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Evaluation of the Thermo and Photodegradation of Curcumin Contained in *Curcuma longa* Extracts, Cultuvar from Sibiti (Republic of Congo)

Madiélé Mabika Aimé Bertrand[1, 4], Biassala Eliane Thérèse[2, 3], Tamba Sompila Arnaud Wenceslas[4] and Loemba Safou Anice[4]

[1]*Life and Plant Chemistry Unit (UC2V), Faculty of Science and Technology, Marien Ngouabi University. BP. 69, Brazzaville- Congo*
[2]*Multidisciplinary Food and Nutrition Research Team: Regional Center of Excellence in Food and Nutrition, Faculty of Science and Technology, Marien Ngouabi University. BP. 69, Brazzaville- Congo*
[3]*National Institute for Research in Exact and Natural Sciences (IRSEN), Brazzaville, Congo*
[4]*National Institute for Research in Engineering Sciences and Technological Innovation (INRSIIT) Brazzaville, Congo*
**Corresponding author*

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A B S T R A C T

The objective of this study was to evaluate the thermo and photosensitivity of the biomolecules contained in *Curcuma longa* extracts. The effects of temperature and light on the stability of curcumin were established in this work. The results suggest that temperature and light induce in vitro structural change of the biomolecules available in the extracts. Analysis of the absorption spectra showed that aqueous extracts and hydro-alcoholic extracts do not absorb in the same wavelength. That is, 460 nm and 620 nm for aqueous extracts and 580 nm and 670 nm for hydro-ethanolic extracts. The kinetics of the thermodegradation of extracts studied between 40°C and 95°C for a duration between 0 and 60 minutes, shows the variations of absorbances as a function of temperature. Also, after 60 min of light irradiation, a decrease in the absorbances of the extracts was observed. Hydro-ethanolic extracts have been shown to be insensitive to heat and the effect of light irradiation.

Introduction

Plant-based colouring materials, natural ingredients and alternatives to certain increasingly controversial synthetic dyes and spices, are currently the subject of growing interest. Plant-based dyes therefore find a favourable context for industrial renewal, but must satisfy the constraints of current products and uses. In a context where environmentally friendly products are increasingly in demand, a return to natural dyes and spices could be considered for certain applications. Food additives are generally used in processed food products for the purpose of improving appearance, flavor, taste, color, nutritional value, and preservation, as visual appearance is an important factor in consumer product selection.

Today, the obstacle to their development is the inferior quality of natural dyes and spices in terms of rendering, colour fastness and cost compared to synthetic products. These problems could be solved by an in-depth study of

fixation methods and their physicochemical characterization. By Order No. 11421 of November 19, 2018, a project called "Support for the domestication and development of turmeric cultivation" was established in the Republic of Congo. The aim of this project is to strengthen the technical capacity for turmeric domestication.

For example, in Sibiti in the department of Lékoumou, turmeric fields are being developed. In parallelism, the transformation of this cultivar into a spice and colorant is the subject of an ongoing physicochemical study. Our study consists in evaluating the stability of aqueous and hydro-ethanolic extracts of *Curcuma longa*, a cultivar from Sibiti (Republic of Congo), through a comparative study with exotic turmeric.

Known above all for their flavour-enhancing effect, the rhizomes of *Curcuma longa* (Figure 1) are also thought to be excellent natural remedies that have the power to cure various infections. *Curcuma longa* is a perennial herbaceous plant belonging to the Zingiberaceae family, native to southern Asia. It is best known for its aromatic rhizomes with the colour of yellow gold. It is sometimes referred to as turmeric. It is widely cultivated in India but also, to a lesser degree, in China, Taiwan, Japan, Burma, Indonesia and Africa.

A very large number of studies on the species *Curcuma longa* (Ching *et al.,* 2014; Das *et al.,* 2015; Esatbeyoglu *et al.,* 2012; Liju *et al.,* 2013; Scotter, 2009), almost all of them contain curcuminoid, which is a mixture of polyphenolic pigments, including curcumin, and is responsible for its yellow coloration and pharmacological properties. This curcumoid mixture consists of 70-75% curcunine or diferuloylmethane, 15-20% dimethoxycurcumin, and 3-5% bisdimethoxycurcumin (Lee *et al.,* 2011; Péret-Almeida *et al.,* 2005).

Curcumin is a complex compound with chemical functions that can change depending on the direct environment, temperature and the presence of light. Curcumin is the main bioactive ingredient in turmeric extract and is widely consumed as part of the curry spice blend or as a dietary supplement.

Turmeric has a long history of therapeutic application in traditional Asian medicine. Biomedical studies conducted over the past two decades have identified a large number of cellular targets and effects of curcumin. Curcumin in vitro degrades rapidly during auto-oxidative transformation into various chemical species, the formation of which has only recently been appreciated (Claus Schneider *et al.,* 2015).

Curcuma longa is a spice known to have been used since ancient times in cooking and traditional medicine. When added at a level of 0.5%, this spice lowers the pH of preparations from 6.2 to 5.2 (Delveau, 1987). Turmeric is used, for its dark yellow color, as a food coloring.

Materials and Methods

Plant Material

The plant material consists of the two samples of *Curcuma longa* powder (Figures 3 and 4).

Turmeric cultivar powder from Sibiti (Cα), processed at the laboratory of the Life and Plant Chemistry Unit (UC2V) of the Faculty of Science and Technology of the Marien Ngouabi University.

Exotic turmeric powder (Cβ), bought in a grocery store in the Total market in district 2 Bacongo (Brazzaville).

Obtaining Turmeric Cultivar Powder from Sibiti

The rhizomes are cleaned before any process, the bark is removed from the surface of the rhizomes and roughly cut with a knife and then boiled for 45 minutes in distilled water until they become soft or until the characteristic smell of turmeric is smelled. After boiling, they are dried for 15 days in an oven at a temperature of 40°C, which is considered to be the optimal temperature. At this stage, the rhizomes are crushed and sieved to obtain a powder.

Preparation of aqueous and hydro-ethanolic extracts

The extracts were prepared according to the methods described by Oulai *et al.,* (2019) slightly modified. This method consists of extracting active substances from plants using water as a solvent for the aqueous extract and a mixed water-ethanol solvent with well-defined proportions for the hydroethanolic extract. The aqueous extract is obtained in the following way: 5g of rhizome powder Cα and Cβ respectively were stirred continuously in 20 ml of distilled water for 1 hour, The macerations are filtered with hydrophilic cotton wool placed in a

funnel. Cα and Cβ filtrates with a concentration of 0.25 g/ml are stored at a temperature of -20°C in the refrigerator. In the case of hydroethanolic extract, 5 g of turmeric powder Cα and Cβ respectively were continuously stirred in 20 ml of mixed solvent Water/Ethanol in a 50/50 ratio by volume for 1 hour.

The macerated grapes are filtered with hydrophilic cotton wool placed in a funnel. The Cα and Cβ filtrates with a concentration of 0.25 g/ml are stored at a temperature of -20°C in the refrigerator.

Determining the Maximum Wavelength of Extracts

Prior to the study of the thermodegradation and photodegradation of the Cα and Cβ extracts, the wavelengths for which the absorbance is maximum (λmax) were determined. Measurements were taken on a series of daughter solutions prepared by dilution of the stock solution. The spectra are obtained in the UV and visible range after spectroscopic scanning.

Stability assessment

The stability assessment consisted of the study of thermodegradation and photodegradation. The mechanisms were monitored by spectrophotometry using a SHIMANDA – 721 UV spectrometer equipped with a 1cm wide quartz tank.

Thermodegradation study

The solutions of aqueous and hydroethanoic extracts Cα and Cβ were exposed in an oven to temperatures ranging from 40 to 95°C for 0 to 60 min. The absorbance of each solution was determined at the maximum wavelength relative to each extract using a spectrophotometer.

Photodegradation study

It consisted of measuring the impact of UV radiation on the extracts. For this purpose, a UV lamp device that emits light rays with a maximum intensity at 254 nm was used to bombard the extracts. The solutions of the aqueous and hydro-ethanoic extracts Cα and Cβ were placed in a closed hermetic medium and then the light rays were sent to the samples for 60 min. The absorbance of each extract was determined at the maximum wavelength.

Results and Discussion

Spectral characteristics of extracts

The spectroscopic scan was used to identify the maximum wavelengths of the extracts. The profiles of the recorded spectra are shown in Figure 3.

The spectra (Figure 4) indicate the maximum wavelength of each extract

The analysis of the absorption spectra shows that aqueous extracts and hydroalcoholic extracts respectively Cα and Cβ do not absorb in the same λmax. A batochrome effect is observed between the aqueous extract and the hydroethanolic extract of turmeric cultivar of sibiti and between the aqueous extract and the hydroethanolic extract of exotic turmeric respectively. These results show that the solvent could induce this effect because the absorption wavelengths (λmax) of Cα aq/EtOH or Cβ aq/EtOH move towards longer wavelengths.

Thermodegradation of extracts

The kinetics of the thermodegradation of extracts were studied between 40°C and 95°C for times between 0 and 60 minutes. Figure 4 shows the variations in absorbance as a function of temperature. The thermal degradation evaluated by UV-Visible spectrophotometry at 460 nm and 620 nm respectively for aqueous extracts and at 580 nm and 670 nm for ethanolic extracts by exposing the different extracts obtained in the oven to different times and temperatures, showed that the biomolecules contained in the said extracts are heat-sensitive. By comparing the curves of different extracts, the results show that Cαaq and Cβaq extracts are more sensitive to heat, however the degradation trend of Cαaq/EtOH and Cβaq/EtOH extracts is weak. Also, for aqueous extracts (Cαaq and Cβaq), the degradation is low up to 20 min and increases between 25 and 60 min. There is a slight change in the color of the extracts. This study coincides with that of Lacheb *et al.,* (2002) who states that, turmeric loses about 85% of the curcumin when cooked for 15 to 30 minutes, however, this does not mean that there is a loss of its medicinal value. So, although the curcumin is broken down during cooking or heating, the color is not altered at all. Figure 6 shows the breakdown products of curcumin in the basic state during cooking (Suresh D. Kumavat *et al.,* 2013).

Table.1 Maximum wavelength value (λmax)

Nature of extract	$C_{\alpha\ aq}$	$C_{\alpha\ aq/EtOH}$	$C_{\beta\ aq}$	$C_{\beta\ aq/EtOH}$
λ_{max} (nm)	460	580	620	670

Figure.1 Rhizome of *Curcuma longa.*

Figure.2 Chemical structure of a curcuminoid: curcunine.

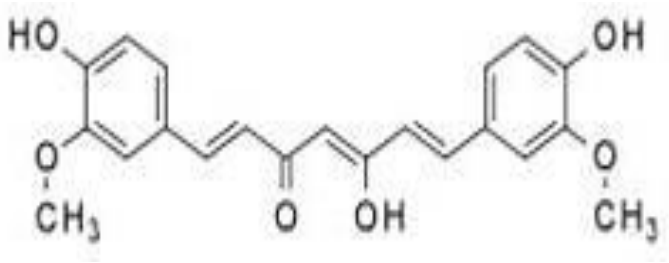


Figure.3 Sibiti cultivar turmeric powder (Cα)

Figure.4 Exotic turmeric powder (Cβ)

Figure.5 Spectral profiles of the extracts

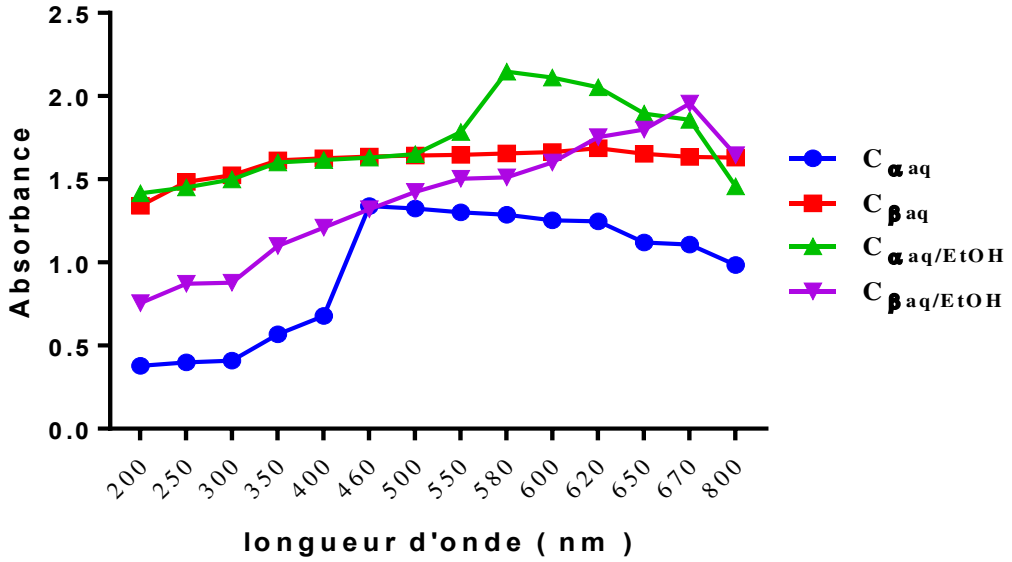


Figure.6 Variation in absorbance of aqueous and hydro-ethanolic extracts during heating

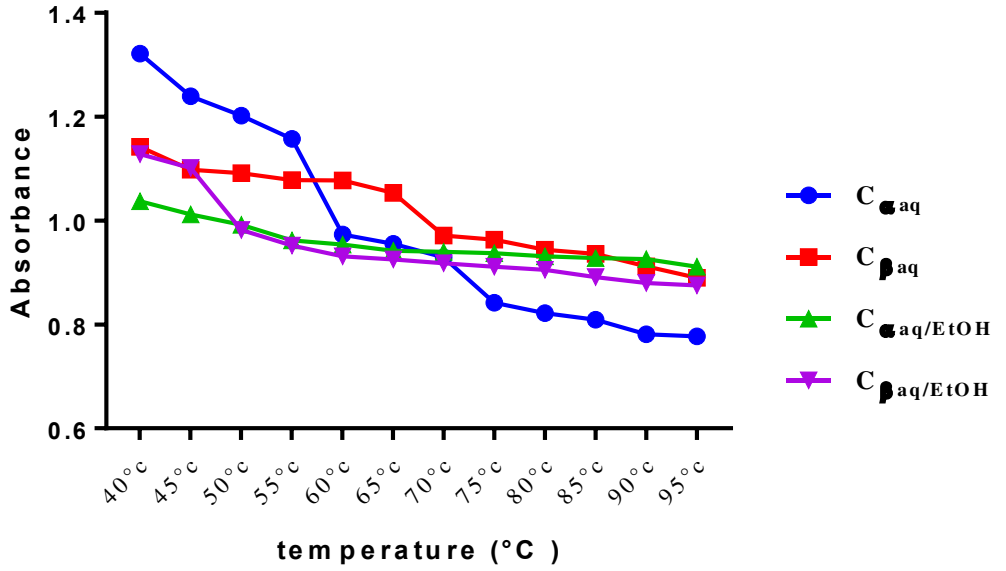


Figure.7 Variation in absorbance of aqueous and hydro-ethanolic extracts as a function of parboiling time (minute)

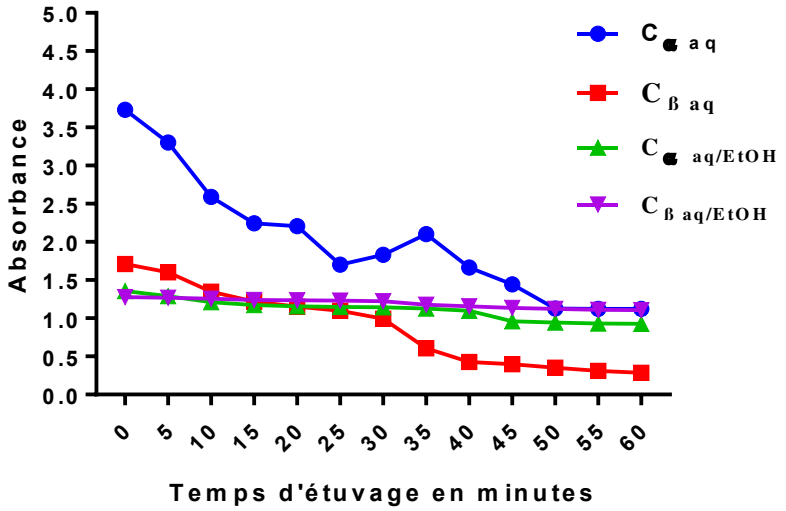


Figure.8 Degradation products of curcumin in the basic state

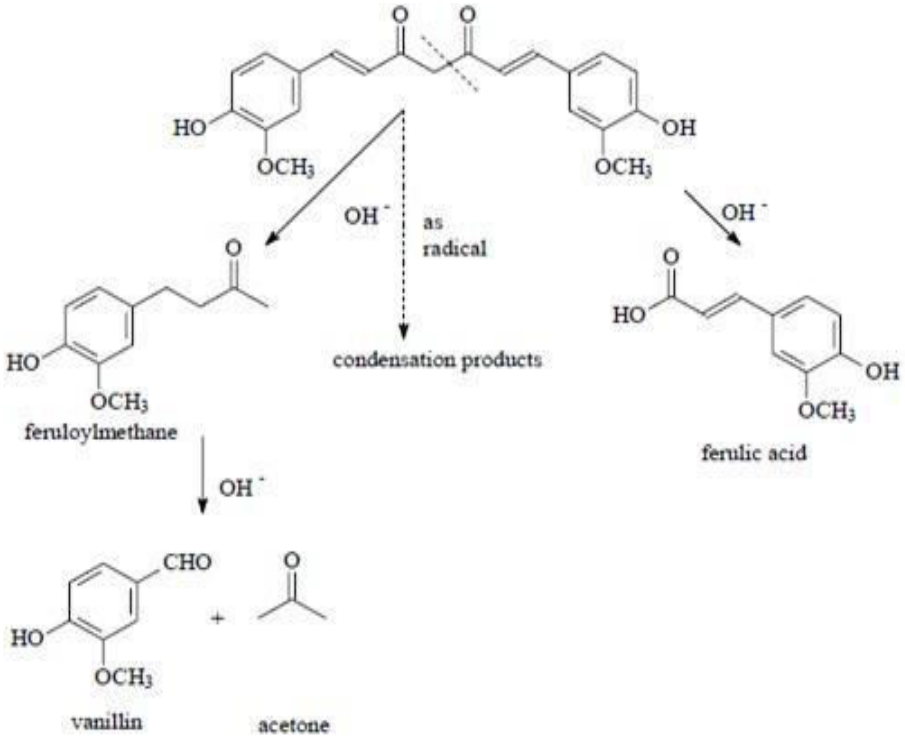
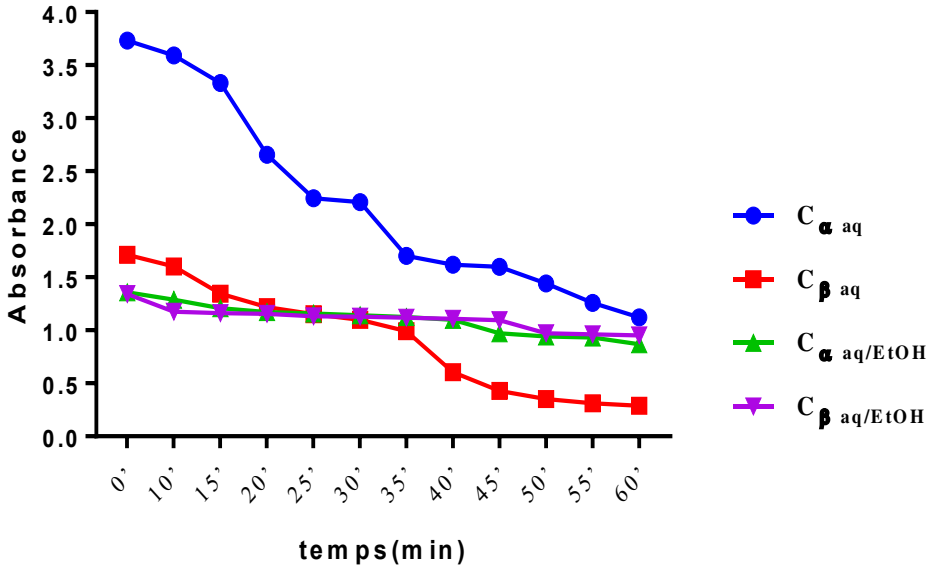


Figure.9 Variation in absorbance of aqueous and hydroethanolic extracts after exposure to UV radiation.



Photodegradation study

Curcumin could be degraded by light or photo-oxidized because it absorbs strongly in the wavelengths of the visible range. This photodegradation can be observed regardless of its chemical environment, crystalline state or solubilization, even in the absence of oxygen or UV light.

The photochemical degradation of curcumin depends on the time of exposure to light and appears to depend on the type of solvent used for extraction. Thus, after 60 min of light irradiation, a decrease in the absorbances of the Cαaq and Cβaq extracts was observed (Figure 7). As a result, the substances contained in aqueous extracts are more sensitive to light, whereas ethanol extracts are less sensitive to the effect of light irradiation.

These results confirm that the substances contained in the different extracts studied participate in photo-oxidation reactions, however the extracts do not change color. This allows us to deduce that light has no effect on the color change of the extracts. These results corroborate those of Wang *et al.,* (1997) and Ortica *et al.,* (2001) who note that light participates in the reaction that can damage photosensitive biomolecules. In addition, according to Maria Luisa del Castila *et al.,* (2015), curcumin degrades considerably in the presence of light, but it is very stable with temperature. From this work, it was deduced that exposure of curcumin to light induces two possible effects: the demethoxylation and isomerization of keto-enol in the form of a diceto in curcumin and the formation of small by-products such as methanol or acetate. Indeed, this observation by Maria Luisa del Castila is contrary to our results on the effect of temperature on extracts.

The many properties of *Curcuma longa* L. are attributed to curcumin. The objective of this work was to monitor the effect of temperature (heating) and light (UV radiation) on the stability of curcumin. Absorption spectroscopy was used to assess the actual effect of heating and UV radiation on curcumin stabilization. The study of thermodegradation and photodegradation led to the conclusion that temperature and light induce an in vitro change in the biomolecules available in *Curcuma longa* extracts. In addition, the nature of the extraction solvent influences the behaviour of the extracts. Curcumin has also been shown to undergo drastic degradation in the presence of light.

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Author Contribution

A. B. Madiélé Mabika: Investigation, formal analysis, writing—original draft. E. T. Biassala: Validation, methodology, writing—reviewing. A. W. G. Tamba Sompila:—Formal analysis, writing—review and editing. A. Loemba Safou: Investigation, writing—reviewing.

Data Availability

The datasets generated during and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethical Approval Not applicable.

Consent to Participate Not applicable.

Consent to Publish Not applicable.

Conflict of Interest The authors declare no competing interests.

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