, theaflavin, and flavonol [5]. The catechins were found in young tea leaves [6]. The number of factors differences between tea clones greatly affect the efficacy of tea produced drugs. Therefore, the clones developed in Jamus tea plantation, both old and new, need to be studied and documented to be a reference in its development in the future and as education for the wider community how great the potential of tea. This study aims to explore the morphological differences of tea clones developed in Jamus tea plantation and the manufactured tea products.

2. Method
Data on tea clones were obtained through surveys and observations of all tea clones in the Jamus tea plantation in July-August 2016. Furthermore, tea clone specimens were collected and identified. In addition, interviews with the manager and experts staff of Jamus tea plantation, PT Candi Loka, were also conducted between 2016-2018.

3. Result
3.1. Tea Clones
Tea (Camellia sinensis, Theaceae) is tree-tall, 15 feet tall naturally. When cultivated only between 0.6 and 1.5 meters. Leaf, light green, 5-30 cm long, wide ± 4 cm. Flower, white diameter 2.5-4 cm. Fruit, flat and round shape. Seeds, the size of beans, one fruit on each fruit. Prior to this, Camellia had several species such as: C. sinensis, C. irrawadiensis and C. assamica. However, beginning in 1958, popular tea of one species, namely: C. sinensis, but has a variety of varieties [7]. Varieties arise due to the progress of vegetative propagation of clones. The clones are obtained through superior tree selection in productivity, quality, dry resistance, and pests and diseases [8].

The clones of tea in the Jamus tea plantation developed rapidly and varied. Most clones planted are the result of the development of research institutes. The system of planting clones of tea in Jamus followed a random system, so these tea clones grew together and mixed. As a result, it is difficult to distinguish between clones if we are in the middle of Jamus tea plantation. There are seven tea clones in Jamus, namely Asamica, Yabokita, Chin, Gambung (GMB) 3, GMB 7, TRI (Tea Research Institute of Ceylon Srilanga) 2024, and TRI 2025 (Table 1).

The asamica is the oldest clone of all tea clones grown in Jamus tea plantation (Figure 1). This clone was planted in 1866. It is now around 150 years old. In 1877, Klico acidica began to grow and expand asamica in Indonesia. This clone originated Ceylon (Sri Lanka). The beginning of R.E. Kerkhoven planted it in Gambung Garden, West Java. The excess is at higher catechin levels [9].

The yabokita clone is a clone from Japan. Given the name yabokita, because it comes from two words namely "yabu" which means bamboo clump and "us" means north (Figure 2). Formerly clone Yabokita developed in bamboo clump bushes by Hikosaburo Sugiyama in Shizuoka, Japan. Yabokita clones are resistant to fungal diseases and high productivity. Since 1999, Yabokita clones cover 77% tea plantation in Japan. The tea product from the yabokita clone is famous for its umami taste [10].

Chin is a Chinese clone. The Jamus tea plantation brings these clones seeds directly from China. This clone has a characteristic shoot of redness (Figure 3). But after some time developed in Jamus, Chin clones productivity is less because the leaves are small. So this chin clone is not bred anymore. Yet in terms of quality tea, tea products from chin clone excerpts pretty well.
### Table 1. Tea clones in Jamus tea plantation of PT Candi Loka, Ngawi Province, East Java, Indonesia

| Tea clones | Root and stem  | Length of the leaves | Thickness of the leaves                                      | Fine hairs on the tea buds                  |
|------------|----------------|----------------------|-------------------------------------------------------------|---------------------------------------------|
| Asamica    | Big and sturdy stem | 11.5 cm             | Thin, toothed margin, and oblong                            | Thin white hair                             |
|            |                 |                      | Thick and oblong, dark green on mature leaves               |                                              |
| Yabokita   | Small stem      | 10.6 cm             | Thick, narrow, small                                        | Thin white hair                             |
| Chin       | Small stem      | 7.4 cm              | Thin white hair, slightly reddish colour                    |                                              |
| GMB 3      | Small stem      | 15.7 cm             | Thin, oblong with long-pointed, long leaves                 | Thin white hair                             |
| GMB 7      | Small stem      | 10.1 cm             | Thin, oblong with long-pointed, shorter than GMB 3 clone leaves | Thick white hair                           |
| TRI 2025   | Small stem      | 16.5 cm             | Thickest leaves                                             | Thin white hair                             |
| TRI 2024   | Small stem      | 13.9 cm             | Slightly thinner than TRI 2025 clone                        | Thin white hair                             |

Figure 1. Asamica clone in Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia: a) stem: big and sturdy stem, b) branch, c) bud and leaves with toothed margin, d) mature leaf.
Figure 2. Yabokita clone in Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia: a) stem and branches; b) foliage, leaf shape: oblong; c) mature leaf.

Figure 3. Chin clone in Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia: a) stem and branches; b) young leaves; c) bud; d) mature leaves and redness shoot

Clones of GMB 3 (Figure 4) and GMB 7 (Figure 5) are the result of the development of tea clones at the Tea and Quinine Research Center Gambung, West Java. Among the GMB series clones, GMB 7 is the best clone because of its high yield potential (5,800 kg/ha/year). Thus, in Jamus tea plantation, the GMB 7 series is the most commonly planted and planted series because of its high productivity and good shoot quality [11].
Figure 4. GMB 3 clone in Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia: a) branches; b) mature leaf, oblong; c) foliage, d) bud

Figure 5. GMB 7 clone in Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia: a) foliage, b) bud and young leaves

TRI 2025 (Figure 6) and TRI 2024 (Figure 7) or which have the length of Tea Research Institute series 2024 and series 2025 are clones developed by Tea Research Institute (TRI) in Ceylon, Sri Lanka. The highest productivity is obtained from TRI 2025 clones due to its long and thick leaves. Indeed, differences in length, width, and thickness of leaves affect tea productivity. While the lowest productivity is obtained from klica asamica. This is because the clavic acid in Jamus is hundreds of years old so that its growth is not as fast as other tea clones.
The harvest of tea leaves is processed and turned into green tea, black tea, and partly into white tea (Figure 8). The large variety of clones in Jamus affects the productivity of the resulting tea. Clonal plants have higher productivity [12]. This is also in accordance with the Kartawijaya [13] who states that if the percentage of plants coming from clones is higher, the productivity of the plantation will increase.
Figure 8. White tea from Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia.

White tea is obtained from young tea leaf that do not undergo oxidation process and are protected from sunlight for the formation of chlorophyll is inhibited. The harvesting of young tea leaves for white tea products is done before sunrise and in shoot condition is still rolled up and covered with fine white hairs. White tea is popular because of its antioxidant content is higher than green tea. In the Jamus tea plantation, tea shoots used for white tea products are derived from GMB 7 clone. GMB 7 shoots have white feathers that are thicker than others. Processing of shoots into white tea does not take a long time to keep the levels of catechins and polyphenols in them. White tea is claimed to have antioxidant content and polyphenol epigallocatechin gallate (EGCG) is higher than other tea products.

Tea leaves used for green tea products (Figure 9) are usually processed immediately after picking. The leaves undergo the oxidation process in a minimal time and then the oxidation process is stopped by drying. Processing into green tea starts from the process of wilting to reduce water content and increase the concentration of catechins. Then the process of rolling and drying to stop the enzymatic oxidation process to the catechins in tea. In the processing of green tea, there is no fermentation process or tea process left for 12 hours to turn the catechins into tea flavin and tea rubigin.

Figure 9. Green tea from Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia.

Black tea (Figure 10) is made from tea leaves that are left for 2 weeks or 1 month for the process of oxidation of compounds in tea. Then the tea is milled and fermented for 12 hours in order to occur enzymatic oxidation process is the meeting of polyphenols and polyphenol oxidase enzymes with the help of oxygen. Catechin polyphenols will be converted into theaflavin and thearubigin which are important components that affect the color, flavor and aroma of steeping black tea into redness and flavor. This black tea can be processed again into fragrant tea with the addition of jasmine flowers. Owuor and Kwach [14] recommend two leaves and a bud for plucking standard of black tea.
Figure 10. Black tea from Jamus tea plantation, Ngawi Regency, East Java Province, Indonesia

Coffee-flavored tea is typical of the Jamus tea plantation. This tea is made with a process similar to black tea. The difference is after the process of withering to fermentation, the tea is then dried for 10 hours to get the taste and aroma of coffee is fragrant and slightly bitter.

The tea products produced by Jamus tea plantation, which is useful as a tea for traditional medicine is white tea and green tea. There have been many testimonials from consumers about the benefits of Jamus tea, such as those recovering from breast cancer, vertigo, high blood pressure, diabetes mellitus and more. Chemical substances contained in tea leaf and beneficial to health include catechin polyphenols, flavanols, tea flavins tea rubigin, and L-theaninee.

3.2. Polyphenol Catechins
Catechin is a secondary metabolite compound, a side compound produced by a tea plant when it makes food for its growth. Fresh tea leaves contain 13.5-31% catechins [15]. Catechins are antioxidants, lowering and maintaining body blood sugar levels [16]. Green tea extract is able to inhibit the digestion of fat so it is not absorbed by the small intestine [17].

Many benefits of tea catechins for the body, but the levels of catechins in tea differ depending on the process of processing. The longer the process experienced by tea to be the product, the catechin content is less. In white tea, because the processing does not go through a long process, the catechin content in it is highest among other tea products. Green tea and black tea are processing longer, making his catechin levels down. From the results of the study, 13.76% of catechins contained in tea before being processed, for green tea dropped to 10.04% and black tea to 5.91% [8]. In addition to the processing, this type of tea clone also affects catechin levels in tea. The GMB 7 clone has the highest catechin level of 17.599% compared to the clones of acidic which ranges from 13-16% only [18].

3.3. Flavanol
Flavanols in tea include kaempferol, myricetin, and quercetin. The amount is greater in green tea than black tea [15]. This flavanol compound determines the quality of tea. The more flavanols in tea make the better the quality of the tea. This flavanol has benefits also for our body. These compounds can strengthen the walls of our blood vessels and trigger the collection of vitamin C [15].

3.4. L-theanine
These compounds make tea have an exotic taste or Japanese people call it umami taste. L-theanine is an amino acid present in tea leaves. The amount can be 50% of the amount of free amino acids in tea. This amino acid is very distinctive because it is found only in the tea plant and the fungus of Xeromonas radius. When we consume L-theanine, this compound can elicit a relaxing effect on the brain and blood vessels, thus helping to reduce stress and lower blood pressure [19]. For those of you who work with high stress levels, attend long-term seminars or training, tea-time tea or tea break seminars are a great way to help you relax and not get stressed easily [20]. In addition, L-theanine can help stimulate brain neurotransmitter that improves memory and learning ability. Tea can be a supplement to our brain. Theanine as a unique and nonproteinic amino acid can also be therapeutic for liver disease and liver injury [21].

4. Conclusion
The Lawu mountain slopes, especially in Jamus tea plantations managed by PT Candi Loka, are still preserving 7 tea clones, namely Asamica (the oldest clone since 1866), Yabokita, Chin, GMB 3, GMB 7, TRI 2024, and TRI 2025. The clones can be distinguished from leaf thickness and length, lifespan and fine hairs on the tea buds. The company produces white tea, green tea, black tea/fragrant tea, and coffee flavor tea. Beside a beverage, white tea and green tea are produced for traditional medicine.

References
[1] Listyaningrum N, Nisa A K, Hidayatullah L, Ihsanjaya M M M, Janah S N, Sugureta N M, Fatkhurrohman W, Primasanti H, Ngadianto A, Sulaiman M, Syahbudin A 2019 *IOP Conference Series: Earth and Environmental Science, 25*

[2] Syahbudin A 2019 *Proceeding of 6th International Conference on Educational Research and Innovation (ICERI 2018), 330*

[3] Robbertse P J and Steyn E M A 1992 *Journal of Plant and Soil, 9:4*, 217–219

[4] Razaq M, Alam H, Ishfaq M, Salahuddin 2015 *Journal of Northeast Agricultural University, 22*, 33–36

[5] Cheruiyot E K, Mumera L M, Ng’etich W K, Hassanali A, Wachira F 2007 *Bioscience, Biotechnology, and Biochemistry, 71*, 2190–2197

[6] Yang Z, Kobayashi E, Katsuno T, Ananuma T, Fujimori T, Ishikawa T, Watanabe N 2012 *Dark Food chemistry, 135*, 2268–2276

[7] Mahmood T, Akhtar N, Khan B A 2010 *Journal of Medicinal Plants Research, 4*, 2028–2033

[8] Ouwor P O and Kwach B O 2012 *Agritech, 32*

[9] Juaniaty T and Balittri 2013 *Warta Penelitian dan Perkembangan Tanaman Industri, 19*

[10] Anonim 2014 Introduction and Identification of GMB Series Tea Clones (in indonesian: Pengenalan dan Identifikasi Teh Klon Seri GMB) http://ditjenbun.pertanian.go.id/perbenihan/berita-278-pengenalan-dan-identifikasi-teh-klon-seri-gmb.html accessed on 15 August 2016.

[11] Anonim 2014 Yabukita www.teapedia.com accessed on 15 August 2016.

[12] Wachira F N and Njuguna C K 1994 *Tea, 15*, 70–73

[13] Kartawijaya W S 1995 *Warta Teh dan Kina, 3*, 74–80

[14] Ouwor P O and Kwach B O 2012 *J. Biol. Life Sci, 1*, 1–7

[15] Hartoyo A 2003 *Tea and Health Benefits* (in indonesia: Teh dan Khasiatnya bagi Kesehatan) (Yogyakarta: Kanisius)

[16] Juneja L R, Chu D, Okubo T, Nagato Y, Yokogoshi H 1999 *Trends in Food Science & Technology, 10*, 199-204

[17] Haskell C F, Kennedy D O, Milne A L, Wensesa K A, Scholey A B 2008 *Biological Psychology, 77*, 113-122

[18] Wang D, Gao Q, Wang T, Qian F, Wang Y 2017 *Asia Pacific Journal of Clinical Nutrition, 26*