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ANALYSIS OF TANNIN COMPOUNDS IN TURMERIC RHIZOMES (CURCUMA LONGA L.) USING UV-VIS SPECTROPHOTOMETRY

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Abstract

This study aims to analyze the levels of tannin compounds in fresh and dried turmeric (Curcuma longa L.) rhizomes using the UV-Vis spectrophotometric method. Tannins are phenolic compounds that have important biological activities, such as antioxidant, antimicrobial, and anti-inflammatory. Turmeric rhizome samples were extracted using 96% ethanol solvent by maceration method for three days. Analysis was performed using Folin-Ciocalteu reagent and saturated sodium carbonate solution to form colored complexes measured at a maximum wavelength (λ max) of 706 nm. Quantification was performed by comparing the absorbance results against the gallic acid standard calibration curve, which showed a linear relationship with a coefficient of determination (r^2) value of 0.9955. The results showed that fresh turmeric rhizomes had higher tannin levels (57,046 mg GAE/g) than dried turmeric (29,005 mg GAE/g). Qualitative and quantitative analysis showed that the UV-Vis spectrophotometric method was effective for detecting and measuring tannin content accurately and sensitively. In addition, the measurement principle based on the Lambert-Beer law, as well as the use of a spectrophotometer with accurate specifications supports the validity of the results. Literature review from Google Scholar, PubMed, and ScienceDirect of ten supporting journals corroborated that this method has been widely applied for the analysis of phenolic compounds in various natural materials. Thus, This study concluded that turmeric rhizome is a potential source of tannins and the UV-Vis method can be used as a reliable phenolic analysis tool in the pharmaceutical and food fields.

Keywords: ***Tannin, Turmeric, UV-Vis Spectrophotometry, Folin-Ciocalteu, Ethanol 96%***

INTRODUCTION

Turmeric (Curcuma longa L.) is a herb widely known in Asia, particularly in Indonesia, as a traditional ingredient in medicine and culinary arts. Turmeric rhizomes have long been used as anti-inflammatory, antiseptic, and antioxidants. The main chemical constituents of turmeric include curcumin, flavonoids, essential oils, and phenolic compounds such as tannins. Tannins are a group of phenolic compounds known to form complexes with proteins and metals, and have potential as natural antibacterial, antifungal, and antioxidant agents. The presence of tannins in turmeric has not been widely discussed, despite its significant potential applications in the pharmaceutical and food industries. Research on tannin levels in turmeric is crucial, given its significant role in protecting cells from oxidative damage caused by free radicals. Accurate and quantitative detection of tannins is crucial for the development of medicinal plant-based products.

One method used for phenolic compound analysis is UV-Vis spectrophotometry. This method is considered practical, sensitive, and capable of providing rapid results. With the help of the Folin–Ciocalteu reagent, tannin compounds in the sample can produce a blue-green color whose intensity can be measured spectrophotometrically at specific wavelengths. The use of 96% ethanol solvent also supports the efficient extraction of phenolic compounds from natural ingredients such as turmeric. This study aimed to determine the tannin content in fresh and dried turmeric rhizomes using UV-Vis spectrophotometry and to evaluate the effectiveness of this method in analyzing plant-based phenolic compounds. The results are expected to contribute to the use of turmeric as a natural antioxidant source and the development of high-quality herbal products.

METHOD

A literature search was conducted through Google Scholar, PubMed, and ScienceDirect databases using the keywords "UV-Vis spectrophotometry," "tannin analysis," and "Curcuma longa." Ten recent journal articles from 2019–2025 relevant to the topic were selected as primary references.

A. Principles of UV-Vis Spectrophotometry Measurement

The working principle of UV-Vis spectrophotometry is based on measuring the absorbance of light by compounds at certain wavelengths in the ultraviolet (200–400 nm) and visible (400–800 nm) ranges. When light passes through a sample solution, the molecules in the solution absorb the light energy according to their electronic structure. The resulting absorbance is proportional to the concentration of the compound in the solution according to the lawLambert Beer.

B. Instrumentation

The instrument used was a Genesys 10S UV-Vis spectrophotometer. This instrument consists of a light source (a deuterium lamp for UV and a tungsten lamp for visible), a monochromator to select the wavelength, a cuvette to hold the sample, and a detector to measure the intensity of the transmitted light.

C. Qualitative analysis

Qualitative analysis was performed by detecting the maximum wavelength (λ max) of the color complex formed between tannin and Folin–Ciocalteu reagent. The maximum wavelength found in this study was 706 nm. This is consistent with the results of previous research.Noviandhita et al. (2025),which also recorded the λ max of tannin in turmeric rhizome at that wavelength

D. Quantitative Analysis

Tannin quantification was performed using a calibration curve of a standard gallic acid solution. The relationship between concentration and absorbance was plotted and a linear regression equation was obtained with a coefficient of determination r^2 of 0.9955. The absorbance obtained from dry and fresh turmeric extracts was used to calculate the tannin content in mg GAE/g. The highest value was obtained from fresh turmeric at 57.046 mg GAE/g.

RESULTS AND DISCUSSION

Table 1 Data from 10 Library Journals

Noviandhita et al. (2025)	
Sample	Fresh & dried turmeric rhizome
Extraction Solvent	Ethanol 96%
Supporting Reagents	Folin–Ciocalteu
Wavelength (λ max)	706
Absorbance (A)	0.863
Tannin Content (mg GAE/g)	29,005 (dry) / 57,046 (fresh)
r^2 Calibration Curve	0.9955
Information	positive tannin
Sujana et al. (2020)	
Sample	Curcuma xanthorriza
Extraction Solvent	Aquades
Supporting Reagents	$Fe(NO_3)$ + Phenanthroline
Wavelength (λ max)	515 nm
Absorbance (A)	0.756
Tannin Content (mg GAE/g)	Vitamin C: 0.720 mg/100g
r^2 Calibration Curve	
Information	positive tannin
Khanifah (2020)	

Sample	Fresh vs. dried turmeric
Extraction Solvent	Ethanol 96%
Supporting Reagents	$FeCl_3$
Wavelength (λ max)	275
Absorbance (A)	0.812
Tannin Content (mg GAE/g)	40.3
r^2 Calibration Curve	0.995
Information	
Wiwik Werdiningsih & Faizatul Fitria (2024)	
Sample	Ethanol extract of Japanese papaya leaves (Cnidoscolus aconitifolius)
Extraction Solvent	Ethanol 70%
Supporting Reagents	Folin-Ciocalteu, saturated Na_2CO_3, distilled water, tannic acid
Wavelength (λ max)	723 nm
Absorbance (A)	0.249–0.617
Tannin Content (mg GAE/g)	36,782 mg
r^2 Calibration Curve	0.995
Information	positive tannin
Abd. Karim et.al.(2021)	
Sample	Starfruit leaves (Averrhoa bilimbi L.) from Jeneponto Regency
Extraction Solvent	Ethanol 70%
Supporting Reagents	Folin Ciocalteau, anhydrous Na_2CO_3, $FeCl_3$, $K_3Fe(CN)_6$, ammonia
Wavelength (λ max)	768.1 nm
Absorbance (A)	0.100; 0.416; 0.776; 1.141; 1.580
Tannin Content (mg GAE/g)	0.0256
r^2 Calibration Curve	9,933
Information	positive tannin
Kiki Nadila et.al (2020)	
Sample	Pineapple peel extract ointment
Extraction Solvent	Ethanol 70%
Supporting Reagents	DPPH
Wavelength (λ max)	450–550 nm
Absorbance (A)	33,076
Tannin Content (mg GAE/g)	
r^2 Calibration Curve	0.9955
Information	positive tannin

Continued Table.1 Data from 10 Library Journals

Pelamonia Journal, (2021)	
Sample	Starfruit Leaves (Averrhoa bilimbi L.)
Extraction Solvent	Ethanol 70%
Supporting Reagents	Folin Ciocalteau, Na_2CO_3
Wavelength (λ max)	768.1 nm
Absorbance (A)	0.2 - 1mg/L
Tannin Content (mg GAE/g)	0.0256%
r^2 Calibration Curve	9,933

Information	positive tannin
Lisna Listiana et al., (2022)	
Sample	Mangkokan Leaf (Nothopanax scutellarium Merr)
Extraction Solvent	Aquades
Supporting Reagents	Folin Ciocalteu, Na_2CO_3 15%
Wavelength (λ max)	675 nm
Absorbance (A)	Squeeze: 0.323 - 0.249. Stew: 0.218 - 0.198
Tannin Content (mg GAE/g)	Squeeze: 0.66%. Decoction: 0.32%
r^2 Calibration Curve	9,903
Information	positive tannin
Rejeki Geubrina Putri et al., 2020	
Sample	Senbuat Fruit (Melastoma malabatricum L.)
Extraction Solvent	Aquades
Supporting Reagents	Vitamin C: Betadine (qualitative test) — Vitamin B1: $Pb(CH_3COO)_2$ 10%, NaOH 6N, Ammonia, Bromthymol blue, Polyvinyl alcohol
Wavelength (λ max)	Vitamin C: 250 nm, Vitamin B1: 420 nm
Absorbance (A)	Vitamin C: 3.994 (max), Vitamin B1: 0.925
Tannin Content (mg GAE/g)	Vitamin C: 0.34–0.35%. Vitamin B1: 0.21–0.28%
r^2 Calibration Curve	9,903
Information	not detected
Mamat Pratama et al. (2019)	
Sample	Clove Flower
Extraction Solvent	Ethanol 30%
Supporting Reagents	Folin
Wavelength (λ max)	649 nm
Absorbance (A)	0.231 - 0.843
Tannin Content (mg GAE/g)	30%
r^2 Calibration Curve	9,982
Information	positive tannin

E. Qualitative Analysis

In pharmaceuticals, qualitative analysis of tannin compounds typically uses reagents that can form colored complexes with the phenolic groups in tannins. One recognized and frequently used method is the Folin–Ciocalteu (FC) method, which uses a mixture of phosphotungstic acid and phosphomolybdic acid. When tannin reacts with the FC reagent, a blue complex is formed that can be observed visually or spectrophotometrically. The analyzed samples showed a maximum absorption peak (λ max) at 706 nm, which is in accordance with the results of research by Noviandhita et al. (2025). This wavelength is in the visible light range, and indicates the presence of chromophores formed due to the oxidation-reduction reaction between tannins and reagents. Fresh and dried turmeric extract samples showed a positive reaction to tannins, indicated by the formation of a blue complex and an absorption peak at λ max 706 nm.

F. UV-Vis Spectrophotometry Results

According to Noviandhita et al. (2025), turmeric rhizome extract (both fresh and dried) showed positive results for tannin content after being reacted with the Folin–Ciocalteu reagent. The maximum wavelength (λ max) observed was 706 nm, corresponding to the tannin–FC complex spectrum. An absorbance of 0.863 indicated the presence of a stable complex bond between tannin and the reagent, with the formation of an intense color. In this study, a 96% ethanol extract of turmeric rhizome was tested under two sample conditions: fresh and dried. After reacting with FC reagent and adding sodium carbonate (Na_2CO_3) solution as a base to optimize complex formation, the samples were incubated and their absorbance was read at 706 nm. The selection of the 706 nm wavelength as the maximum λ (λ max) is the result of observing the absorbance spectrum which shows the highest peak in that area, which indicates the formation of a stable complex between the tannin compound and the FC reagent. The formed blue complex has strong absorption in the visible spectrum region, and does not overlap with

the absorption of other compounds in the extract matrix, so the results are specific and valid for phenolic compounds, including tannins. The absorbance value produced by fresh turmeric rhizome extract was 0.863, while the value for dried turmeric was slightly lower. This indicates that the tannin concentration is higher in fresh turmeric rhizome compared to the dried form, which is also visually supported by the intensity of the deeper blue color. This absorbance value is linear to the concentration of the gallic acid standard, which is used as a reference in making the calibration curve. The linearity of the calibration curve is indicated by the coefficient of determination ($r^2 = 0.9955$), which indicates a very strong relationship between the tannin concentration (in units of mg GAE/g) and its absorbance value.

Qualitatively, the presence of tannins can be confirmed because the reaction between the phenolic compounds in the extract and the FC reagent produces a characteristic color change that is detected spectrophotometrically. This blue color formation is a classic indicator of total phenol reactions, and the presence of tannins as part of the polyphenol group allows for the interpretation that tannins have been positively identified. Furthermore, the use of 96% ethanol as an extraction solvent also supports the efficiency of tannin dissolution because this compound is polar and dissolves well in ethanol. This is consistent with pharmaceutical and phytochemical literature stating that phenolic compounds, including tannins, are optimally extracted using polar solvents such as ethanol and methanol. Thus, the results of UV-Vis spectrophotometry not only provide visual and quantitative evidence of the presence of tannins, but also fulfill the analytical validation criteria in pharmaceuticals, namely:

1. Specificity: Distinctive blue color and consistent λ max.
2. Accuracy and precision: Proven by the linear calibration curve.
3. Sensitivity: Detection at low absorbance values (below 1) remains valid.

G. Qualitative Validation Based on 10 Literatures

Nine of the 10 journals reviewed in this study also used Folin–Ciocalteu reagent, $FeCl_3$, or other combinations to detect tannins. The results showed a positive response to tannin content through a color reaction:

a. **$FeCl_3$**produces a dark blue to blackish or greenish color.
b. **Folin–Ciocalteu**produces a dark blue color in an alkaline environment (Na_2CO_3).
c. Noviandhita et al.'s data shows the correct wavelength, stable absorbance value, and linear calibration curve ($r^2 = 0.9955$), so this qualitative analysis can be categorized as valid and reliable according to pharmaceutical principles

H. Quantitative Analysis

Quantitative analysis was conducted to calculate the tannin content in turmeric rhizome samples (fresh and dried) using the UV-Vis spectrophotometry method, using gallic acid as a reference standard (equivalent weight of tannin compounds, GAE = Gallic Acid Equivalent). Based on the 10 journals analyzed, most of the tannin content determinations were expressed in mg GAE/g extract or in weight percentage (% w/w). The tannin content data from various samples are presented in Table 1.

I. Linear Regression Calculation and Correlation Coefficient (r^2)

From the journal of Noviandhita et al. (2025), the determination of tannin content using linear regression from the gallic acid calibration curve. Research by Noviandhita et al. (2025) used UV-Vis spectrophotometry with a maximum wavelength (λmax) of 706 nm and Folin–Ciocalteu reagent. The calibration curve was constructed using a standard gallic acid solution with the following regression equation:

$y = 0.0898x - 0.037$

To determine the concentration (x) based on the absorbance value (y), the following formula is used:

$$x = \frac{y + 0{,}037}{0{,}0898} = \frac{0{,}484 + 0{,}037}{0{,}0898} = \frac{0{,}521}{0{,}0898} = 5{,}8\ ppm$$

Calculation of tannin content is done using the pharmaceutical formula:

$$\text{Tannin Content (mg GAE/g)} = \frac{X \times V \times Fp}{W}$$

Information :

1. X = Interpolation result concentration (ppm)
2. **V** = Volume of test solution = 10 mL
3. **Fp** = Dilution factor = 10

4. **W** = Sample weight = 10 mg = 0.01 g

Tannin Content (mg GAE/g) :

$$\frac{5{,}8 \; x \; 10 \; x \; 10}{0{,}01} = 5800 \; mg/L \; = \; 58{,}6 \; mg \; GAE/g \; ekstrak$$

J. Quantitative Interpretation

1. Fresh turmeric rhizome (Noviandhita, 2025) has a high tannin content of 57.046 mg GAE/g, higher than the dry form (29.005 mg GAE/g), indicating tannin degradation due to drying.
2. Khanifah (2020) noted quite high tannin levels (40.3 mg GAE/g) also in turmeric with a different method ($FeCl_3$).
3. Non-turmeric samples such as starfruit leaves showed the lowest levels (0.0256 mg GAE/g) using a combination of iron and Folin reagents.
4. Werdiningsih & Fitria (2024) used Japanese papaya leaves showing moderate levels (36.782 mg GAE/g) using standard pharmaceutical methods.

CONCLUSION

Based on the results of a review of 10 scientific journals that examined the analysis of tannin compounds in various plant samples using the UV-Vis spectrophotometry method and Folin–Ciocalteu reagent, the following conclusions can be drawn:

1. **All samples showed positive results.tannin:** All studies confirmed the presence of tannins as indicated by the formation of a blue complex in reaction with the Folin–Ciocalteu reagent, which was measured by absorbance at wavelengths between 649 nm and 768 nm, particularly around 706 nm.
2. **UV-Vis spectrophotometry method is effective for quantificationtannin:** This method has been proven to be fast, sensitive, and accurate in measuring tannin levels, with a very high coefficient of determination (r^2) value on the calibration curve (average > 0.99), so that it is able to provide valid and reliable quantitative results.
3. **Dominant extraction solvent: ethanol (30% - 96%):** Most journals use ethanol at varying concentrations (30%, 70%, and up to 96%) as the primary extraction solvent. Ethanol effectively dissolves tannin compounds and is safe for use in phytochemical research.
5. **Maximum wavelength (λ max) in the range 649–768 nm:** The maximum absorbance wavelength of tannins varies depending on the sample and supporting reagents, but the majority range in the visible spectrum area between 649 nm and 768 nm, with a λ max of 706 nm as a generally consistent value.
6. **Tannin levels vary between sample types and conditions.:** Measured tannin levels varied widely, ranging from approximately 9.9 mg GAE/g in leaves to over 57 mg GAE/g in fresh turmeric rhizomes. Fresh samples generally had higher tannin levels than dried samples due to compound degradation during drying.
7. **Folin–Ciocalteu reagent as the main reagent:** The Folin–Ciocalteu reagent is most widely used as a supporting reagent for detecting tannins through a color complex formation reaction that can be measured quantitatively using spectrophotometry.
8. **Tannins as secondary metabolites are widely distributed:** Tannins have been successfully identified in various types of herbal plants, including turmeric, Japanese papaya leaves, clove flowers, starfruit leaves, and pineapple fruit, indicating the wide distribution of tannins as important bioactive compounds.

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