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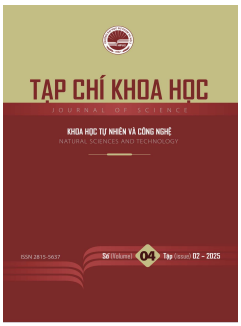

Article type: Research article

Analysis of morphological characteristics and initial development of tea bag products from *Camellia* in Na Hang - Tuyen Quang

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Abstract

The Yellow camellia was first discovered in Vietnam in the early 20th century. The leaves of the camellia plant contain many phenolic compounds such as ellagitannin, taxifolin deoxyhexose, proanthocyanidin, kaempferol derivatives, apigenin derivatives, glucosyl isorhamnetin, quercetin derivatives and platphylloside. Using morphological comparison methods, we initially identified the large yellow-flowered camellia in Khau Tinh commune, Na Hang district, Tuyen Quang province as *Camellia megasepala* Hung T. Chang & Trin Ninh. To create tea bags from yellow camellia leaves, we have built a production process and with evaluated food hygiene and safety criteria, and as well as assessed sensory quality criteria according to TCVN 3218: 2012) is built. The evaluation results indicated that the tested formulas achieved high sensory scores, all exceeding 19.5 points.

Keywords: Morphology, procedure, plant taxonomy, tea bag, *Camellia megasepala*

1. Introduction

Yellow-flowered tea plants generally include species of the *Camellia* genus, (Theaceae family). There are about 350 species of *Camellia* in the world, spreading across tropical Asia, especially in the southeast area. The two main distribution centers are Guangxi - China and northern Vietnam [1]. Yellow-flowered tea plants were first documented in Vietnam in the early 20th century. These species are recognized for their considerable economic importance, as they are widely valued both as ornamental plants and as sources of traditional medicinal compounds [2]. Yellow camellia prefers hot and humid climates, specifically humid forests at altitudes below 500 m. In loose soil on shady, well-drained stream banks. Current research on yellow-flowered camelliaoften focuses on areas such as Ba Che (Quang Ninh), Tam Dao National Park (Vinh Phuc), Cuc Phuong National Park (Ninh Binh). Additionally, as Tuyen Quang and

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Bac Kan share a border with Cao Bang, some species of yellow flower camellia are also recorded such as *C. tuyenquangensis* (Chiem Hoa-Tuyen Quang yellow-flowered camellia), *C. hamyenensis* M. Sealy (Ham Yen yellow flower camellia), *C. megasepala* Hung T. Chang & Tran Ninh (Ba Be yellow flower tea/Big yellow flower tea), *C. tienii* Ninh (Yellow begonia/Tien yellow flower tea) [3].

Recent studies have reported numerous *Camellia* genomes, including those of tea plants [4]–[10] and oilseed *Camellia* [11]. These investigations identified genes associated with the biosynthesis of terpenoids and fatty acids; however, it remains unclear whether these genes exhibit signs of human selection. Furthermore, population structure and genetic diversity analyses in tea plants have produced two conflicting hypotheses regarding their evolutionary history [6], [7], [9], [10]. One theory suggests the parallel domestication of two tea varieties (CSS and CSA) [10], while the other proposes a single origin in southwestern China [7]. In comparison, oilseed *Camellia* and ornamental *Camellia* populations demonstrate significant genetic diversity [11], [12]. For ornamental *Camellia*, simple sequence repeat (SSR) markers have differentiated populations from northern and southern China based on their geographic origin and genetic background [12]. Meanwhile, *C. oleifera* cultivars are primarily distinguished by morphological traits rather than geographic origin, as evidenced by 25,581 SNPs derived from transcriptome sequencing data of 221 oilseed *Camellia* cultivars [11]. Despite these advancements, further analyses incorporating a broader collection of cultivars are necessary to deepen the understanding of the complex evolutionary history of Camellia.

As demonstrated by *Camellia sinensis*, whose leaves are used globally in the tea industry, and Camellia oleifera, whose seeds are mainly used in the production of edible and essential oils, a considerable number of species in the genus *Camellia* (Theaceae) have drawn a significant amount of attention due to their health-related qualities [13]. According to Teixeira and Sousa [13], camellias can exhibit antioxidant, anti-inflammatory, antimicrobial, antiviral, and antitumoral properties. These properties are the result of the accumulation of specialized metabolites with associated bioactivities, such as alkaloids, polyphenols, and terpenoids.

The leaves of the camellia plant contain many phenolic compounds such as ellagitannin, taxifolin deoxyhexose, proanthocyanidin, kaempferol derivatives, apigenin derivatives, glucosyl isorhamnetin, quercetin derivatives and platphylloside. These compounds have great medicinal value in the form of reducing the possibility of stroke, preventing cancer, supporting the elasticity of blood vessels and regulating blood pressure [14].

Creating drinking tea products from natural yellow flower tea leaves collected in Khau Tinh commune, Na Hang district, Tuyen Quang province, is oriented to become a typical local product, and contribute to the diversity of regional tourism products. The research results also path the way for the development of yellow camellia growing area in the province.

The study aims to determine the morphological characteristics and scientific classification of *Camellia sp.* collected from Na Hang, Tuyên Quang, hence providing a foundation for species conservation and development. Additionally, the research investigates the extraction process of bioactive compounds from golden camellia leaves, quantifies specific characteristic compounds of the *Camellia* genus, and evaluates antibacterial activity using the agar diffusion method. Based on these findings, the study focuses on developing Yellow-flowered tea in filter bag form, with view to leveraging local potential and guide product commercialization in alignment with regional characteristics.

2. Materials and research methods

2.1. Materials

The research object is leaf and flower samples of *Camellia* in Na Hang district, Tuyen Quang province.

Samples of leaves for experimental production tea bags can be found in Khau Tinh commune, Na Hang district, Tuyen Quang province (22°28'01"N 105°26'02"E; 22°28'00"N 105°26'39"E; 22°28'59"N 105°26'34"E).

2.2. Research Methods

Analyze morphological characteristics of yellow flower camellia in Na Hang, Tuyen Quang

The specimens were described and analyzed for the morphological characteristics of vegetative and reproductive organs using a descriptive-analytical method. The scientific identification of the collected specimens was conducted based on morphological comparison and carried out using classification keys and species descriptions from both domestic and international botanical literature, particularly the *Camellia* classification key by the research group of Trần Ninh - Hakoda and the Flora of China.

Create a yellow flower tea product in filter bag form

The process of creating tea bag products is carried out as described by Son Luu Hong *et al.,* [15] with some modifications: Leaves are dehydrated at 40 ^{o}C, ground in a blender, and formulated into a tea recipe containing THV ingredients. Afterward, the blend is left to dry at 50 ^{o}C for 3 hours. Finally, a scale of 2 grams of THV to put into a filter bag and pack according to the procedure described previously.

The yellow flower tea formulas were evaluated using the scoring method of TCVN3218:2012. The number of candidates surveyed was 25 people.

The product is throughoutly checked for harmful microorganisms E.coli, samonella sp. at the Institute of Food Safety and Hygiene Testing.

Minitab statistical software and all experiments were repeated 3 times with 95 % confidence.

3. Results and discussion

Morphological characteristics and identification of yellow flower camellia species in Na Hang, Tuyen Quang

The morphology of the reproductive organs is one of the important criteria for identifying the scientific name of a species in biology. In this study, yellow camellia samples collected from Khau Tinh commune, Na Hang district, Tuyen Quang province were used to describe the morphology according to the guidance of specialized documents [16]. Comparative morphological methods are essential for distinguishing this species from others within the Camellia genus, particularly in regions with high species diversity [17],[18].

The species is a shrub reaching 5–6 m in height. Young branches are light brown, while older branches are smooth and grayish-white. Leaves are simple and alternate, with glabrous petioles 10–15 mm long. Leaf blades are thick, yellowish-green, and oblong to narrowly elliptical, measuring 14–18 cm in length and 5–8 cm in width. The apex is acute to acuminate, and the base is rounded. Margins are serrated, sometimes with coarser teeth in the upper portion. The adaxial surface is green, smooth, and dull, whereas the abaxial surface is yellow-green and glabrous. Each blade bears 9–11 pairs of lateral veins, which are sunken on the adaxial side but raised on the abaxial side.

Flowers are solitary or paired, borne at branch tips or in leaf axils, and measure 5.5–6.0 cm in diameter. Pedicels are smooth and about 10 mm long. Bracts number 4–5, broadly triangular, overlapping, with hairy margins and smooth surfaces, 3–6 mm long and 2.5–4 mm wide. Sepals number 7, spirally arranged, broadly triangular to elliptical, 7–11 mm long and 4.5–9 mm wide, also with hairy margins and smooth surfaces. Petals number 12, yellow, and arranged in three whorls. The outer whorl has four elliptical petals, 17–30 mm long and 13–20 mm wide. The middle whorl has four obovate to elliptical petals, 38–45 mm long and 23–33 mm wide. The inner whorl has four petals connate at the base for 5–6 mm, obovate to elliptical, 42–45 mm long and 24–30 mm wide, smooth on both surfaces.

There are approximately 250 stamens, arranged in 4–5 whorls. The outer whorl is fused at the base for 10–14 mm and attached to the petal base. Filaments are glabrous, 25–30 mm long, and bear yellow anthers 2–2.5 mm in length. The ovary is ovoid, three-loculed, about 5 × 5 mm, and smooth. The style is about 30 mm long and terminates in three lobes, either arising from the middle or extending halfway along its length.

Table 1. Morphological characteristics of large-stemmed yellow-flowered camellia.

Numerical	Characteristic	Specifications	Numerical	Characteristic	Specifications
1	Life form:	Tree	12	Number of leaf veins:	11-12
2	Tree height:	5-7 m	13	Petiole length:	6-8 mm, hairy
3	Distribution location:	Na Hang, Tuyen Quang	14	Sepals:	7-8, smooth
4	Upper leaf surface:	Smooth	15	Sepal shape:	Oval
5	Lower leaf surface:	Hairy	16	Sepal length (mm):	20-30
6	Leaf length (cm):	22-24.5	17	Sepal width (mm):	18-25
7	Leaf width (cm):	9.5-12	18	Sepal hairs:	Smooth inside, hairy outside
8	Leaf shape:	Elliptical	19	Ovules:	With fine hairs
9	Leaf edge:	Serrated	20	Ovule type:	3 compartments
10	Leaf tip:	Pointed	21	Number of styles:	3
11	Leaf base:	Round			

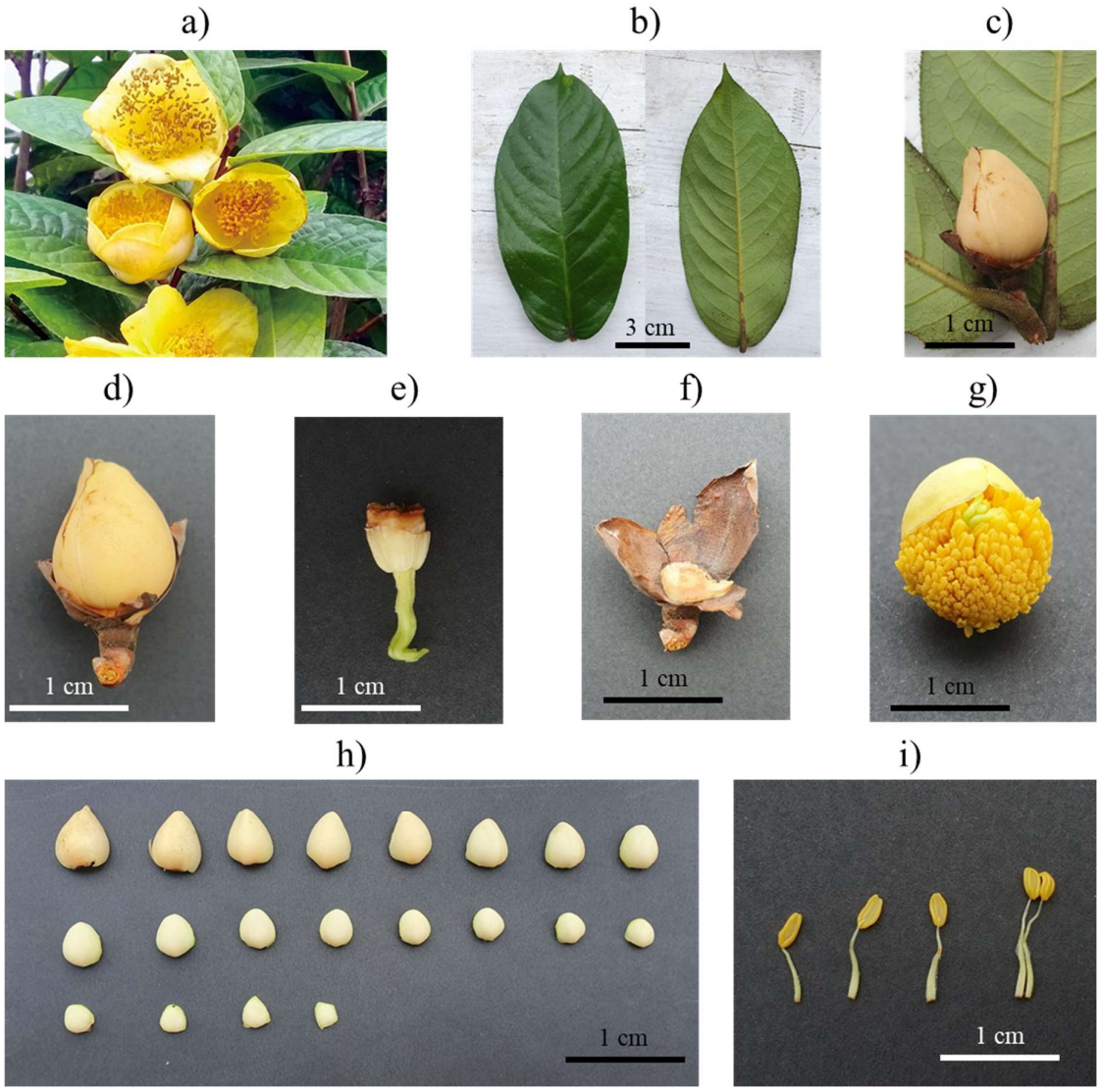

Figure 1. Morphological characteristics of autumn yellow-flowered camellia in Na Hang, Tuyen Quang. (a) Life form of the autumn yellow camellia plant in Khau Tinh commune, Na Hang district, Tuyen Quang province; (b) upper (left) and lower (right) surfaces of the THV leaf; (c) flowers and petioles of THV; (d) THV bud; (e) THV stamens and pistils; (f) bracts; (g) diploid; (h) flower petals (corolla); (i) gynoecium

Using comparative morphological method, it is possible to initially identify the yellow flower camellia sample with the scientific name Camellia megasepala Hung T. Chang & Trin Ninh, aslo known in Vietnamese as Camellia large calyx yellow flower. Previously, this species was recorded in Ba Be, Bac Kan or described as commonly found in Tuyen Quang, but the distribution location was not specified. Thus, it can be concluded that this is the first time recording Camellia megasepala Hung T. Chang & Trin Ninh in Khau Tinh commune, Na Hang district, Tuyen Quang province.

Create yellow flower tea products

Creating yellow flower tea products involves innovative methods of combining yellow tea with various floral elements to enhance flavor, aroma, and health benefits. Golden Yellow Green Tea, made from the "Ye Se 1" variety, exhibits a golden yellow color and a distinct floral aroma, that appeals to both visual and taste preferences [19]. In addition, yellow tea contains bioactive compounds such as catechins

and brownies, which show strong antioxidant activities, helping to combat oxidative stress and reduce the risk of chronic diseases [20].

Flow chart of creating yellow flower tea in filter bag form

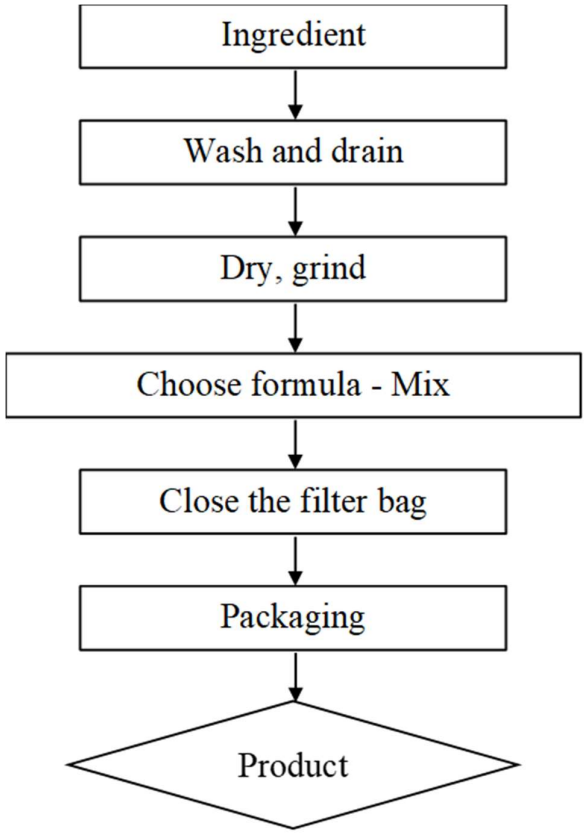

Figure 2. Diagram of the expected technological process to create Tuyen Quang yellow flower tea.

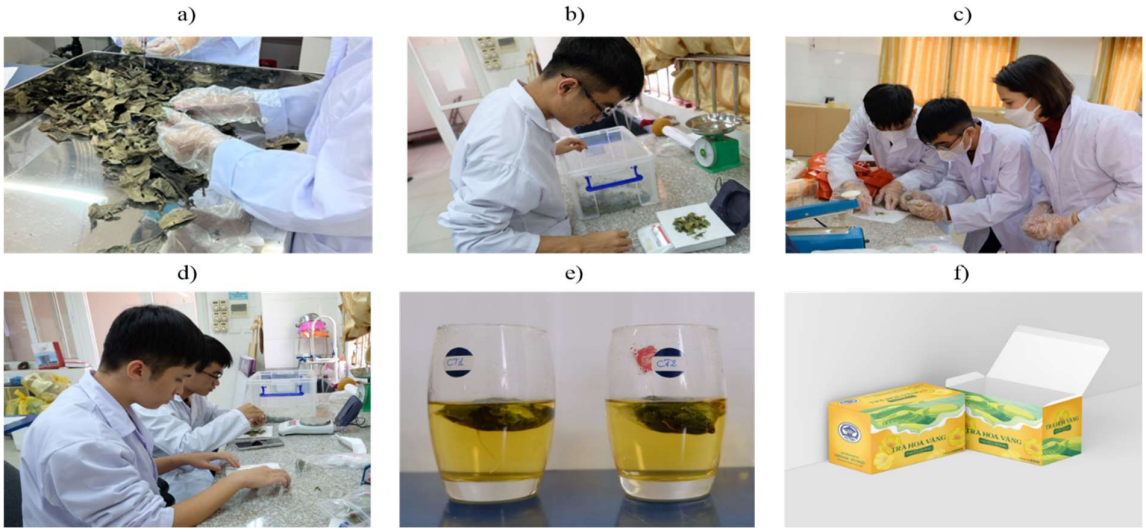

Figure 3. Some steps in the process of creating Tuyen Quang yellow flower tea in filter bag form. (a) dried, crushed materials; (b) weigh and mix ingredients; (c) tea bag packaging; (d) product finishing; (e) finished product for testing; (f) canned tea products.

Characteristics and testing of yellow flower tea in filter bag form

Analyze quality indicators

The quality of yellow flower tea was analyzed at the Food Safety and Hygiene Testing Institute, shown in Table 2.

Table 2. Determination of harmful microorganisms in yellow flower tea products.

Target / Sample name	Coliforms (CFU/g)	*Salmonella* spp. /25g
THV Tuyen Quang	Not detected	Not detected

Results Table 3 shows that the research group's yellow flower tea product does not contain harmful microorganisms such as Coliforms and Salmonella spp. According to food safety and hygiene requirements for microbiological standards, the conditions are satisfied and the product can continue to be used for sensory evaluation.

Sensory evaluation of tea bag products using scoring method

Table 3. Determination of sensory criteria by scoring method for yellow flower tea products (according to TCVN 3218:2012).

Experimental formula	**Average score for each assessment criterion**				**Importance of each indicator**				**Total score**
	Transparency	Color	Smell	Taste	Transparency	Color	Smell	Taste	
1	5	5	4,8	4,92	5	3	5,76	5,904	19,664
2	4,92	4,96	4,96	4,88	4,92	2,976	5,952	5,856	19,704

Analysis of Table 3 shows that tea samples in different formulas have different total scores, ranging from 19.664 to 19.704 (points), both of which achieved Good quality (according to TCVN 3218:2012). However, formula 2 was rated slightly higher, hence it is chosen (a blend of yellow flower tea leaves and red apples) as a potential formula to conduct further studies.

4. Conclusion

Our study has provided the first description of the morphological characteristics and scientific identification of the large yellow-flowered camellia species collected in Na Hang, Tuyen Quang is *Camellia megasepala* Hung T. Chang & Trin Ninh. Additionally, this study explored the potential application of this species in the development of yellow flower tea products. The technological process for tea production was designed to optimize sensory properties and ensure compliance with food safety standards. Microbial analysis confirmed the absence of harmful contaminants, while sensory evaluation indicated that formula 2, a blend of yellow flower tea leaves and red apples, demonstrated superior quality. These findings suggest promising commercial and health-related applications for *Camellia megasepala*, warranting further research on its bioactive compounds and potential for large-scale tea production.

Acknowledgements

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