



## Quantitative assessment of tannins in commercially available tea beverages utilizing UV/Vis spectrometry

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### KEYWORDS

Tannin analysis  
UV/Vis Spectrometry  
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### ABSTRACT

This research quantitatively analyzes the tannin content in commercial tea drinks using UV/Vis spectrophotometry. Tannins are polyphenolic compounds that influence tea's flavor, quality, and health benefits. Traditional methods for measuring tannin content often require extensive sample preparation, time-consuming and involve hazardous reagents. This project aims to streamline the process using a simpler method: UV/Vis spectrophotometry. The study includes the extraction and purification of tannins from tea samples, the creation of calibration curves and the analysis of various commercial tea types, including jasmine green tea, iced lemon tea, white grape green tea with aloe vera and iced black tea. Results indicate that flavour jasmine green tea contains the highest tannin concentration (2.9166 ppm), while iced lemon tea has the lowest (2.284 ppm). These findings are valuable for improving quality control in the beverage industry and enhancing consumer awareness of the nutritional value of teas.

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### 1.0 INTRODUCTION

Tea also known as *Camellia Sinensis* is one of the world's most popular beverages due to its health benefits, unique flavor, and cultural significance [1]. Beyond being just a drink, tea symbolizes cultural heritage in many countries, such as Japan's Chanoyu tea ceremony, which emphasizes harmony and tranquillity, and China's Gong Fu Cha, which highlights the skill of tea brewing. This research aims to analyze tannins in commercial tea drinks, focusing on their properties, health benefits and the influence of preparation methods on their concentration. By exploring these aspects, the study seeks to enhance the understanding of tannins to improve marketing strategies for tea products, benefiting both consumers and the tea industry.

Tannins are polyphenol compounds, which are the primary secondary metabolites in plants, have a vital role in determining the sensory and nutritional quality of tea, fruits, vegetables, and other plants [2]. Tannins being polyphenolic compounds are characterized by the presence of aromatic rings and conjugated double bonds in their chemical structures [3]. These compounds have benzene

rings with one or more hydroxyl groups in their structures, ranging from basic phenolic molecules to sophisticated high-molecular polymers. It's including catechins and theaflavins, are known for their antioxidant properties, which help reduce oxidative stress and may prevent chronic diseases like cardiovascular conditions, cancer, and neurological disorders [4]. However, due to the variety of polyphenols found in tea, tea polyphenols are categorized as catechins, flavonoids and flavonols, anthocyanins, and phenolic acids [5]. Tannins are vital in preserving cardiovascular health because they inhibit low-density lipoproteins (LDL), also known as bad cholesterol, from oxidizing, lowering the risk of atherosclerosis [6]. Tannins may also improve cardiovascular health by lowering blood pressure, reducing LDL cholesterol, and enhancing vascular function [7]. However, excessive tannin consumption can inhibit iron absorption, posing risks for individuals with iron deficiency [8]. Tannins in tea act as antioxidants, neutralizing free radicals and protecting cells from oxidative damage [9]. These properties are linked to reduced risks of chronic diseases such as heart disease and cancer. Tannins also exhibit anti-inflammatory effects and may support digestive health [10]. Furthermore, tannins, particularly catechins, and theaflavins, have significant free radical-scavenging activities, aiding in the decrease of oxidative stress and potentially avoiding chronic diseases such as cardiovascular disease, cancer, and neurological disorders [11]. Polyphenols not only have a powerful antioxidant impact that has been scientifically established to be helpful to the human body, but they also influence the organoleptic value of food goods, such as taste, smell, and colour [12].

Tea is highly valued not only for its taste but also for its potential health advantages [13]. Tannins are one of the key bioactive compounds in tea, contribute significantly to the drink's astringency, bitterness, color, and antioxidant properties. Furthermore, its astringency promotes digestive health by reducing diarrhea and functioning as an effective protein precipitant in the intestines [14]. This research specifically examines tannin content in teas, which are popular for their convenience and variety of flavors, such as black and green tea [15]. Tea beverages can be made from freshly brewed tea extracts or instant tea powders. This study includes products from four flavour of teas, which were, iced lemon tea, jasmine green tea, white grape green tea with aloe vera and iced black tea.

Sustainable tea production focuses on environmental care, social responsibility, and economic benefits. Tannins in tea play a key role by naturally deterring pests, which helps reduce the need for chemical pesticides and lowers environmental harm [16]. They can also disrupt pest life cycles, offering a more sustainable approach to pest control [17]. Tannin-rich tea plants support local ecosystems by attracting insects and birds, enhancing biodiversity around tea farms [18]. These teas also have unique flavors that can increase their market value, supporting economic sustainability. Additionally, tannin analysis can improve water efficiency and soil health, reducing the need for fertilizers and conserving resources [19]. Overall, tannin analysis helps make tea farming more sustainable by protecting the environment and supporting local ecosystems.

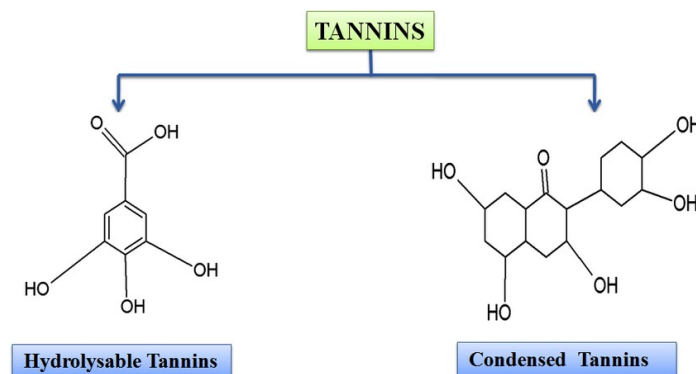


Figure 1: Classification of Tannin [20]

The UV/Vis spectrometry method was standardized in this research to evaluate tannin concentrations across diverse tea products, providing a consistent and reliable means of analysis. Traditional methods, such as titration, are often time-consuming and involve the use of hazardous reagents, making them less suitable for routine quality control in the food and beverage industry. Moreover, standard approaches may not fully capture the complex tannin profiles present in teas. This research aims to close this knowledge gap by establishing UV/Vis spectrometry as a practical and effective tool for analyzing tannins in teas. In the fast-paced world of tea production and quality control, speed and efficiency are critical. UV/Vis spectrometry provides quick findings, making it ideal for high-throughput examination of a large number of tea samples [21]. Furthermore, the minimal sample preparation requirements save time and resources, which contributes to the overall efficiency of the analysis process. There were several factors can affect the accuracy of tannin analysis [22]. Interferences from other compounds in tea, such as caffeine and pigments, can occur when they absorb light at similar wavelengths to tannins. Proper wavelength selection and sample purification methods can help mitigate these interferences. The high sensitivity of this technique provides reliable quantification of tannins even at low concentrations, which is critical for trace analysis [23].

UV/Vis spectrometry had a substantial benefit in terms of quantitative precision. This technique delivers accurate and consistent quantitative measurements by generating calibration curves using known tannin concentrations [24], which is important for quality control and research purposes. UV/Vis spectrometry's adaptability for diverse tannin assays and broad analytical range make it an adaptable instrument for both qualitative and quantitative investigations of tannins in tea.

The real-time monitoring capabilities of UV/Vis spectrometry are critical for studying the kinetics and processes of tannin reactions [25]. It enables researchers to see changes as they occur, making it an invaluable tool for researching and analyzing numerous processes in tea production and analysis. As a result, the sensitivity, speed, precision, and real-time monitoring capabilities of UV/Vis spectrometry make it an incredibly effective choice for tannin detection in tea.

Other research shows that more complex methods such as High-Performance Liquid Chromatography (HPLC) provide high sensitivity and quantitative accuracy at the expense of complexity and higher operational expenses [26]. Moreover, the research of tea using Fourier Transform Infrared (FTIR) spectroscopy is simple and quick, however, it may lack the sensitivity needed for trace-level tannin analysis [27]. The previous studies also mentioned the challenges and gaps in the analysis of tannin content in commercial tea beverages. The use of Folin-Denis Reagent and absorbance at 760 nm with a UV/Vis spectrometer is a common method for tannin analysis [28]. However, the choice of Folin-Denis Reagent as a standard might introduce variability in the results, making it difficult to compare data across different studies.

Additionally, the variation in sample types (tea leaves versus tea beverage) and the different processing stages involved in tea production could significantly impact tannin content. Previous research chose tea leaves as sample materials [29]. Therefore, the methods involved were extraction and evaporation. Factors such as tea preparation, packing, and pasteurization also influenced the final tannin levels in tea products. Since the numerous significant advantages, UV/Vis spectrometry is a frequently used and useful analytical technique for tannin determination in tea. It has great sensitivity, detecting tannins even at low concentrations and ensuring reliable measurement in diluted samples. This is especially important when working with complex tea matrices [30].

The main objectives of this research were to quantify tannin content in various commercial tea beverages using UV/Vis spectrophotometry and to explore the correlation between tannin content and key attributes such as colour and price. The scope of this study includes developing a standardized UV/Vis spectrometry method, optimizing calibration, and comparing this approach with traditional techniques to assess its accuracy and practicality. Additionally, the study investigates how tannin levels influence the visual and economic aspects of tea products, providing valuable information for product differentiation and pricing strategies in the market.

## 2.0 EXPERIMENTAL PROCEDURE

### 2.1 Materials and equipment

This research focused on using commercial tea beverage from four different brands and flavors. The samples were obtained from local markets. The samples used in this study are tabulated in Table 1.

Table 1: Samples and main ingredients

Sample No.	Tea flavour	Price/ml	Color	Main ingredients
1	Jasmine green tea	RM1.65/300ml	Greenish-yellow	Brewed jasmine green tea, fructose, sugar, sodium polyphosphate, ascorbic acid, sucralose, and flavoring
2	Iced lemon tea	RM1.50/300ml	Brownish with a lemony taste	Water, sugar, fructose, citric acid, flavoring, black tea extract, vitamin C, lemon juice concentrate, acesulfame potassium, and sucralose.
3	White Grape Green Tea with Aloe Vera	RM2.00/300ml	Yellowish-green	Water, aqueous extract of green tea, cane sugar, aloe vera, permitted flavorings, food containers (citric acid), and vitamin C.
4	Iced Black Tea	RM10.10/300ml	Deep reddish-brown	Tea extract from fresh black tea, water, cane sugar, natural bee honey, citric acid (INS330), natural flavors, ascorbic acid (vitamin C E330), acesulfame-K (E950) and sucralose (E955)

This study employed UV/Vis spectrophotometry, a method that measures the absorption of ultraviolet and visible light to quantify tannins within a wavelength range of 250 to 400 nm. Due to its simplicity, speed, and cost-effectiveness, UV/Vis spectrometry offers a valuable alternative to traditional, more complex methods of tannin analysis [31]. This approach provides insights into the quality and consistency of tea, making it a reliable tool for assessing tea products.

### 2.2 Sample Preparation and Analysis

The preparation of reagents involved five main solutions. First, a tannin standard solution of 100 mg/l was prepared by dissolving 100 mg of tannic acid in 100 ml of distilled water. A disodium EDTA solution (0.05M) was prepared by measuring 12.5 ml of EDTA solution and diluting it to 25 ml with distilled water. For the ferric chloride solution (0.01M), 0.041 g of ferric chloride was dissolved in distilled water and diluted to 25 ml. An acetate buffer at pH 4.4 was prepared by dissolving 15 g of acetic acid and 20 g of sodium acetate in 250 ml of distilled water. Calibration standards were prepared using tannin standard solutions in 25 ml volumetric flasks, with final concentrations ranging from 0.0 to 5.0 mg/l. The preparation of tea samples involved several steps. Firstly, 0.32 ml

of the tea sample was measured into a 25 ml volumetric flask, followed by the addition of 2.5 ml of ferric chloride solution. This mixture was then heated at 80 °C for 20 minutes. After heating, the solution was mixed with 2.5 ml of acetate buffer and 0.5 ml of EDTA solution, then allowed to cool before being diluted with distilled water and mixed thoroughly. The absorbance of the sample was then measured using a 10 mm path-length cuvette in a UV/Vis spectrophotometer at 270 nm.

The analysis using UV/Vis spectrometry involved calibration of the spectrophotometer with a blank solution (0 ppm) and tannin standards ranging from 1.0 to 5.0 ppm. The absorbance of each tea sample was measured at 270 nm, and a calibration curve was plotted for the tannin standard solution to determine the tannin concentration in the samples.

Additionally, the visual comparison of colors for various commercial tea beverages was conducted. Iced lemon tea exhibited a brownish hue with a hint of lemon, suggesting a blend of black tea with a citrus element. Grape green tea with aloe vera appeared yellowish-green, indicative of a green tea base with a lighter, fresher profile. Jasmine green tea showed a greenish-yellow color, suggesting a stronger green tea presence with a balanced flavor. Lastly, iced black tea presented a deep-reddish brown, indicative of a robust black tea with complex notes.

The analysis was conducted using the UV-1800 Shimadzu Spectrophotometer at 270 nm, with distilled water serving as the blank reference. Proper handling of cuvettes was emphasized to avoid measurement errors caused by fingerprints or dust on the clear sides of the cuvettes.

### 3.0 RESULTS AND DISCUSSION

The colour of tea can be visualised as in the Figure 2 below. It could be observed that jasmine green tea (2.9166 ppm) have a higher number of tannin content, followed by iced black tea (2.5008 ppm). Then, iced lemon tea and white grape green tea with aloe vera had a lowest tannin content which were 2.2824 and 2.4227 respectively. The tannin content in tea samples are tabulated in Table 2.

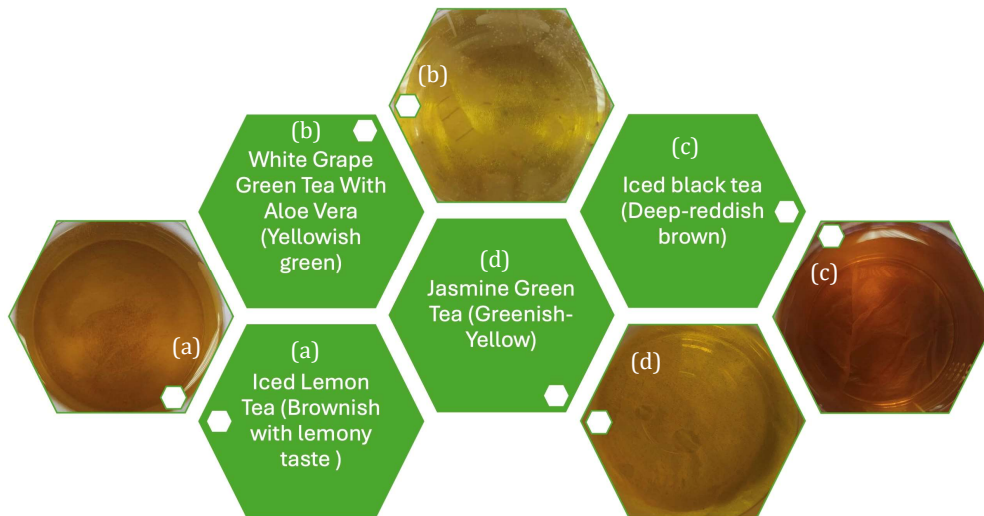


Figure 2: Brand and Colour of Tea

Table 2: Tannin Content in Tea Samples

Brand/Flavour	Sample Number	Concentration, ppm
<b>Iced Lemon Tea</b>	1	48.21
	2	38.23
	3	47.73
	4	48.29
	5	45.78
	Total average	45.65
<b>White Grape Green Tea with Aloe Vera</b>	1	53.97
	2	48.39
	3	47.87
	4	49.57
	5	42.48
	Total average	48.45
<b>Jasmine Green Tea</b>	1	56.95
	2	58.87
	3	59.50
	4	57.00
	5	59.34
	Total average	58.33
<b>Iced Black Tea</b>	1	47.59
	2	51.66
	3	53.29
	4	49.46
	5	48.08
	Total average	50.02

The previous research using iced tea as materials [13]. Then, the results of tannin concentration would be different. Table 3 shows the comparison results between different tea but same flavours. Previous results recorded a tannin concentration of 155 ppm, while the findings showed a significantly lower concentration of 50.02 ppm in black tea flavour. This large difference may be due to several factors, such as the analytical methods used, the specific source or brand of the black tea, or differences in preparation methods. These variables could contribute to the lower tannin levels observed in this analysis.

For green tea, previous research found a very high tannin concentration of 1041 ppm, but the finding analysis found only 58.33 ppm. Similar to black tea, the disparity in tannin content could be related to the type of green tea used or the methodology. It is also possible that the previous study tested more concentrated forms of green tea, such as matcha, which would explain the higher levels.

Table 3: Comparison results between previous study

Flavour of Tea	Previous Results	Current Finding
Black tea	155ppm	50.02ppm
Green tea	1041ppm	58.33ppm
Black tea with flavoured	-	45.65ppm
Green tea with flavoured	-	48.45ppm

Overall, the comparison reveals significant differences in tannin content between the findings and previous research, particularly for black and green teas. The variability could be attributed to differences in tea processing, types of tea, and analytical methods used across studies. Additionally, our study provides new insights into tannin levels in flavored teas, which were not previously examined. These results underscore the need for standardized testing methods to accurately compare tannin content across different types and preparations of tea. The tannin concentration in current study is much lower than the 7% by dry weight standard set by the Malaysian Food Regulations 1985 [30]. This suggests that, based on the samples tested, the tea does not meet the regulatory requirement for tannin content, due to typical brewing conditions and conversion to dry weight.

The tannin concentration in tea is not directly related to its price. Factors such as tea variety, processing methods, and the parts of the tea plant used primarily determine tannin content. While price might reflect some quality aspects, it is not an accurate indicator of tannin levels. Lower-cost teas are often made from lower-quality leaves, stems, and dust, leading to higher tannin content and a more astringent flavor. In contrast, higher-priced teas typically use whole leaves or buds, are more carefully processed, and offer a smoother, refined flavor with potentially lower tannin content, emphasizing overall quality rather than just tannin levels.

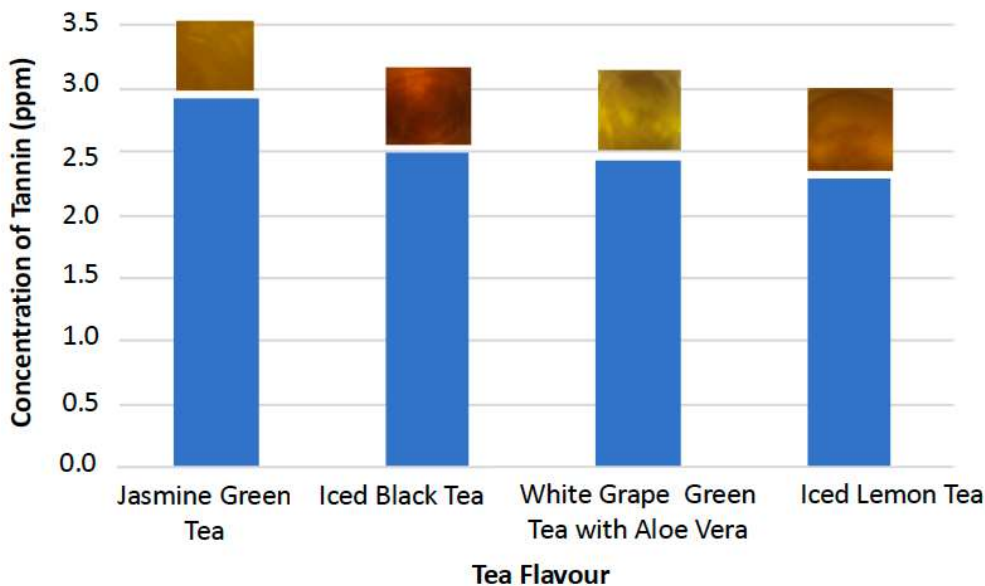


Figure 2: Tannin content in tea by each flavour

Figure 2 illustrates the color and tannin levels in different teas flavours, such as green teas, with their lighter color, usually have lower tannin levels due to minimal oxidation, resulting in softer

astringency. Black teas undergo extensive oxidation, releasing more tannins, which contribute to their darker color and robust, astringent flavor. For example, iced lemon tea, often made with black tea, typically retains the tannin content of its base tea, although additives like lemon and sugar modify its flavor profile.

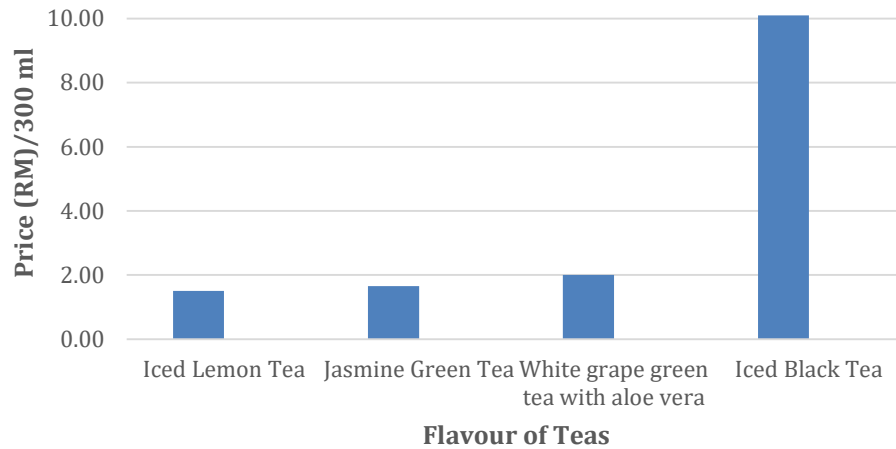


Figure 3: The difference between price and flavour of tea

Figure 3 illustrates the price per 300 ml for commercial tea beverages used in this research. The prices for iced lemon tea, jasmine green tea and white grape green tea with aloe vera are under RM 2.00 per 300ml, suggesting they target similar market segments focused on affordability. In contrast, iced black tea have a, priced at RM 10.10 per 300 ml, stands out as a premium brand, appealing to consumers seeking higher-quality or luxury teas.

#### 4.0 CONCLUSIONS

The final analysis in this research aimed to develop and validate a UV/Vis spectrophotometry method for analyzing tannin content in commercial tea beverages, investigate the correlation between tannin content, color, and price of these products, and ultimately provide a standardized protocol for tannin analysis. These findings contribute valuable knowledge to both the scientific community and the tea industry, promoting better quality control and product differentiation in the growing tea market.

The research successfully developed a UV/Vis spectrophotometry method adapted for tea products. This method included creating a calibration curve, selecting suitable wavelengths, and optimizing the sample preparation process. The new method demonstrated high accuracy and precision, as evidenced by consistent results across multiple trials. The UV/Vis spectrophotometry method proved effective in quantifying tannin concentrations with minimal sample preparation and without the need for hazardous reagents. By employing techniques such as UV/Vis spectrometry, tannin analysis helps maintain batch consistency by monitoring tannin levels across different batches, ensuring the desired taste and astringency. In analyzing the correlation between tannin content and other variables, the study found no significant correlation between tannin content and the color of teas. The color of tea was determined more by the type of tea leaves used and the specific processing techniques rather by tannin concentration. Similarly, there was no significant correlation between tannin content and the price of tea products.

Notably, low-cost teas, often less processed, tend to feature higher tannin content. Conversely, high-cost teas, derived from superior-quality leaves, are characterized by smoother, refined flavors

and an overall elevated quality. It is crucial to emphasize that the tannin concentration in teas can significantly vary. Green tea, for instance, typically exhibits lower tannin levels compared to flavored variants like iced lemon tea and white grape green tea with aloe vera. This nuanced understanding underscores the complexity of factors influencing both the pricing and tannin composition of various tea types.

In conclusion, the research successfully developed a standardized method for tannin analysis in teas, provided insights into the non-correlation between tannin content and key product attributes, and highlighted the importance of balanced tannin consumption for health. These findings contribute valuable knowledge to both the scientific community and the tea industry, promoting better quality control and product differentiation in the growing tea market. Beyond quality control, tannin analysis also plays a significant role in optimizing tea processing. The previous research, shows that it also helps monitor the fermentation process, particularly for teas like oolong and black teas, where tannin levels are critical for achieving the desired flavour and aroma. Understanding tannin content variations allows producers to fine-tune their processing methods, leading to consistent improvements in tea quality.

### Author Contribution

N. K. Adnan: Conceptualization, methodology, investigation, visualisation, writing and editing. S. I. Rani: Supervision, writing and editing.

### Conflict of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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