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Antioxidant and hypoglycemic activities of *Curcuma longa* L. rhizomes harvested from the plateau of Bateke (Kinshasa), Democratic Republic of the Congo

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ABSTRACT

Introduction

Diabetes is a chronic disease that constitutes a public health problem worldwide and more particularly in Africa, because of its morbidity and mortality and the cost of its management. The use of nutritional therapy represents the best strategy for managing this chronic disease.

Purpose

The present work aimed to determine the chemical composition of *Curcuma longa* L. rhizomes and to evaluate their antioxidant and hypoglycemic activities.

Methods

Chemical screening, energy value, and anti-radical and anti-diabetic activities were respectively carried out according to standard protocols.

Results

The results of the chemical composition revealed that the rhizomes of *C. longa* contain (per 100g of fresh mater) proteins (2.81%), lipids (18.76%), ashes (5.08%), and fibers (1.79%). Phytochemical screening showed that *Curcuma longa* rhizomes harvested from the Bateke plateau contain secondary metabolites such as total polyphenols, anthocyanins, tannins, alkaloids, and steroids. The antioxidant activity of *C. longa* aqueous extracts showed interesting antiradical activity (IC50: 2.88 µg/mL). The hypoglycemic activity was assessed in vivo in NMRI mice, and our extract showed hypoglycemic activity with a medium glycemic load index.

Conclusion

Curcuma longa displayed in vivo antidiabetic activity and constituted a source of nutrients and can be valued as a food with good antioxidant properties likely to protect against pathologies associated with radicals. Scientific-based alternative medicine and nutritional therapy represent the best approach for managing chronic diseases.

INTRODUCTION

For centuries, populations have generally died of communicable diseases such as plague, cholera, tuberculosis, or influenza. Thanks to improved hygiene conditions, the development of the food industry, and advances in medicine, life expectancy has increased in recent decades. However, the proportion of chronic non-communicable diseases (CNCD) such as diabetes, arterial hypertension, cancers, etc. is significantly higher than before (WHO, 2016).

In March 2013 WHO's report stated that there are 347 million people with diabetes worldwide (Caroline, 2014). The prevalence of diabetes could well reach 10% with 552 million diabetics in 2030 according to the International Diabetes Federation (IDF), which also estimates that 183 million people are undiagnosed. 80% of diabetic patients live in developing countries, especially in Africa (Caroline, 2014; WHO, 2016).

Moreover, diabetes is a chronic disease that constitutes a real public health problem on a global scale more particularly in Africa, because of its morbidity and mortality and the cost of its management. Type 2 diabetes constitutes the bulk of this epidemic and represents 90% of diabetic patients worldwide. The number of type 2 diabetic patients is increasing in all countries (Caroline, 2014). Also, the report predicts that the burden of non-communicable diseases in general, and diabetes in particular, is becoming increasingly heavy in Africa and should take over that of communicable diseases by 2030 (WHO, 2013).

The main cause of chronic non-communicable diseases is oxidative stress, which is an imbalance between the production of free radicals and the body's antioxidant defenses (endogenous and exogenous) (Gutteridge et al., 2000; Rioux, 2009; Magali, 2013; Savina, 2014; Adoui et al. 2015). It has been shown that this imbalance may be due to a nutritional deficit in antioxidants, an endogenous overproduction of reactive species, environmental exposure to prooxidant factors (UV, ionizing radiation, etc.), or even the consumption of tobacco and certain medications (Auberval, 2010). This motivates the use of antioxidants as dietary supplements to reduce the prevalence of diseases due to oxidative stress and to maintain good health (Namani et al., 2016; Boukri, 2014). Food plants are one of the sources of antioxidants. This is the case of Curcuma longa, the literature of which indicates a remarkable antioxidant potential. A growing body of evidence reports that curcumin, a polyphenolic compound extracted from *C. longa*, is ten times more antioxidant than vitamin E and possesses anticancer and antimicrobial activities (Perry, 2008; Hombourger, 2010; Cheikh, 2013; Shanmugam & Bhavani, 2014).

Vaquier (2010) showed that the antioxidant potential of *C. longa* rhizome extracts is linked to the presence of a cocktail of polyphenolic compounds (curcuminoids). Furthermore, Jelena et al. (2016), reported that essential oils extracted from *C. longa* rhizome also exhibit antioxidant properties. Several works reported that *C. longa* rhizome extracts can scavenge free radicals (superoxide anions, hydroxyl radicals, H_20_2, nitrite radical, etc.), to inhibit or regulate the inducible enzyme of the synthesis of nitrite oxide (NO), iNO-Synthetase (iNOS), to prevent lipid peroxidation, to allow the chelation of metals, to maintain the activity of antioxidant enzymes such as superoxide dismutase, catalase, and glutathione peroxidase (Mbadiko et al., 2019).

Furthermore, several data from the literature indicate that extracts of rhizomes and leaves of *C. longa* have many pharmacological properties including antidiabetic potential (Roshan et al., 2017; Seggani & Boukehil, 2017). Vincent (2013) echoed recent studies accrediting the use of *C. longa* in type 1 diabetes to stimulate insulin secretion in the pancreas, and even to prevent type 2 diabetes very effectively in individuals predisposed to it (state of overweight and obesity, for example).

According to Vaquier (2010), the hypoglycemic action of *C. longa* extracts would result from the presence of polyphenolic compounds (curcuminoids) and sesquiterpenoids and/or their combined effects. The present study aimed to determine the chemical composition and evaluate the antioxidant and hypoglycemic activities of *Curcuma longa* rhizomes.

METHODS

A. Samples collection

The rhizomes of *C. longa* were harvested from the Bateke plateau in the city of Kinshasa. They were then sent to the Food and Nutrition Analysis and Research Laboratory (LARAN). They were cut into thin slices, then dried at

laboratory temperature for two weeks, and ground into powder. The powder obtained was sifted and stored in a plastic bottle away from light and humidity.

B. Laboratory animals

The evaluation of the hypoglycemic activity of the extracts was carried out in vivo: 10 male mice (Mus musculus) of NMRI (Naval Medical Research Institute) strains aged 3 months, whose weight varied between 19 and 26g were provided by the animal service of the I.N.R.B (National Institute for Biomedical Research) and used for the realization of our experiences.

Determination of nutrient composition

The chemical composition of the sample was determined in the nutrition and dietetics laboratory of the "Higher Institute of Medical Techniques" according to the method described by Makengo (2018).

Moisture determination

2 g of *C. longa* rhizome powder was weighed (P1) on a previously tared glass capsule (PO) using an analytical balance (Philips). The capsule and its contents were then placed in an oven (HERAEUS) set at 105 °C for 24 hours. After drying, the capsule was removed from the oven and cooled in a desiccator containing silica gel before being weighed again (P2).

The moisture content was calculated according to the following formula: (%) Humidity= (P1-P2)/(P1-P0) x 100

Where:
P0: Weight of the empty capsule
P1: capsule weight + sample + sample before incubating
P2: Weight of capsule + sample after incubating

Determination of total ash

Weighed using a porcelain crucible previously tared (P0), 2g of the sample to be tested (P1), were carbonized on a hot plate and then incinerated in a muffle furnace at 480°C overnight until to obtain the white ash which we also weighed (P2).

C.T (%) = (P1-P2)/(P1-P0) x 100 or % C.T =(P1-P2)/Pe x 100

Where:
Pl=Weight of the capsule + sample+sample before putting in the oven
P2: Weight of capsule + sample after incubating
Pe: P1-P0: test portion or fresh sample weight

Crude protein determination

The protein assay was carried out according to the KJELDAHL method (Makengo, 2018).

In summary, weigh 1 g of the sample to be tested then place it in a Kjeldahl tube; Incorporate a protein catalyst (3 g) and concentrated H_2SO_4 (20 ml) and mineralize the sample until a clear solution is obtained, which was placed in a 100ml volumetric flask and then cooled in the open air. 170 ml of distilled water was added to the solution and then 50 ml of 33% NaOH was placed in a reaction mixture in a distiller and 140ml of distillate was collected in an Erlen Meyer containing H_2SO_4 0.1N plus a few drops of mixed indicators. The distillate was then titrated with an H2SO4 0.1N solution to the equivalence point.

The calculation and expression of the results were done according to the following formula:
% GW= (VA-VB)x1.4xf/Pe

Where:
GW: Gross weight
VA=Volume of acid
VB=Volume of base
Pe = Test Portion or Sample Weight

The crude protein content is converted into nitrogen using the Cris and Sands factor (1978) inspired by OIE (1991).
% Nitrogen = % Crude protein x 6.25

Hence, f = Protein factor equal to 6.25 for foods in general.

Determination of total lipids

Total lipids were assayed using the Soxhlet method described by Vervack (Makengo, 2018). Briefly, 2 g of sample was weighed to be tested, then 20 ml concentrated HCl was placed on a hot plate to obtain a blackish leg, add 100 ml of hot water to the leg, then filter until the blackish leg stuck to the beaker is recovered and let it dry in the air the filter paper into a cartridge, weigh the empty capsule and then add 50 ml of n-hexane was added into the capsule; Next the cartridge, the empty capsule was placed in the extractor, by immersing the capsule in the glass extractor. After that, they were in use for 15 minutes and reweighed after cooling them in a desiccator.

The calculation and expression of results are based on the formula below:

MG (%) = P (Pf-Pcv)/(Pe) x 100

Where:
Pe= test portion
Pvc=empty capsule weight
Pf = weight of capsule with fat.
AT 5. Fiber determination

This method is based on the attack of the food substance under a reflux condenser by a mixture of acetic acid and nitric acid (KRUSHNER method) (Makengo, 2018).

A test sample was taken (from the extraction of the fat) in a flask with a ground joint, then 10ml of acetic acid and nitric acid were added and then it was heated for 30 minutes, stirred regularly. The reaction mixture was cooled and filtered using a previously weighed filter paper (Pfo). the residues were first washed with a dilute solution of glacial acetic acid (20 ml of acid + 20 ml of heated distilled water) and then with hot water, before drying them in an oven at 105 °C.

The empty crucible (Cv) or Co was weighed to carbonize the residue using filter paper (Pfi) and then incinerated at 650 °C, finally, it was cooled and then weighed.

The calculation and expression of results are found using the following formula:

(%)Fibers=[(Pf1-Pf0)-(C1-C0)]/Pe x100

Determination of Total Carbohydrates

It consists of subtracting from 100 the sum of the contents of the other constituents of the sample analyzed (moisture, proteins, lipids, fibers, and ash), as described previously (Makengo, 2018).

The carbohydrate content is deduced by applying the following formula:

% total carbohydrates = 100% - (% moisture + % protein + % ash+% fat +% fiber).

Energy values

It consists of adding the contents of the other constituents analyzed (moisture, proteins, ashes, lipids, and fibers). The calculation and expression of results, including the energy value, are deduced from the formula below:
Energy (in Kcal) = (% proteins x 4) + (% lipids x 9) + (% carbohydrates x 4).

Phytochemical screening

Chemical screening was carried out according to the method recently described by Mpiana et al. (2007) and Pawar et al. (2015).

Preparation of aqueous extracts

Using a sensitive balance, we weighed 5 g of *C. longa* rhizome powder which was then macerated in 50 ml of distilled water at room temperature for 24 hours before slight stirring. After 24 hours, the macerates were filtered using filter paper, and the filtrates were used for phytochemical screening.

1. Search for polyphenols

a. Research of total polyphenols (Mpiana et al., 2007). We searched for polyphenols using BURTON's reagent which consists of a mixture of FeCl3 2%, K3Fe (CN)6 1% (1:1, v/v):

   1 ml of aqueous extract was introduced into a test tube and then a few drops of BURTON's reagent. A blue color indicates the presence of total polyphenols.

b. Research of flavonoids (Mpiana et al., 2007).
   The search for flavonoids was done using the SHINODA reagent (95% ethyl alcohol, concentrated HCl, distilled water, Mg or Zn shavings):

   1ml of aqueous extracts of C. longa rhizome was taken into a test tube; a few drops of SHINODA's reagent and then some Magnesium shavings were added; effervescence is observed. In addition, a few drops of isoamyl alcohol were added to the reaction mixture and stirred vigorously to homogenize the solution. Different variants of colorations distinguish different types of flavonoids:

   Flavones: red to red-orange coloration;
   Flavanols: cherry red color;
   Flavanones: purplish red color

c. Research of anthocyanins (Mpiana et al., 2007).
Anthocyanins are water-soluble pigments that colour certain plants blue, red, or orange. They belong to the family of total polyphenols (Hopkins, 2013). This pigment can be detected using hydrochloric acid (20%).

d. Preparation of organic extracts
We placed 3 ml of extract in a test tube and a few drops of Hydrochloric acid. 20%, and heated in a water bath for 20 minutes.in the presence of anthocyanins, a purplish colour develops due to the formation of anthocyanin chloride which can crystallize.

Weigh 3 g of C. longa rhizome powder, and then macerate them in 30 ml of methanol for 24 hours. Filter the macerate obtained using Wathman paper. This filtrate is used for the detection of lipophilic compounds (steroids, triterpenoids, and free quinones).

Screening for steroids and triterpenoids (Mpiana et al., 2007).
The search for steroids and triterpenoids is done using Lieberman's reagent consisting of a mixture of concentrated sulfuric acid and concentrated acetic anhydride (2:1). Take 1ml of organic extract and place it in a test tube; then add a few drops of Liberman Bürchadat reagent. The appearance of a purple color indicates the presence of triterpenoids and steroids in a mixture while the purple or green color denotes the presence of triterpenoids and steroids respectively.

Search for free quinones (Mpiana et al., 2007).
The search for free quinones is done using Bornträger's reagent (NaOH 10% or NH4OH 10%). Take 1ml of organic extract and then place it in a test tube; add a few drops of Bornträger and shake vigorously. A change in the reaction mixture to orange or bright red predicts the presence of free quinones in the sample.

Evaluation of antioxidant activity (Makengo, 2018; Djolu et al., 2023; Masengo et al., 2023).
Spectrophotometry is a method of quantitative and qualitative analysis that consists of measuring the absorbance (optical density) of a given chemical substance generally in solution. The absorbance of the samples is determined by a spectrophotometer previously calibrated on the absorption wavelength of the substance to be studied. The more the sample is concentrated, the more it absorbs light within the limits of proportionality stated by the Béer-Lambert law (Jiri et al., 2010).

Sample preparation

i. Analysis of samples
Weigh 10 g of powder; Mix with 100 ml of hot water; Leave to macerate, in a beaker, for 30 minutes; Filter then collect the macerates; Place in an oven (40 °C) until the dry extract is obtained.

ii. Analysis solution
Dissolve 10 mg of dry extract of each sample in 1 ml of methanol for the total extracts and the polyphenolic fractions (solution A: 10 mg/mL). Perform dilutions to obtain the following concentration levels: 8 mg/mL, 6 mg/mL, 4 mg/mL, and 2 mg/mL for the total extracts and the polyphenolic (polar) fractions.

2, 2 Acid azino-bis (3-ethylbenzothiazolin-6-sulfonique (ABTS) radical test
The ABTS test was performed according to the method described by Kapepula et al. (2016). Briefly, dissolve in 500 µl of distilled water a quantity of ABTS reagent corresponding to 20 millimoles: solution A; Dissolve in 500 µl of distilled water a quantity of potassium persulfate (K2S2O8) corresponding to 10 millimoles: solution B; Mix solution A and B in equal volumes and keep the mixture protected from light for 12 to 16 hours: stock solution of the ABTS•+ radical; Dilute the radical stock solution x times with methanol to obtain an analysis solution whose absorbance varies between 0.800 and 1.000; Read the solutions successively for each concentration level (3 repetitions) on the spectrophotometer at 734 nm: the blank (methanol), the control solution, the sample solutions.

The percentage inhibition of the ABTS•+ radical by the sample is determined using the following formula:

Ax: the absorbance of the ABTS•+ radical in the presence of the extract

Ac: absorbance of the ABTS•+ radical (control solution)
The IC50 values of the different samples are determined using GrapPadPrism 6.0 software.

DPPH radical test

The DPPH• test was performed according to the method described by Kapepula et al. (2016) and Medjoujda (2017). Briefly, dissolve 3.2 mg of radical DPPH in 100 ml of 80% methanol; Keep the solution protected from light for at least one hour; The absorbance of this solution must be adjusted to 0.7 ± 0.05 using 80% methanol. Read the solutions successively for each concentration level (3 repetitions) on the spectrophotometer at 517 nm: the blank (methanol), the control solution, and the sample solutions.

Evaluation of hypoglycemic activity

The hypoglycemic activity was assessed using the techniques described by Médard et al. (2005 and 2009), Mohammad et al. (2014), and Bukatuka et al. (2016).

Preparation of solutions

0.1 g of glucose was completely dissolved in 1 ml of water to prepare the control (glucose) solution. While 0.201 g of sample powder containing 0.1 g of carbohydrate is dissolved in 1ml of water to prepare the powder solution.

Blood collection technique

The sample was taken by cutting off one end of the tail. The blood flowed spontaneously, without exerting a strong, without exerting a strong pressure (Médaille et al., 2005). Blood sugar was measured using a German brand glucometer: One touch Verio, which allowed us to follow the evolution of key measures of glycemic control on the reader. We repeated the test for all mice, after 30 minutes for 3 hours with a new strip each time.

Evaluation of the glycemic index

The glycemic indexes were determined by the classic technique of OGTT (oral-induced hyperglycemia) described by Médart (2009) and Pucheu (2005).

Briefly, induce hyperglycemia, by administering 4 g of carbohydrates per kilo of weight, i.e., 0.1 of carbohydrates contained in each portion of powder, and this per mouse (5 mice in groups of 2). The different solutions were administered by gavage to the mice. Before any force-feeding, take a blood sugar test after about 12 hours of fasting since the day before, then every 30 minutes after force-feeding for 3 hours.

The calculation and expression of the result are done according to the formula below:

IG= S2/S1 x 100

S2: area under the curve corresponding to the food studied

S1: area under the glucose curve (taken as reference).

After the collection of all the blood glucose measurements of the samples, these are placed in a graph with the abscissa the time (minute), and the ordered blood glucose level (glycemia) in mg/dl.

From the blood glucose graph, determine the area (area) under the curve of the samples using the trapezium method expressed by the following formula:

$x=[(y2+y1)/(2X (x2-x1)]$

Statistical analysis

Data are analyzed using GrapPadPrism 6.0 software (GraphPad Software, San Diego California, USA). The means and standard deviations of the triplicates of analyzes were determined and we carried out an analysis of Variance (one-way ANOVA) for the comparison of the means. Values of $p < 0.05$ are considered significant.

RESULTS AND DISCUSSION

Determination of chemical composition

Table 1 gives the chemical composition of rhizomes of *Curcuma longa* L

Table 1:
Chemical composition of the rhizome powder of C.

DOSED ELEMENTS	SAMPLE ANALYSED IN %
Proteins	2.81±3.03
Lipids	18.76±0.60
Ashes	5.08±24.19
Fibers	1.79±3.24
Glucids	49.71±4.01
Calculation of the energy in Kcal	
Energy	434.36±1.45

Results in **Table 1** indicate that the *C. longa* rhizome sample used is rich in nutrients and has a high energy value. Compared to the results obtained by Mbemba (2013), the water content found in the present work seems largely lower. Indeed, the latter had found a content equivalent to 76.7% in the rhizome of *C. longa*. On the other hand, the work of Ikpamea et al. (2014) and Tanzela et al. (2015) found the water content lower than what we found, i.e., 8.92 and 13.2% respectively. Carbohydrates contribute to the glucose requirements of many tissues (Mbemba, 2018). Compared to carbohydrates, Mbemba's study (2013) showed low carbohydrate content (19.67 g) compared to the present

study. In addition, Hombourger (2010) noted that 100 g of *C. longa* rhizome presented 6.9 g of carbohydrate, a value higher than that found in the present work. The lipid content is 18.76% in the present study. Previous studies have reported low lipid contents in *C. longa* rhizome powder. Mbemba (2013), Ikpamea et al. (2014), Tanzela et al. (2014), and Hombourger (2010) respectively reported the following contents: 0.33 g, 6.85%, 2.7%, 9.9 g. The fiber content (1.79%) gives the food beneficial effects in increasing the fecal mass and reducing the transit time of the food during digestion (Nah et al., 2005). According to Mbemba (2018), food intake rich in fiber helps to retain water during the passage of the food bolus through the intestine, thus producing more abundant and softer salts. Also, a diet high in fiber is associated with a lower incidence of diverticulosis, colon cancer, cardiovascular disease, and diabetes mellitus.

Furthermore, studies by Ikpamea et al. (2014), Tanzela et al. (2015) and Hamburger (2010) reported higher fiber contents than found in our study, i.e., respectively: 4.60%, 4.80%, and 21.10 g whereas Mbemba (2013), reported a low content 0.80 g of fibers. According to Abdou (2009), the determination of the ash content predicts the concentration of mineral salts. Thus, given the results obtained in this study, the rhizomes of *C. longa* constitute a potential source of minerals (i.e., 5.08%). Several studies have shown the presence in the rhizomes of *C. longa* of certain minerals (Ca, P, Fe, Mg, Zn, Cu, etc.) and vitamins (Vit. A, C, E, B1, B2, B3, B6, B9, etc.) (Hombourger, 2010; Mbemba, 2013; Tanzela et al., 2015; Saggini et al., 2017). It should be emphasized that mineral salts (P, Mg, Na, K, etc.), trace elements (Fe, Mn, Zn, etc.), and vitamins are required in the diet in small quantities and play essential physiological roles (Mbemba, 2013). Ikpamea et al. (2014) and Tanzela et al. (2015), had reported low ash values (2.85% and 3.49%) respectively.

The protein content of the present study (2.81%) is slightly higher than that found by Mbemba (2013), who showed that 100g of *C. longa* rhizome powder contains 1.9g of protein. However high values have been reported by Ikpamea et al. (2014), Tanzela et al. (2015), and Saganni et al. (2017), who reported values that vary between 4.6 to 7.8%.

Phytochemical screening

Table 2:
Phytochemical screening of aqueous extract of *C. longa* rhizome

CLASS OF COMPOUNDS	RESULT
Flavonoids	+
Anthocyanins	+
Tannins	+
Leucoanthocyanins	+
Alkaloids	+
Saponins	-
Steroids	+
Quinones	+

Analysis of the **table** above shows the presence of flavonoids, anthocyanins, tannins, leucoantocyanins, alkaloids, quinones, and steroids in the rhizome extracts of *C. longa*, and the absence of saponins and triterpenoids. The presence of anthocyanins, alkaloids, and quinones in the rhizome extracts of *C. longa* has also been indicated by Mbadiko et al. (2017). In addition, the literature provides several studies relating to the phytochemistry of *C. longa* rhizome extracts. Most of these works have reported that the rhizomes of *C. longa* contain various types of secondary metabolites including alkaloids, flavonoids, tannins, cardiac glycosides, terpenes, steroids, saponins, anthocyanins, leucoanthocyanins, anthraquinones, saponins, etc. The absence of saponins in our samples can be justified by the different geographical origins of the samples used during the phytochemical screening.

Secondary metabolites constitute a source of therapeutic agents and most of the medicinal properties reported in plants are linked to the presence of these phytocompounds (Gravot, 2009). Thus, the fact that the rhizomes of *C. longa* contain various types of secondary metabolites can justify its multiple uses in traditional medicine for the treatment of various diseases including diabetes.

Evaluation of antioxidant activity

The antioxidant capacity of the aqueous extract of *Curcuma longa* L. rhizomes is determined from the values of the IC50 (Inhibitory Concentration 50%), i.e., the lowest concentration of an extract capable of reducing 50% of the radical (DPPH or ABTS) within a defined period. A low IC50 value corresponds to a higher antioxidant activity of the extract. **Table 4** presents the results of the antioxidant activity screening.

Table 3.
IC50 values (µg/mL) of the extract in the ABTS and DPPH tests (n=3)

SAMPLES	DPPH RADICAL	ABTS RADICAL
Curcuma longa L.	Inactive	2,88±0,65
Gallic acid	1,07±0,01	0,71±0,08

Table 3 shows that the sample of *C. longa* rhizomes used in our study has very strong antioxidant activity (IC50 = 2.88 µg/ml) because the IC50 value obtained is close to that of the gallic acid (IC50 = 0.71 µg/ml) used as control. Regarding the DPPH radical test, the IC50 value of the extract was not active in the range of concentrations used. Mutwale (2017) reported that the ABTS radical reacts simultaneously with polyphenolic and non-polyphenolic compounds; unlike the DPPH radical which only reacts with hydrophilic, i.e., polyphenolic, compounds.

The fact that the ABTS radical showed very strong antioxidant activity predicts that the antioxidant potential of *C. longa* rhizome extract is related to the synergistic effect of polyphenolic and non-polyphenolic compounds.

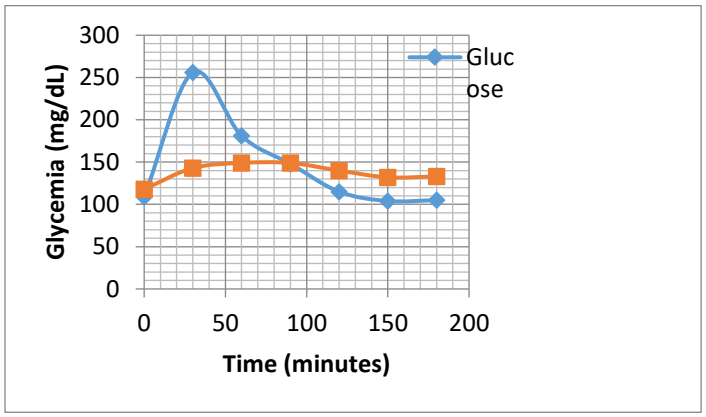
Indeed, many studies have reported that the antioxidant action of *C. longa* rhizome extracts is linked on the one hand to the presence of polyphenolic compounds including curcuminoids, and on the other hand to the presence of essential oils (Jelena et al., 2016; Mbadiko et al., 2019). By comparing the results obtained in the present work with those reported by Mbadiko et al. (2019), we find that the sample used a high antioxidant activity (IC50 = 2.88µg/ml) compared to those of Mbadiko et al. (2019), who reported an IC50 of 4.43 µg/ml. In addition, Tanvir et al. (2017) showed higher IC50 values of 1.08 µg/ml. This difference may result from the fact that the samples were not collected in the same medium. It was reported that other factors can also influence the bioactivity of plant samples, in particular the storage time of the sample and the post-harvest treatment (drying method).

Evaluation of hypoglycemic activity

1. Blood glucose measurement

The results of the hypoglycemic activity evaluation are shown in Figure 1.

Figure 1:
Variation of glycemia as a function of time in mice force-fed with *Curcuma longa* powder and glucose as a control.



We found that the *Curcuma longa* rhizome extract curve shows a peak after 60 minutes of ingestion followed by a drop in blood sugar until it reaches the initial level. This pace indicates that *Curcuma longa* has a hypoglycemic activity, which would be linked to the presence of flavonoids and sterols within it as reported by Singh et al. (2009) in an earlier study. On the other hand, given the carbohydrate content of around 49%, this evolution suggests that very little glucose is released into the bloodstream of mice in the experiment, which suggests that curcumin and other chemical constituents could inhibit enzymes that hydrolyze glucose. In this regard, studies conducted by Lekshmi et al. (2013) on turmeric longa rhizomes showed that curcumin and bisdemethoxycurcumin inhibit α-glucosidase and β-glucosidase, which gives *Curcuma longa* antidiabetic activities. Indeed, one of the therapeutic approaches to lower postprandial blood sugar is to inhibit the breakdown of starch by inhibiting enzymes that hydrolyze glucose. Thus, α-amylase inhibitors could be used in the treatment of diabetes.

2. Determination of the Glycemic index

The determination of the glycemic index (GI) and the glycemic load (GL) of our sample were carried out using the triangle method and the results obtained are given in Table 4.

Table 4:
Value of GI and CG.

FOOD	GI	GL PER GRAM OF FOOD
Curcuma longa	58	0,28

Table 4 shows that *Curcuma longa* has a glycemic index of 58 classified in the medium index category according to the Médart classification (2009). Regarding the glycemic load of Curcuma longa, it is 0.28 per gram of food.

CONCLUSION AND RECOMMENDATIONS

The purpose of this work was to determine the chemical composition, and the phytochemical screening before evaluating the antioxidant and hypoglycemic activities of *Curcuma longa* rhizomes, and to calculate the glycemic index and the glycemic load. The results of the chemical composition allowed us to show that the rhizomes of *C. longa* contain 100g of fresh materials: humidity 21.47%, proteins 2.81%, lipids 18.76%, ashes 5.08%, fibers 1.79g. The phytochemical screening showed that the rhizomes of *Curcuma longa* harvested on the Bateke plateau contain secondary metabolites such as total polyphenols, anthocyanins, tannins, alkaloids, and steroids. Furthermore, the absence of saponins and triterpenoids was noted. The antioxidant activity of Turmeric extracts was evaluated by the spectrophotometric method using free radicals: ABTS and DPPH. The results indicate that the aqueous extract with the ABTS radical possesses good antioxidant activity.

The value of inhibitory concentrations (IC50) obtained, i.e., 2.88 µg/ml from the ABTS radical, is close to that of the control. The hypoglycemic activity was assessed in vivo in NMRI mice, and our extract showed hypoglycemic activity with a medium glycemic load index. The set of results obtained in vitro for the antioxidant activity and in vivo for the hypoglycemic activity shows that the rhizomes harvested on the Bateke plateau are endowed with very important biological properties that can find many applications in various fields, namely: medicine (curative and preventive), pharmacy and dietetics. The results obtained demonstrate that the *Curcuma longa* studied constitutes a source of nutrients and can be valued as food with good antioxidant properties likely to protect against pathologies associated with radicals. In the future, we encourage further studies to elucidate the hypoglycemic mechanism of *Curcuma longa*.

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