**RESEARCH**

# A Validated TLC-Densitometric Analysis of Curcumin in Eight Important Zingiberaceae Rhizomes and Their ATR-FTIR Fingerprint Profiles

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## Abstract

Zingiberaceae family is highly significant, particularly in the food and medicinal sectors. Some of them are characterized by yellow-orange to pale yellow color due to their curcuminoid (curcumin, demethoxycurcumin, and bisdemethoxycurcumin) content leading to misidentification. Such misidentifications can result in reduced efficacy, compromised safety, and inaccuracies in quality control, highlighting the need for precise differentiation methods. This research aimed to differentiate eight Zingiberaceae rhizomes—*Curcuma longa*, *Curcuma xanthorrhiza*, *Curcuma mangga*, *Curcuma heyneana*, *Curcuma zedoaria*, *Curcuma aeruginosa*, *Zingiber montanum*, and *Zingiber aromaticum*—using curcuminoid profiles and curcumin content through TLC-densitometry and ATR-FTIR fingerprints combined with chemometrics. Thin-layer chromatography (TLC) employed silica gel 60 $F_{254}$ and chloroform:methanol (40:1, v/v) solvent system, confirming method specificity with identical UV–Vis spectra for standards and samples ($\lambda_{max} = 422$ nm). The method demonstrated high linearity ($r^2 = 0.9655$) for curcumin in the range of 200–1400 ng/band, with detection and quantification limits of 199.35 and 604.08 ng/band, respectively, alongside excellent precision and accuracy. Curcuminoids were undetected in *C. zedoaria* and *C. aeruginosa*, while the others exhibited varying curcumin concentrations, the highest in *C. longa*. ATR-FTIR combined with principal component analysis (PCA) and cluster analysis (CA) successfully differentiated all eight Zingiberaceae rhizomes as distinct entities. Each rhizome was clearly identified without forming any overlapping clusters. In conclusion, the ATR-FTIR method proved more sensitive than TLC, highlighting the need for multiple analytical approaches to accurately distinguish these rhizomes. These findings provide a critical foundation for improving quality control, ensuring the authenticity of raw materials, and supporting their safe and effective use in both traditional and modern applications.

**Keywords** Authentication · ATR-FTIR fingerprint · *Curcuma* · Curcuminoids · TLC-fingerprint · Zingiberaceae

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## Introduction

The Zingiberaceae, also known as the ginger family, is the largest family in the order Zingiberales, with over 52 genera and 1300 species (Alolga et al. 2022). These plants are characterized by their scented, creeping rhizomes or tubers. It is commonly found in tropical and subtropical regions, particularly in Asia, Africa, and the Americas (Alolga et al. 2022; Mahmudi et al. 2020). Due to its wide range of uses, including as a cooking spice or flavoring agent, food preservative, dye, medicine, cosmetic ingredient, and decoration, *Curcuma* is one of the most significant genera in the Zingiberaceae family. The number of species within the *Curcuma* genus has been reported to include up to 110 species (Sun et al. 2017). In addition to *Curcuma*, *Zingiber* is another