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Optimization Of Heating Time For Maximum Curcuminoid Yield In A Traditional Turmeric Tamarind Drink

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Abstract

Background: Jamu kunyit asam is a traditional Indonesian beverage whose health benefits are mainly attributed to curcuminoids from Curcuma longa L. However, their thermal instability and the lack of standardised heating duration may lead to degradation and inconsistent concentrations, affecting therapeutic reproducibility.

Objectives: To evaluate the effect of heating duration on curcuminoid content and determine the optimal heating time for maximising its concentration in jamu kunyit asam.

Methods: Fresh turmeric (Curcuma longa L.) rhizomes and tamarind were prepared and heated in water at 90 ± 2°C. Samples were collected at 5, 10, 15, 20, and 30 minutes. Curcuminoids were extracted using liquid–liquid extraction with chloroform and quantified by a validated UV–Vis spectrophotometric method at 423 nm. The analytical method was validated for linearity, accuracy, and precision. All measurements were conducted in triplicate. Statistical analysis was performed using one-way ANOVA to assess differences in curcuminoid content across heating durations, with significance set at $p < 0.05$.

Results: The analytical method was validated and demonstrated excellent linearity ($r = 0.9997$), accuracy (recovery = 92%), and precision (%RSD = 0.89). A non-linear relationship was observed between heating time and curcuminoid content, with the concentration reaching a maximum of 57.602 ppm at 10 minutes, then declining gradually to 24.576 ppm at 30 minutes.

Conclusion: The optimal heating time to achieve the maximum curcuminoid concentration in Jamu Kunyit Asam is 10 minutes at 90°C. Shorter durations result in incomplete extraction, while longer durations lead to significant thermal degradation of curcuminoids.

Keywords: *Boiled Herbs, Curcuma Rhizome, Curcuminoid, Spectrophotometry, Tamarind Fruit*.

Introduction

Turmeric (Curcuma longa L.) has been a cornerstone of traditional medicine for centuries, particularly in Asia. Its acclaimed health benefits are primarily attributed to a group of bioactive compounds known as curcuminoids[1]. The most prominent of these is curcumin, which alongside demethoxycurcumin and bisdemethoxycurcumin, constitutes the primary active fractions[2]. In Indonesia, turmeric is most commonly consumed as a traditional herbal drink combined with tamarind pulp (Tamarindus indica L.) and palm sugar[3]. This formulation known as Jamu Kunyit Asam (JKA) is deeply ingrained in local culture for its role in maintaining health and wellness. JKA exhibits several health benefits, including the promotion of menstrual flow, enhancement of digestive processes, reduction of gastric acidity, stimulation of the immune system, and aid in acne treatment[4–8]. These effects are attributed to the pharmacological properties of curcuminoids particularly curcumin and its derivatives which exhibit analgesic, antiseptic, anti-inflammatory, antimalarial, and antioxidant activities[7,9–11].

Curcuminoids, the rich compounds found in turmeric, possess poor solubility in water due to their classification within the flavonoid group[12]. Characterized by the presence of a phenolic, curcuminoid, typically dissolves more readily in hot water than regular water. This characteristic facilitates the effective extraction of curcuminoids from turmeric when the rhizomes are boiled. This process enhances the availability of beneficial compounds, making them more accessible for consumption and utilization in various applications. The heating time of herbal medicine has a significant impact on the levels of phenolic compounds[13,14]. Extended heating or boiling times generally lead to a reduction in these compounds, while increased temperatures can induce oxidation reactions that further diminish their content. Previous research has confirmed that heating an aqueous extract of Curcuma longa rhizome significantly impacts curcuminoid yield[15]. However, these findings were derived from systems containing only the pure extract and did not account for the influence of other ingredients. This is a significant limitation, as the presence of co-ingredients can alter the chemical

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environment, tamarind for instance in JKA[16–18]. A separate study demonstrated that curcumin exhibits greater stability in an acidic environment within a nano-dispersion system during storage[19]. This finding suggests that the inclusion of tamarind fruit, which provides a naturally acidic matrix, could potentially mitigate thermal degradation in a complex formulation like JKA.

The researcher conducted a study on the analysis of curcuminoid levels in the filtrate based on the heating duration of turmeric tamarind herbal drink. The aim is to determine the effect of boiling time on the curcuminoid levels and to identify the optimal boiling time for achieving the maximum curcuminoid content in turmeric tamarind herbal drink using the UV-Vis spectrophotometry method.

Methods

This study employed a UV-Vis spectrophotometer (Shimadzu UV2600) for quantitative analyses. The primary materials included fresh *Curcuma Longa* rhizome and *Tamarindus indica* fructus, procured from the standardized herbs in Wisata Kesehatan Jamu - Tegal, along with palm sugar purchased from local market, chloroform (Merck), distilled water, ethanol 96% (Merck), and curcuminoid standard (Sigma S7912154 219).

The rhizomes were thoroughly washed under running water and then cut into uniform 2 cm^3 cubes prior to use. Tamarind fruits were manually peeled to remove the brittle outer husk. The remaining material (the sticky pulp containing the seeds) was collected and subsequently used in this study. The palm sugar was thinly sliced to facilitate rapid dissolution during heating.

The ingredient composition for JKA was based on the traditional formula documented by Susan & Beers (2012)[20], using a ratio of 150 g fresh turmeric rhizome, 30 g tamarind pulp, and 20 g palm sugar per liter of water. However, a novel and controlled preparation method was developed for this study to enable precise optimization. Instead of conventional boiling, all ingredients were heated together in water until the mixture reached a stable temperature of 90 ± 2°C, which was then maintained. The heating duration was meticulously timed from this point, with samples collected at specified intervals.

During maintained heat, a 50 mL samples were taken at 5, 10, 15, 20, and 30-minute intervals. The aliquot was filtered prior to liquid-liquid extraction for curcuminoid isolation. Liquid-liquid extraction was performed by adding 10 mL of chloroform and vigorously shaking the mixture for 10 minutes in separation funnel. The mixture was then allowed to settle until a clear separation into two distinct phases was achieved. The lower phase was carefully separated and stored. This extraction process was repeated twice on the remaining aqueous phase to ensure complete recovery. The combined chloroform extracts were then evaporated at room temperature to dryness in a porcelain dish placed inside a fume hood. The resulting dry curcuminoid extract was subsequently dissolved in 10 mL of ethanol to prepare the test solution for spectrophotometric analysis.

A standard curcuminoid solution (1000 µg/mL) was prepared and serially diluted with 96% ethanol to create a calibration curve with concentrations of 0.5, 1, 1.5, 2, 2.5, and 3 µg/mL. The maximum wavelength for analysis was determined by scanning the 3 µg/mL standard solution between 400-600 nm. The analytical method was validated for linearity, accuracy, precision, selectivity, limit of detection (LoD), and limit of quantitation (LoQ). Accuracy was assessed via a recovery test (80-110% acceptance criteria), while precision was confirmed with a relative standard deviation (RSD) of ≤ 2% for six replicate measurements. Finally, the curcuminoid content in all test samples was determined by measuring their absorbance at the predetermined maximum wavelength against the validated calibration curve.

Result

The visual characteristics of the extracts throughout the process provided initial qualitative insights. The heated JKA samples exhibited a clear, bright yellow color. Following liquid-liquid extraction with chloroform and subsequent evaporation in a fume hood, the purified curcuminoid extract was obtained as a vivid orange, flaky powder. The maximum wavelength for curcuminoid analysis was determined to be 423 nm (Figure 1).

The analytical method was validated. The linearity test for standard curcuminoid solutions (0.5-3 µg/mL) yielded a regression equation of y=0.1949x + 0.147 with a correlation coefficient (r) of 0.9997. The accuracy test resulted in a %recovery of 92% (Table 1) where dilution factor is 20x. The precision test, conducted with six replicates of a 3 µg/mL standard solution, showed a %RSD of 0.8926%. The LOD and LOQ were calculated to be 0.0715 µg/mL and 0.2384 µg/mL respectively. The selectivity test confirmed that the absorption spectra of the sample and the standard were identical, with a maximum

wavelength of 423 nm and no significant interference from the JKA matrix (Figure 2).

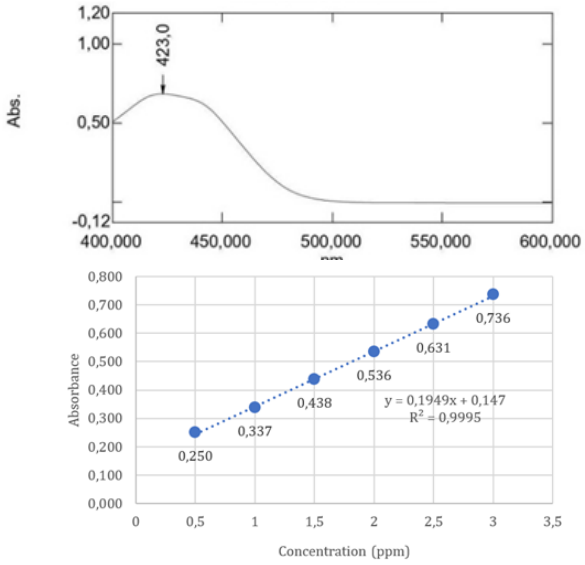

Figure 1. Spectrum of curcuminoid (top) and calibration curve (bottom) used throughout the study.

Table 1. Accuracy and Precision result

	Abs	Conc (ppm)	Result
Accuracy A	0,260	0,5798	Recovery = 92%
Accuracy B	0,287	0,7183	
R 1 Precision	0,731	2,9964	SD= 0,8969 RSD= 0,8926%
R 2 Precision	0,739	3,0375	
R 3 Precision	0,738	3,0323	
R 4 Precision	0,739	3,0375	
R 5 Precision	0,734	3,0118	
R 6 Precision	0,726	2,9708	

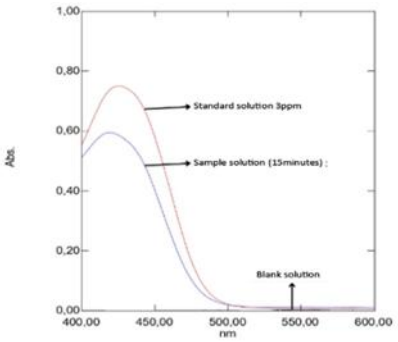

Figure 2. Selectivity result.

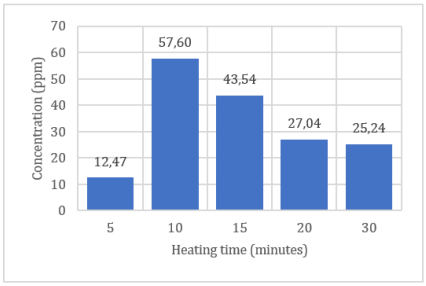

Figure 3. Level of curcuminoid measured in each different heating time

The curcuminoid content in the JKA samples was calculated using the regression equation and a 20x dilution factor. The results indicate an increase in dissolved curcuminoid concentration from 5 to 10 minutes of boiling, followed by a consistent decrease from 10 to 30 minutes. The highest curcuminoid level was observed at the 10-minute mark (Figure 3).

Discussion

The present study clearly demonstrates that the boiling time has a profound and non-linear impact on the curcuminoid content in JKA. The observed trend where a sharp increase to a peak at 10 minutes followed by a steady decline, reveals a critical interplay between extraction efficiency and thermal degradation.

Curcuminoids were isolated from the JKA samples using liquid-liquid extraction with chloroform. Chloroform was selected due to its ability to dissolve curcuminoids effectively and its immiscibility with the aqueous solution, a property aided by its higher density (1.476 g/mL) compared to water (1.0 g/mL). This process separated the curcuminoids from other water-soluble compounds in the JKA.

However, the pivotal finding of this study is the identification of the degradation phase post the 10-minute mark. Curcuminoids are known for their poor thermal stability. The decline in concentration beyond 10 minutes can be attributed to the degradation of these phenolic compounds under sustained heat[18]. Curcuminoids undergo oxidative decomposition when heated in aqueous solutions[25]. The degradation products, such as vanillin and ferulic acid, lack the extended conjugated system of curcuminoids[26]. This is a crucial point, as these breakdown products are reported to absorb light primarily in the lower UV range (280-320 nm) rather than at the visible wavelength of 423 nm, which is specific to the conjugated diketone structure of intact curcuminoids. Therefore, their formation would not contribute proportionally to the measured absorbance at 423 nm, directly explaining the observed decrease in the analytical signal over extended heating times[25]. This phenomenon is often visually confirmed by a lightening or browning of the solution, which was observed during the experiment.

The role of tamarind in this system is significant, primarily due to its high content of organic acids such as tartaric acid and malic acid, as well as ascorbic acid. These compounds impart a distinctly acidic character to tamarind pulp. Consequently, its inclusion in the JKA formulation substantially lowers the pH of the medium, creating an acidic environment[18,27]. The stability of curcumin

is highly pH-dependent; it is most stable in acidic conditions and undergoes rapid degradation in neutral or basic environments[28]. Therefore, the acidic environment provided by the tamarind plausibly acts as a stabilizing agent, slowing the degradation kinetics and allowing for a measurable peak at 10 minutes instead of an earlier, more rapid decline[29]. This highlights a potential synergistic interaction in traditional JKA formulations, where one tamarind may help preserve the bioactive components of turmeric.

This study has several limitations. The use of a fixed sub-boiling temperature (90°C) differs from traditional boiling, potentially limiting direct applicability to all preparation methods. Furthermore, the effects of individual ingredients (tamarind and palm sugar) on curcuminoid stability were not isolated, as the complete traditional formulation was used. Finally, while the UV-Vis method quantified total curcuminoids, it could not distinguish between individual curcuminoids with potentially different degradation kinetics. Future studies should investigate traditional boiling methods, deconstruct the formulation using factorial designs, and employ chromatographic techniques such as HPLC to obtain a detailed curcuminoid profile.

Conclusions

This study demonstrates that a 10-minute heating at 90°C yields the highest curcuminoid concentration in JKA, whereas shorter times lead to incomplete extraction, and longer durations cause significant thermal degradation.

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Author Contribution

Study design	:	ASR, RDR, NAN
Data acquisition	:	RDR
Data analysis	:	RDR, ASR, NAN
Manuscript writing	:	ASR, RDR, NAN

Competing Interests

The authors declare no conflict of interest.

Ethical Consideration

This research did not require ethical approval as it did not involve human participants, animals, or sensitive data.

Author Contribution

Study design	:	ASR, RDR, NAN
Data acquisition	:	RDR
Data analysis	:	RDR, ASR, NAN
Manuscript writing	:	ASR, RDR

Competing Interests

The authors declare no competing interests.

Abbreviation

JKA	:	Jamu Kunyit Asam
UV-Vis	:	Ultra Violet – Visible

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