



Proposing monograph for the quality control of *Curcuma longa* L. in Cambodia

Chhavarath Dary^{a,b}, Philippe Bessioud^c, Anne Mandeau^c, Sunkaing Cheang^a,
Bernard Fabre^c, Sothea Kim^d

^aAix-Marseille University, Avignon Université, CNRS, IRD, IMBE, Faculté de Pharmacie, Marseille, France

^bPublic Health Unit, University of Health Sciences, 73 Blvd Monivong, Phnom Penh, Cambodia

^cLaboratoire des Produits Végétaux, Centre de R&D Pierre Fabre, Toulouse Cedex 1 France ^dUniversity of Health Sciences, 73 Blvd Monivong, Phnom Penh, Cambodia

*Corresponding author: dr_chhavarath@uhs.edu.kh
(accepted April 4, 2025)

ABSTRACT

Context: Turmeric (*Curcuma longa* L.) has been used for centuries in Khmer Traditional Medicine to treat various diseases especially gastrointestinal conditions. Due to its widespread use, this plant can be adulterated with other plants mostly those of the same genus and the detection of adulterants are mainly based on experienced traditional healers and herbalists. **Objectives:** Establish a monograph of turmeric to assure its quality. **Methods:** Primary and secondary rhizomes were obtained from a local market in Phnom Penh and five provinces in Cambodia. Analytical methods were selected from literature review and previously published monographs. Macroscopic and microscopic characterisation and physicochemical assays including color reaction, Thin Layer Chromatography (TLC) (toluene : acetic acid 80:20 v/v) and UV-Visible spectrophotometry were proposed in this monograph development. **Results:** Macroscopic, microscopic study and colored reaction were rapid and practical methods for turmeric identification while TLC provided good selectivity in differentiating turmeric from similar species *Curcuma zanthorrhiza* Roxb. To measure the curcuminoids, the active ingredients in Cambodian turmeric, a quantification method was realised by UV/Visible spectrophotometry at 427 nm and its content was not less than 5%. **Conclusion:** The affordable and reliable monograph of *Curcuma longa* was established to ensure its quality and regulate its usage.

Keywords: Cambodia, *Curcuma longa*, curcuminoids, medicinal plant, monograph, quality control.

INTRODUCTION

Curcuma longa L., popularly known as turmeric (Zingiberaceae) is a common spice of the world while originating from South or Southeast Asia. Curcumin and its derivatives, collectively known as curcuminoids (curcumin, demethoxycurcumin, bisdemethoxycurcumin), are the major bioactive compounds in turmeric that have received increasing attention from scientific community. Curcuminoids is a term used to describe the diarylheptanoids or diccinamolymethan derivatives (1997). Of more than 40 curcuminoids, at least 30 have been detected in turmeric rhizome (*Curcuma Longae Rhizoma*). Another class of active compounds in this plant is essential oils and to date more than 39 were isolated from its rhizome. Turmeric rhizome also contains sugars, sterols, flavonoids, organic acids, alkaloids, polypeptides, and a variety of minerals and trace elements such as Ca, K, Na, Zn, Cu, Mn, Pb, and Cd (Zhu et al., 2023). Thanks to its major bioactive constituent namely curcumin, *C. longa* possess antioxidant, anti-inflammatory, neuroprotective, anticancer, hepatoprotective, cardioprotective, immunomodulatory, antifertility, antimicrobial, antiallergic, antidermatophytic, and antidepressant properties (Fuloria et al., 2022). A significant number of clinical trials on curcumin and turmeric's extracts have completed phase 3 and suggested its efficacy and safety while the U.S. Food and Drug Administration has certified turmeric as "Generally Regarded As Safe" (GRAS) (FDA, 2024, NIH, 2024, WHO, 2011).

In Cambodia, *Curcuma longa* is used together as spice, cosmetic and medicinal plant. It is a popular spice in Cambodian curry paste called "Kroeung" (ក្រឡែង) which is one of the signature cooking ingredients in Khmer cuisine (Edelstein, 2011). In Khmer traditional medicine, it is administered in the form of powder or whole rhizome extract, either dried or fresh, mainly for digestive, anti-ulcer, choleric, jaundice, menstrual, post-partum bleeding, edema, contusion, wound healing and arthritis disorders. (Petelot, 1952, Cheng et al., 1996). The poultice made from the powder of this plant has been practiced by women for centuries to brighten and rejuvenate the skin (Gonipath and Karthikeyan, 2018). The consumption of turmeric and its traditional use in Cambodia is well-established and has a long history (Chhem and Antelme, 2004, Finot, 1903, Thuy, 2018). Despite the proven efficacy and safety of this plant, turmeric-based products are commercialised under the status of traditional medicine rather authorized drug, health or dietary supplements. Since herbal monograph focusing on the quality control of medicinal plants is not yet available, it is challenging to regulate medicinal plants and botanical products in the country. Under the technical and financial supports from Pierre Foundation and World Bank, an herbal pharmacopoeia project was launched in Cambodia focusing on the most commonly used medicinal plants including turmeric.

METHODS

Plant material: The collection of plant material was carried when aerial parts of the plants were withered usually between late February to early May in Cambodia. The plant materials consisted of two plant parts: primary and secondary rhizomes (Figure 1). First, rhizomes were purchased from herbal shops in Phnom Penh. The second part of the samples consists of rhizomes collected from Kandal, Kampong Cham, Kampot, Kep, Svay Rieng provinces. Sample information was summarized in Table 1. The

eISSN-0128-1119

© Asian Society of Pharmacognosy

DOI: <http://dx.doi.org/10.71221/ajp.09205>

obtained plant sampled were authenticated botanically by Prof. Cheng Sun Kaing, Cambodian well-known botanist of medicinal plants at Faculty of Pharmacy, University of Health Sciences. The herbarium specimens from fresh plants were deposited at Herbarium of Faculty of Pharmacy. After removing the dust and adventitious roots and cork, the resulting rhizomes were chopped into small pieces and dried in a ventilated oven at 45°C for five to ten days, depending on the moisture content. Finally, the plant material was stored in hermetically sealed pots, shielded from light, and placed in an air-conditioned room until the intended use.



Figure 1: primary and secondary rhizomes collected and washed:

Table 1. Characteristics of samples of *Curcuma longa* used in monograph development.

Code	Harvested part	Harvested date	Origin
E1	Primary and secondary rhizome	16/06/2011	Kandal
E2	Primary and secondary rhizome	11/06/2011	Kampong Cham
E3	Primary and secondary rhizome)	17/06/2011	Kandal
E4	Primary and secondary rhizome	22/06/2011	Svay Rieng
E5	Primary and secondary rhizome	26/06/2011	Kep
E6	Primary and secondary rhizome	27/06/2011	Kampot
E7	Primary and secondary rhizome	11/01/2012	Phnom Penh
E8	Primary rhizome	21/06/2011	Market
E9	Primary rhizome	21/06/2011	Market
E10	Primary rhizome	29/06/2011	Market

Macroscopic studies: Macroscopic and organoleptic studies were conducted on intact and powdered dried materials of primary and secondary rhizomes. All samples were observed for color, shape, odor, taste, size, fracture and other surface characteristics following Good Pharmacopoeial Practices (WHO, 2018). Morphological examinations were conducted using a magnifier ($\times 6$). Cross-sections were prepared by free hand sectioning cleared with glycerol 50 (v/v) (Sigma-Aldrich® G5516) and distilled water were used to increase visibility. All the images presented were taken by the author using a digital camera.

Microscopic studies: For powdered drug, shade dried material was ground and passed through sieve 10. The sample slides were observed by mixing the powder with distilled water and glycerol 50 (v/v) under light microscope (Mobic®, Serie SFC-18®). All the images presented were taken by the author using a digital camera (1997).

Color test: The color reaction was carried out under two protocols to detect the presence of curcuminoids in an acid-base medium.

Protocol 1: 0.5g of the plant drug was grinded and macerated in 5 mL of 96% ethanol (VWR BDH Prolabo® 20 108 292) for 5 minutes. Filter and finally add 1 mL of pure sulfuric acid (VWR BDH Prolabo® 20 692 290). The appearance of the characteristic purple color is observed (API, 1986).

Protocol 2: 0.5 g of dried turmeric powder was macerated in 5 mL of 96% ethanol. Next, a piece of filter paper was soaked completely with the obtained extract. Once dried, it was moistened with a mixture of boric acid (Merck®, 1,00165.0100) and hydrochloric acid (VWR BDH Prolabo®, 20 252 290) (1mg boric acid : 4mL water : 1mL chlorhydric acid). Once the paper is dried, it must pass through ammonia vapor (Merck®, 21 192 298) to observe the characteristic black color.

To ensure the selectivity of the reactions, the color test was compared to one related species *Curcuma zanthorrhiza* Roxb. (previously known as *Curcuma xanthorrhiza* D.Dietr.) and curcuminoids as the standard (2003).

Thin Layer chromatography: Identification of *Curcuma longa* was carried by thin layer chromatography to develop an optimal detection of curcuminoids present in this plant. Based on previous studies, four chromatographic conditions were studied as described in Table 2. Curcuminoids (Merck®, S5437154), fluorescein (Merck®, 46960) and thymol (Sigma Aldriche®, 72477) were used as the fluorescent and essential oil standards, respectively (1997). To determine the selectivity of TLC conditions developed in differentiate *C.longa* from *C. zanthorrhiza*, xanthorrhizol was used as the standard of the latter species (Rimpler et al., 1970).

UV-Visible spectrophotometry: UV-Visible spectroscopic method was optimized to quantify the content of curcuminoids in turmeric samples collected from markets and five provinces in Cambodia. The method was then studied for linearity, repeatability, and intermediate precision following ICH validation guideline of analytical procedure (ICH, 1995). Procedure: 0.5 g of freshly ground plant material was extracted under heating reflux in 30 mL of 96% ethanol for two hours and thirty minutes. The resulting extract was then cooled and filtered into a 100 mL flask before being topped up with 96% ethanol to the mark. One mL of the filtrate was taken to dilute to the 100th with

the same solvent and analyzed in UV-Visible spectrophotometre (Thermo® Helios α) (1997).

The content of dicinnamoylmethane derivatives was calculated by the following formula:

$$T = Ab \times 100 \times 100 / \epsilon \times M$$

Where T: Content of dicinnamoylmethane derivatives in %. Ab: Absorbance of the sample.

ϵ : absorptivity of curcuminoids. M: mass of the test sample in grams.

Table 2. Experimental conditions of Thin Layer Chromatography to detect curcuminoids in *Curcuma longa* Rhizomae

Sample preparation	Stationary phase	Mobile phase (v/v)	Spot volume	Revealing agent
Rhizome (0.5 g) macerated in methanol (20 mL) stirred for 15 min	Silica gel glass plate 60F _{254nm}	Ethyl acetate:hexane (70 :30 :1)	5 µl	-UV -Day light
Rhizome (0.1 g) macerated in methanol (5 mL) for 10 min	Silica gel glass plate 60F _{254nm}	Chloroform:benzene:ethanol (45:45 :10)	5 µL	-UV -Sulfuric vanilline solution and heating
Rhizome (0.2 g) macerated in methanol (20 mL) stirred for 20 min	Silica gel glass plate 60F _{254nm}	Chloroform:methanol:formic acid (96:4:0.7)	5 µL	-Day light -366 nm
Rhizome (1 g) macerated in ethanol (10 mL) stirred for 30 min	Silica gel glass plate 60F _{254nm}	Toluene:acetic acid (80:20)	5 µL	- 366 nm - Dichloroquinochlorimide

RESULTS

Macroscopic characters

Curcuma longa rhizomes have a characteristic aromatic odor. Their texture is hard and difficult to break. The taste is pungent and slightly bitter, coloring saliva and mucous membranes yellow after chewing. The primary rhizome is ovoid, and the secondary in length and 3 cm in width, and 8 cm in length and 1.5 cm in width, respectively. They bear scars sometimes in cyclic and collateral knots originating either from primary rhizomes, secondary rhizomes, or the stem. The slightly powdery, speckled outer surface, in yellow-brown, yellow, or gray-brown, is finely grained with

longitudinal striations. It may sometimes and occasionally exhibit the bark and scales as slightly pubescent. The transverse section of rhizome exhibits a shiny, smooth, non-fibrous, waxy granulation; three layers are shown from the outside to the inside: bark, cortical parenchyma, and endodermis; the latter is defined and larger than the cortical parenchyma; the epidermis (the skin) is irregular while the pericycle consists of more than 2 layers of cells; the coloration varies from pale yellow to orange-red. In cross-section, the observed spots correspond to the vessels that are more densely dispersed in the central cylinder than in the cortical parenchyma (Figure 2).

Microscopic characters

The powder drug microscopically of rhizome shows the following diagnostic and anatomical features: fragments of parenchyma sometimes colored yellow by curcumin, reticulated, spiral, or scalariform vessels, cork composed of brick-shaped cells; long and flexible unicellular trichomes, free or on epidermal fragments; oleoresin cells dispersed in the parenchyma. The free starch grains (sometimes in bottle-shape) or those included in parenchyma cells are generally altered and agglomerated into a pasty mass of starch paste; rare oval starch grains, with a punctiform hilum located in the narrow part, yellow masses released from parenchyma cells, phelloderm colored in red-orange, fiber, scale, dark yellow or orange mass. Thin layer epidermis filled with cubic cells of varying dimensions (Figure 3 and 4).

Color reaction

The results of the color reaction from the two tested protocols indicated that while procedure 1 is relatively simple and faster, it lacks an important analytical criterion—selectivity i.e. ability to differentiate *Curcuma longa* from closely related species, *C. zanthorrhiza* leading to potential misinterpretation (Figure 4). Indeed, *C. longa* and *C. zanthorrhiza* ethanol extract shared the same purple color after contact with sulfuric acid. In contrast, procedure 2, though more time-consuming and consumables, demonstrates superior selectivity with more reliable results (Figure 5). After passing by ammonia vapor, paper soaked with *C. longa* extract showed intense darkened color while *C. zanthorrhiza* was slightly dark (Figure 5 and 6).

Thin Layer Chromatography

Of the studied experimental conditions, primary and secondary rhizomes shared common chromatographic profile with three characteristic bands of curcumin, demethoxycurcumin and bisdemethoxycurcumin. The one involving the mobile phase (toluene:acetic acid 80:20 v/v) provided the best resolution (Figure 6). The three bands of the curcumin, demethoxycurcumin and bisdemethoxycurcumin in turmeric were well resolved with the R_f values of 0.28, 0.41, 0.53, respectively and they were comparable to those of the standards and positioned above the band of fluorescein. After revelation with dichloroquinoxaline solution, the chromatogram showed the characteristic spot of xanthorrhizol ($R_f=0.65$) just above the band of thymol which is a marker compound in *C. zanthorrhiza*. This highlighted the selectivity of chromatographic conditions in differentiating *C. longa* from similar species (Figure 7).

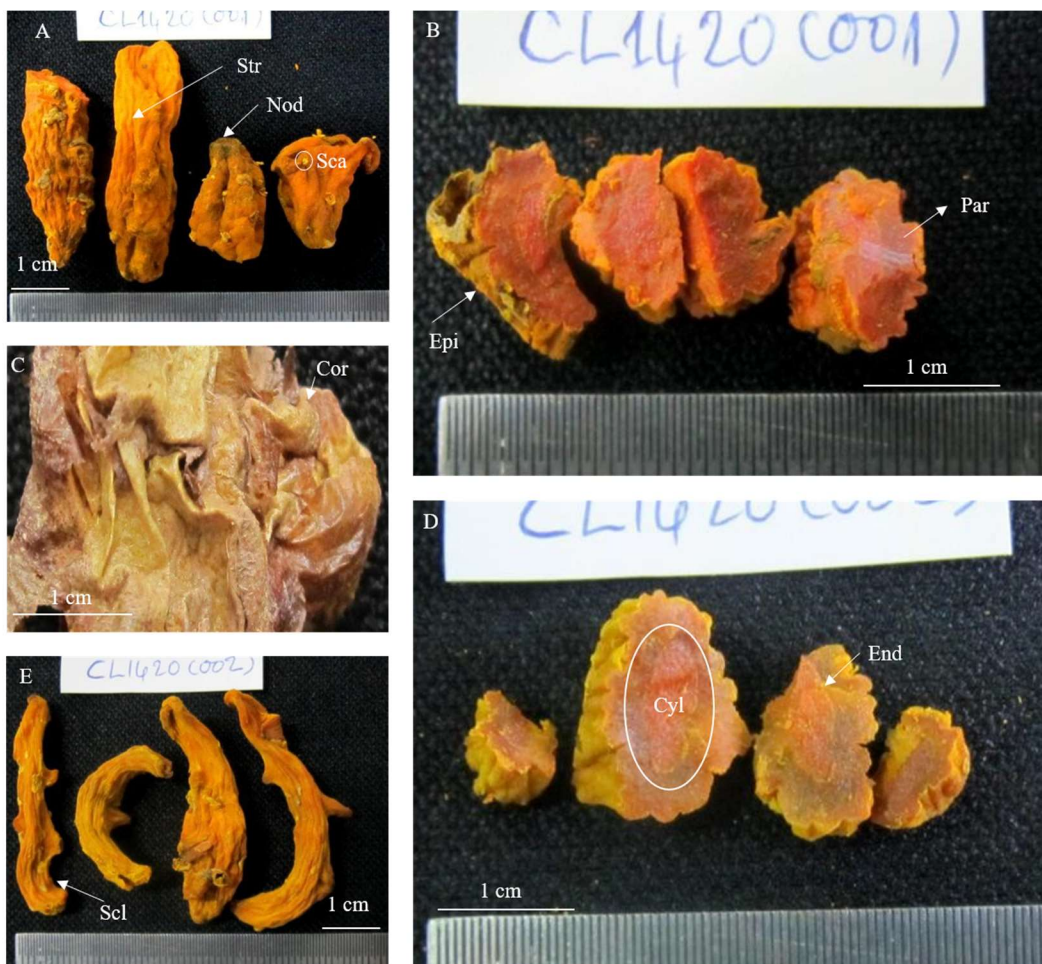


Figure 2. Macroscopic characteristics in dried turmeric. A. Dried primary rhizome (Str=longitudinal striates, Nod=cyclic node originating from pseudostem, Sca=adventitious root scars), B. Transversal cut of dried primary rhizome (Epi=epidermis, Par=parenchyma), C. Dried secondary rhizome with pubescent cork rhizome is cylindrical or digitated, stripped of adventitious roots, and can reach 6 cm layer (Cor: pubescent cork layer), D. Transversal cut of dried secondary rhizome (Cyl=central cylinder, End=endodermis), E. Dried secondary rhizome (Scl=scars of lateral branches of rhizomes).

UV-Visible spectrophotometry

The screening of spectra for standard solution of curcuminoids indicated that the maxima ranged between 427 and 428 nm (Figure 10). From external five-point standard curve from standard curcuminoid solution, the linearity was calculated using Linear regression model (p -value=0.05) and obtained the equation: $y=0.1347x+0.1456$ ($R^2=0.9852$). The absorptivity value was 1539 (1g/100 mL in ethanol 96%). The repeatability and intermediate precision were tested on three samples of turmeric and the analysis of each sample was carried out in triplicate. The resulting coefficient of variation (CV) of repeatability and intermediate precision ranged between 2 to 2.6% and 3.8 to 8%, respectively - indicating that the quantification of curcuminoids using this UV-spectrophotometric method was precised. The optimized spectroscopic method was applied to determine the minimum content of curcuminoids from turmeric rhizomes collected from 5 provinces. We found that primary rhizomes

eISSN-0128-1119

© Asian Society of Pharmacognosy

DOI: <http://dx.doi.org/10.71221/ajp.09205>

contained more diccinnamoylmethane content than secondary rhizomes, with the exception of those harvested in Kampong Cham province (One-way Anova, two-sided, p -value<0.05). Moreover, among the samples harvested, those from Kampong Cham, Kep and Svay Rieng had the highest content of diccinnamoylmethane derivatives: 12.30%, 11.60% and 11.30%, respectively (Figure 8 and 9).

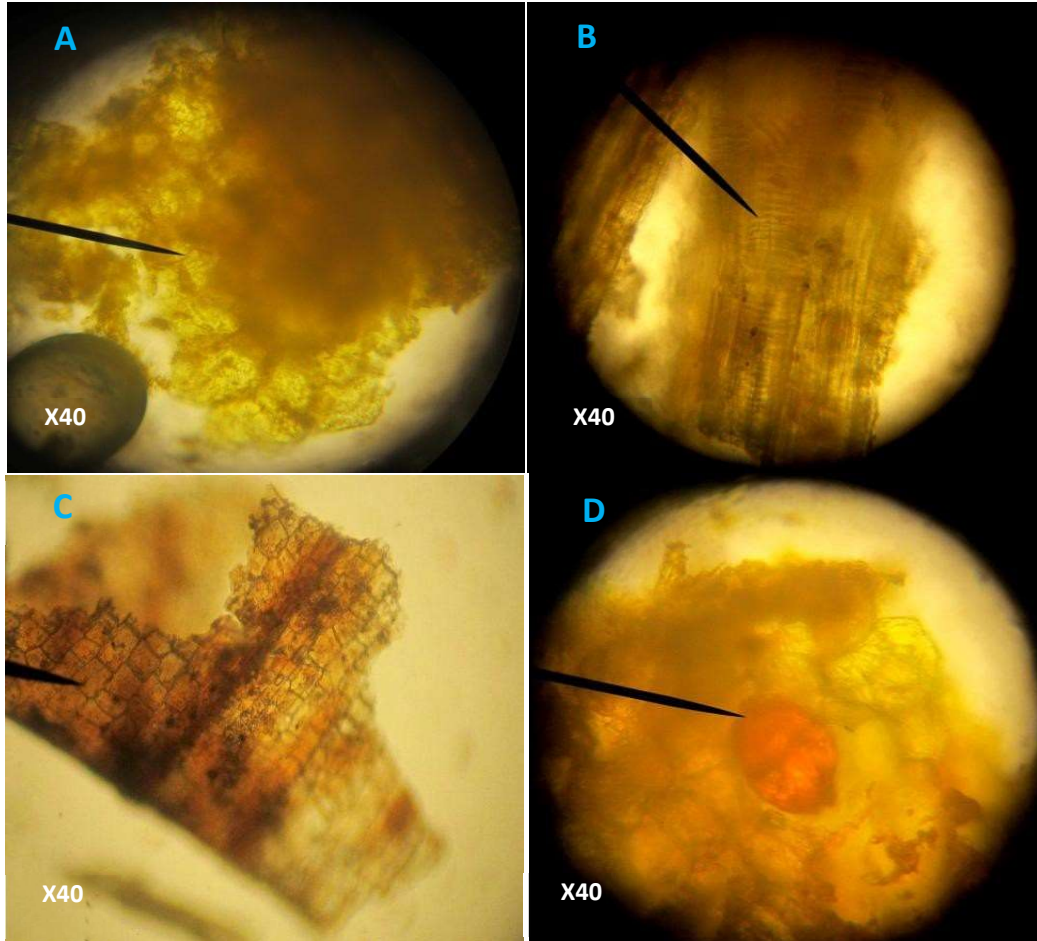


Figure 3: Microscopic characteristic elements in turmeric powder (A. parenchyma with yellow color of curcuminoids, B. spiral-shape vessels, C. cork composed of brick-shaped cells, D. oleoresin cells dispersed in the parenchyma).

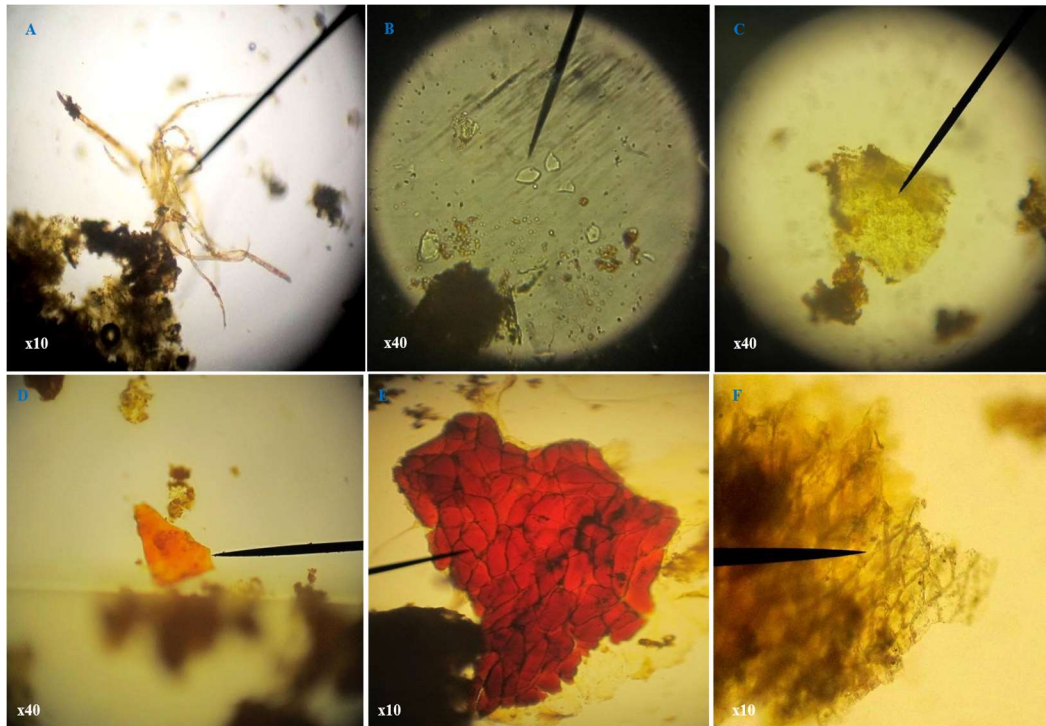


Figure 4: Characteristic microscopic elements in turmeric powder (A. Epidermis fragment with fibres, B. Intact starch grains with hilum (rare), C. Gelatinized starch, D. Orange parenchyma fragment, E. Phelloderm, F. Thin layer epidermis filled with cubic cells).

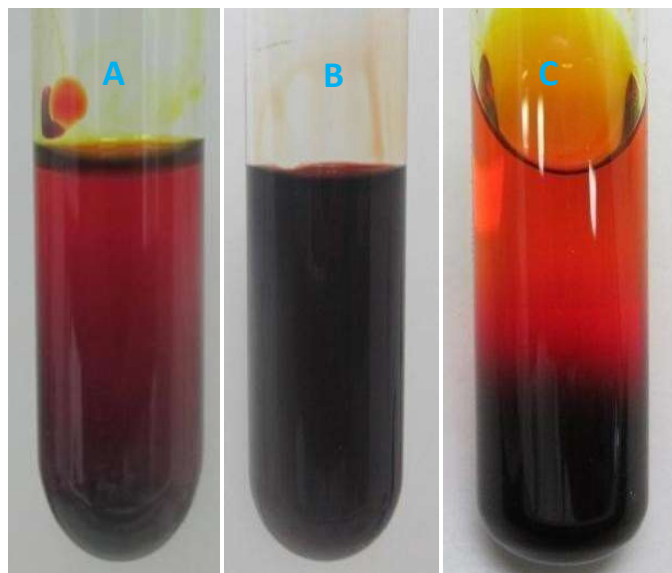


Figure 5: Similar purple color was observed in *Curcuma longa* extract (A), curcuminoid solution (B) and *C. zanthorrhiza* extract (C).

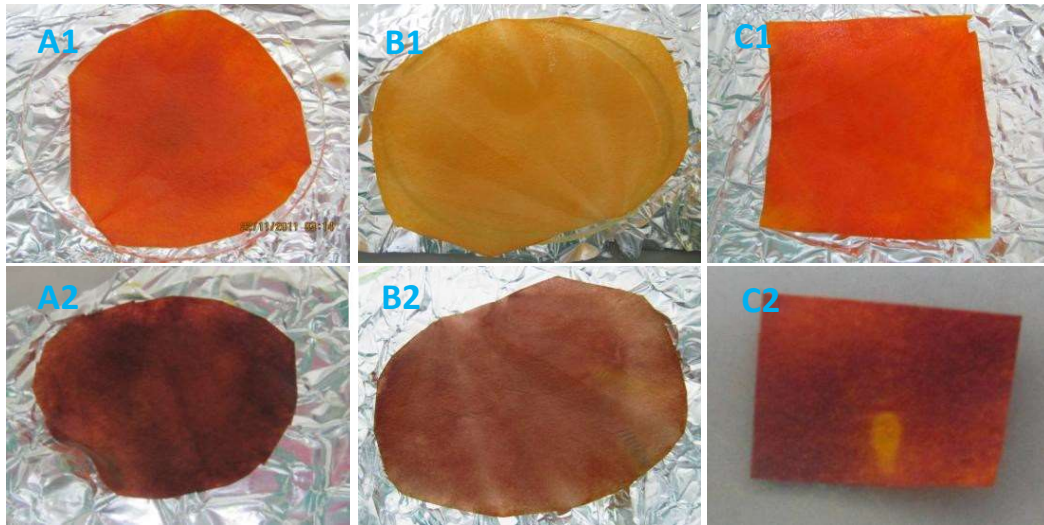


Figure 6: Papers after soaking in the ethanolic extract of *Curcuma longa* (A1), *C. zanthorrhiza* (B1), and curcuminoids (C1) before contact with ammonia; paper colors of *Curcuma longa* (A2), *C. zanthorrhiza* (B2), and curcuminoids (C2) after contact with ammonia vapor.

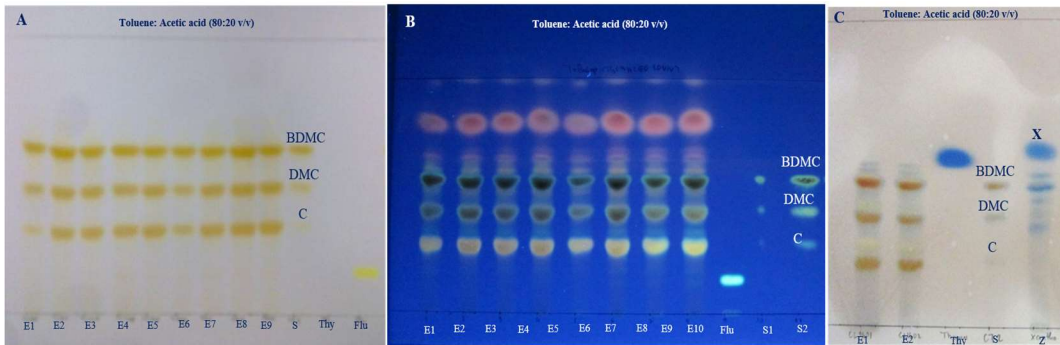


Figure 7: Chromatogram of the samples of *Curcuma longa* (E1-E10) and *C. zanthorrhiza* rhizomes (Z) eluted by toluene/acetic acid (80:20 v/v) revealed under day light (A), 366 nm (B) and after spray of dichloroquinoclorimide solution. BDMC=bisdimethoxycurcumin, DMC=dimethoxycurcumin, C=curcumin, Thy=thymol, Flu=Fluorescein, S=standard curcuminoids (S1 & S2) and X=xanthorrhizol.

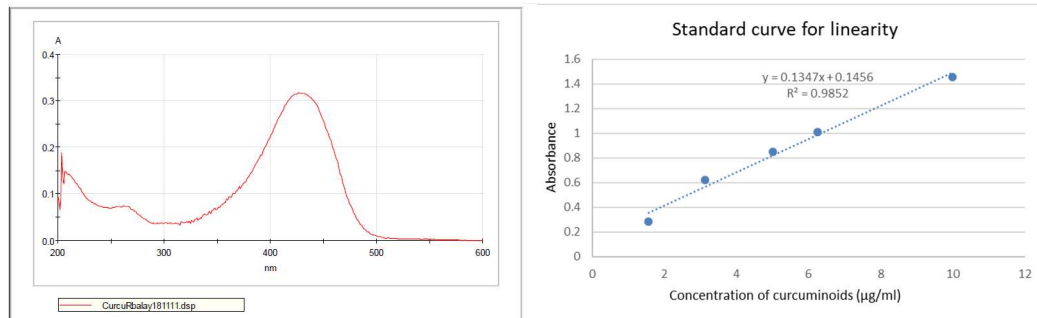


Figure 8: Absorption spectrum of curcuminoid solution with the maxima values and standard curve for linearity.

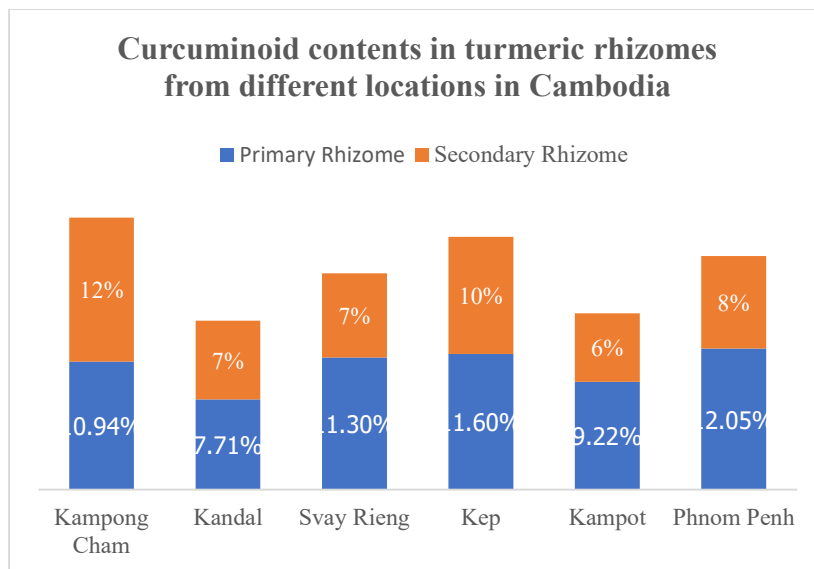


Figure 9: Contents of diccinamoylmethane derivatives measured by UV-Spectrophotometre. (KD: Kandal, KC: Kompong Cham; SR: Svay Rieng, KEP: Kep, KP: Kampot).

DISCUSSION

To the best of our understanding, the monograph of turmeric (*Curcuma longa*) focusing on quality control methods was first reported in Cambodia ranging from macroscopic and microscopic characterization, and physico-chemical assays including color reaction, chromatographic and spectroscopic methods. Macroscopic and microscopic characterization could be applied for the quality control of many forms of turmeric usage including fresh and dried and whole or cork removed. Macroscopic and microscopic characterization of crude drugs is a generally known as fast, practical, affordable, and the first steps of establishing the identity and purity of medicinal plants before any further tests. These methods are even more important and applicable in resource-limited context of quality control of medicinal plants (Zhao et al., 2011). As for color reaction, even though protocol 1 (API, 1986) was simple and fast to realize, it lacked of selectivity in differentiating with *Curcuma longa* from its similar species namely, *C. zanthorrhiza* (2003). More importantly, the quality control methods in the proposed monograph became more reliable and robust by the semi-quantitative and quantitative assays (Thin Layer Chromatography and UV-Visible spectrophotometry). While the optimized chromatographic conditions in this study were able to separate bioactive compounds in turmeric with good resolution and could be revealed by a wide range of revealing methods, this TLC method was more affordable to detect adulterant species *C. zanthorrhiza* comparing with molecular spectroscopic methods (Rohman et al., 2020). Also, in Indonesia TLC was applied to differentiate similar *Curcuma* species (Rafi et al., 2011). As for the analysis of curcuminoids that are the main bioactive compounds in quality assessment of turmeric, the optimized spectroscopic assay could detect the presence of curcuminoids and measure their content with good linearity and precision (CV was not greater than 15%) (ICH, 2022). However, HPLC analysis may serve as a useful method for the standardization of the drug (Wichitnithad et al., 2009).

From spectroscopic results on turmeric samples collected from different provinces, Cambodian turmeric may have agricultural and economic potentials as its content of curcuminoids was at least 6% which is higher than minimal threshold to be exported to big markets such as European Union (2-5%) (CBI, 2023). Despite the fact that turmeric is value for its curcuminoid content, its non-curcuminoid compounds such as turmerones, elemene, furanodiene, bisacurone, germacrone, calebin A, curdione, and cyclocurcumin possessed potential pharmacological activities (Nair et al., 2019). Expanding the analysis to other classes of bioactive compounds in turmeric monograph would be hence essential for this medicinal and cosmetic plant.

CONCLUSION

This study aimed to establish the monograph of *Curcuma longa* L. The results obtained provided practical and reliable methods for the quality control of this popular plant widely used for culinary, cosmetic and medicinal purposes thus contributing to the regulation of turmeric use in Cambodia.

ACKNOWLEDGEMENTS

The work has been successfully carried out thanks to grants from Pierre Fabre Foundation and Laboratoire Commun de Phytochimie (University of Health Sciences – Pierre Fabre Foundation). The authors gratefully acknowledge support and encouragement from Prof. Cheng Sun Kaing, Prof. Tep Rainsy, Prof. Bun Hot, Prof. Tea Sok Eng, Dr. Mathieu Leti, and Dr. Bruno David.

DECLARATIONS OF INTEREST

None.

DECLARATION OF HONOUR

We declare in our honor that our results are not fake and made up.

REFERENCES

- API.** *Curcuma longa* Linn. THE AYURVEDIC PHARMACOPOEIA OF INDIA Part – I Ministry of health and family welfare; 1986.
- CBI.** Entering the European market for curcuma longa (turmeric). Centre for the Promotion of Imports from developing countries; 2023 [cited 2024]; Available from: <https://www.cbi.eu/market-information/spices-herbs/curcuma/market-entry>.
- Cheng SK, Cheng LB, Prak SS, Huon C.** Les plantes médicinales au Cambodge (Livre 1): Ministry of Health 1996.
- Chhem KR, Antelme MR.** The Treatment of the Four Diseases Manuscript. Siksācākṛ. 2004 (6). *Curcuma longae rhizoma*. Pharmacopée européenne. 3rd ed: The European Pharmacopoeia Commission; 1997.
- Curcuma longa* L. Iranian Herbal Pharmacopoeia. Teheran: Food and Drug Deputy of Health Ministry; 2002. p. 365.
- Edelstein S.** Food, Cuisine, and Cultural Competency for Culinary, Hospitality, and Nutrition Professionals: Jones & Bartlett Learning; 2011.
- FDA.** TURMERIC (*CURCUMA LONGA* L.). 2024 [cited 2024]; Available from: <https://www.hfpappexternal.fda.gov/scripts/fdcc/index.cfm?set=FoodSubstances&id=TURMERICCURCUMALONGA>.
- Finot L.** L'inscription sanskrite de Say-fong : II. L'inscription sanskrite de Say-Kong. Bulletin de l'Ecole française d'Extrême-Orient. 1903;3:18-33. doi: <https://doi.org/10.3406/befeo.1903.1187>.

eISSN-0128-1119

© Asian Society of Pharmacognosy

DOI: <http://dx.doi.org/10.71221/ajp.09205>

- Fuloria S, Mehta J, Chandel A, Sekar M, Rani N, Begum MY, et al.** A Comprehensive Review on the Therapeutic Potential of *Curcuma longa* Linn. in Relation to its Major Active Constituent Curcumin. *Front Pharmacol.* 2022;13:820806. PMID: 35401176. doi: 10.3389/fphar.2022.820806.
- Gonipath H, Karthikeyan K.** Turmeric: A condiment, cosmetic and cure. *Indian J Dermatol Venereol Leprol. Indian Journal of Dermatology, Venereology and Leprology.* 2018;84(1):16-21. doi: 10.4103/ijdvl.IJDVL_1143_16.
- ICH. ICH Topic Q 2 (R1) Validation of Analytical Procedures: Text and Methodology. International Council for Harmonisation of Technical Requirements for Registration of Pharmaceuticals for Human Use. : European Medicines Agency; 1995.
- ICH. Bioanalytical method validation and study sample analysis ICH; 2022.
- Nair A, Amalraj A, Jacob J, Kunnumakkara AB, Gopi S.** Non-Curcuminoids from Turmeric and Their Potential in Cancer Therapy and Anticancer Drug Delivery Formulations. *Biomolecules.* 2019 Jan 2;9(1). PMID: 30609771. doi: 10.3390/biom9010013.
- NIH. ClinicalTrials.gov. National Library of Medicine; 2024; Available from: <https://clinicaltrials.gov/search?term=turmeric&aggFilters=phase:3>.
- Petelot A.** *Plantes Medicinales du Cambodge, du Laos et du Vietnam Tome III* 1952.
- Rafi M, Rohaeti E, Miftahudin A, Darusman LK.** Differentiation of *Curcuma longa*, *Curcuma xanthorrhiza* and *Zingiber cassumunar* by thin layer chromatography fingerprint analysis. *Indonesian Journal of Chemistry.* 2011;11(1):71-4. doi: <https://doi.org/10.22146/ijc.21423>
- Residue Monograph prepared by the meeting of the Joint FAO/WHO Expert Committee on Food Additives (JECFA): Curcumin. Compendium of food additive specifications -Addendum 11: FAO/WHO; 2003.
- Rhizoma Curcuma Longae.* Pharmacopoeia of the People's Republic of China: Chemical Industry Press; 2000. p. 260-1.
- Rimpler H, Hansel R, Kochendoerfer L.** [Xanthorrhizol, a new sesquiterpene from *Curcuma xanthorrhiza*]. *Z Naturforsch B.* 1970 Sep;25(9):995-8. PMID: 4394594.
- Rohman A, Rawar EA, Sudevi S, Nurulhidayah AF, Windarsih A.** The use of chemometrics in combination with molecular spectroscopic and chromatographic methods for authentication of *Curcuma* species: a review. *Food Research.* 2020;4(6):1850 - 8. doi: [https://doi.org/10.26656/fr.2017.4\(6\).345](https://doi.org/10.26656/fr.2017.4(6).345).
- Thuy C.** Health and herbs in ancient Cambodia. Royal Academy of Cambodia 2018.
- WHO. International clinical trials registry platform. 2011 [cited 2024]; Turmeric Phase 3]. Available from: <https://trialsearch.who.int/Default.aspx>.
- WHO. WHO Technical Report Series 1010 Annex 7: WHO good pharmacopoeial practices: Chapter on herbal medicines. 2018.
- Wichitnithad W, Jongaroonngamsang N, Pummangura S, Rojsitthisak P.** A simple isocratic HPLC method for the simultaneous determination of curcuminoids in commercial turmeric extracts. *Phytochemical Analysis.* 2009;20(4):314-9. PMID: 19402187. doi: 10.1002/pca.1129
- Zhao Z, Liang Z, Ping G.** Macroscopic identification of Chinese medicinal materials: traditional experiences and modern understanding. *Journal of ethnopharmacology.* 2011;134(3):556-64. PMID: 21251968. doi: 10.1016/j.jep.2011.01.018
- Zhu X, Quan YY, Yin ZJ, Li M, Wang T, Zheng LY, et al.** Sources, morphology, phytochemistry, pharmacology of *Curcuma Longae Rhizoma*, *Curcuma Radix*, and *Curcuma Rhizoma*: a review of the literature. *Front Pharmacol.* 2023;14:1229963. PMID: 37719857. doi: 10.3389/fphar.2023.1229963.