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EDXRF and GC Characterization of *Curcuma longa* L. (Zingiberaceae) Rhizome from Madagascar

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ABSTRACT

Curcuma longa is mostly distributed in Asia and is the most common traditional drug of Indian and Chinese medicines used as anti-inflammatory, wound healing, antibacterial, anticancer and antioxidant agents. The present study was designed to characterize *Curcuma longa* L. from Madagascar by the determination of heavy metals and mineral elements of 3 samples of *Curcuma longa* L. rhizomes powder from 3 local companies by X fluorescence method and the essential oil chemical composition from 2 regions of Madagascar: Anivorano and Manjakandriana by gas chromatography (GC). The major compounds were Ar-Turmerone (42,19-47,32%), β-Turmerone (07,26-09,63%) and α-Turmerone (16,78-17,59%). The major mineral elements *Curcuma longa* L. rhizome powder was Magnesium (28000,0 ± 280,0), Calcium (1236,5 ± 111,3 mg/kg) and Iron (1102,0 ± 110,2) from Manjakandriana. It is thus desirable that the chemical composition of Malagasy turmeric from vrarious place in Madagascar would be compared to those from African continent.

Keywords: *Curcuma longa*, essential oil, rhizome, GC/MS, Ar-Turmerone, EDXRF

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INTRODUCTION

Turmeric (*Curcuma longa*) is mostly distributed in Asia[1] and is the most common traditional drug of Indian and Chinese medicines used as anti-inflammatory.[2,3] wound healing antibacterial[4] anti-cancer[5] and antioxidant.[6] It has been reported that Curcuma longa possesses multiple pharmacological activities, including antioxidant, antimicrobial, anti-inflammatory, anti-carcinogenic, anticoagulant, antidiabetic and immunological ones.[7,8] Study have been conducted not only to increase our immunity but also to improve the diet of pregnant women in Madagascar.[9,10] Malagasy traditional medicine "prescribes" rice soup mixed with *Curcuma longa*, *Ginger officinalis*, *Mentha piperita*, *Allium sativum* and breds such as *Centella asiatica*, *Spilanthes acmella*, patsai and leaves of *Ipomoea batatas* (SPMT: Service Phytotherapie et Medecine Traditionnelle or Phytotherapy and Traditional Medicine Service). It is prepared for sterile women who nevertheless wish to give birth.

In Western countries, ground turmeric rhizome is widely used in the food industry, in particular as a coloring agent (E 100 in the European Union) in processed foods and sauces. Turmeric is an important medicinal and aromatic plant which is considered as one of the golden resources with immense exports potential as medicine, beauty aid, cooking spice, and as a dye.[11]

The fresh juice, alcoholic and aqueous extracts, and essential oils of Curcuma longa have demonstrated insecticidal effects against a number of insect pests, and also repelled mosquitoes.[12-15] Climatic and genetic factors, harvesting time, soil type, fertilization, drying process, and periods of storage can all affect the chemical composition of essential oils from *Curcuma longa*.[16]

Curcumin, a naturally occurring chemical compound found in the spice turmeric has been proposed as a supportive therapy in the treatment of COVID19 disease in any clinical settings to circumvent the lethal effects of SARS-CoV-2.[17] It may be beneficial as adjuvant to other drugs to prevent COVID-19 and cytokine storm in severe COVID-19.[18] Similar to SARS-CoV and influenza viruses, respiratory syncytial virus (RSV) also causes acute respiratory infections and is considered

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a major threat to people of different ages globally. Curcumin derived from *Curcuma longa* decreased the yield of the influenza virus by more than 90% in cell culture at 30 µM concentration, which might have been because it affected the synthesis of viral proteins such as haemagglutinin, neuraminidase and matrix protein.[19] Curcumin was also found to be effective against RSV, by inhibiting its replication and budding in the nasal epithelial cells of humans, and it also improved epithelial barrier activity.[16] It has been shown that oral administration of *Curcuma longa* can reduce inflammation by inhibiting the synthesis of inflammatory prostaglandin and neutrophil functions effectively.[20] Curcumin derived from *Curcuma longa*, does not cause any severe toxicity at a dose of up to 8 g per day, over a short period of time. However, human based studies showed that Curcumin at doses ranging from 0.9 to 3.6 g per day for 1–4 months can cause nausea and diarrhoea.[21]

Plants have been used for centuries in almost all cultures worldwide as traditional medicines to cure many chronic infections, including viral diseases.[22-24] In recent decades, scientists have been attempting to scientifically validate the health-improving potential of functional and nutraceutical foods.[25,26,24] Turmeric is a functional food plant that might not only enhance the immune system and cure respiratory tract infections but can also greatly impact the overall health of the general public. As many people in the world are now confined to their homes, the inclusion of this easily accessible plant in the daily diet may help to strengthen the immune system and guard against infection by SARS-CoV-2. This might reduce the risk of COVID-19 and initiate a rapid recovery in cases of SARS-CoV-2 infection.[27]

The aim of this study is to characterize *Curcuma longa* L. from Madagascar by the determination of the essential oil chemical composition by gas chromatography (GC) from 3 local companies and heavy metals and mineral elements of 2 samples of *Curcuma longa* L. rhizome powder from Anivorano and Manjakandriana (Madagascar).

MATERIAL AND METHODS

Determination of heavy metals and mineral elements of Curcuma longa L. rhizomes powder

The powdered Curcumas samples are coded ANVR and MJR. They are dried at a temperature of 40° C for 24 hours in an electric oven brand GALLENKAMP SANYO.

Sample preparation continues with pelletizing. It is about turning the turmeric powder into tablets. It is compressed under a pressure of 10 tons per cm^2, i.e. 109 Pa to manufacture intermediate samples. The pellets thus prepared are analyzed by the energy dispersive X fluorescence method.

The Department of X-ray Fluorescence Technique and Environment (TFXE) within (INSTN)-Madagascar has an X-ray fluorescence spectrometer of the SPECTRO X-Lab Pro brand using the energy dispersive X ray fluorescence method (EDXRF) for sample analyzes. This spectrometer is equipped with a sample platform that allows twelve (12) samples to be placed simultaneously. It is connected to a microcomputer allowing to control the analysis by using the X-Lab Pro 5.1 software. Data relating to each sample is entered through this software.

Determination of the Essential Oil Chemical Composition

The Gas Chromatography (GC) Mass Selective (MS) analysis of the essential oils was performed using a Chromatograph SHIMADZU GC-14A at LPN laboratory of Ministry of Agriculture, fitted with a capillary column (30 m × 0.32 mm, in thickness 0.25 µm). The oven temperature varied from 60–210°C with the scanning rate of 3°C/min. Azote was used as a carrier gas at a flow rate of 3 mL/min. 0.5 micro liter of essential oil was diluted with 1.5 microliter of hexane. After dilution, the samples of essential of 0,8 µL had been injected manually.

RESULTS AND DISCUSSION

Determination of heavy metals and mineral elements

Table 1 shows the concentrations of mineral elements present in Curcumas in 2014 and 2020 from different regions of Madagascar.

The powders of the rhizomes of *Curcuma longa* L. samples from Madagascar are rich in Calcium (between 929.2 and 1236.5 mg / kg). The sample from Manjakandriana has the highest Calcium content. Dairy foods, with their high levels of calcium positively interact on several physiological mechanisms involved in the maintenance of bone health and the prevention of osteoporosis.[28] An increase in calcium intake slightly reduces both systolic and diastolic blood pressure in normotensive people, particularly in young people, suggesting a role in the prevention of hypertension.[29] The study of Bergel and *al.*[30] shows a modeling effect of calcium intake during pregnancy on dental caries of the offspring. At around 12 years of age children whose mothers received calcium supplementation when pregnant showed a significant reduction in dental caries.[31] Calcium supplementation during pregnancy is associated with a reduction in risk of gestational hypertensive disorders and pre-term

Table 1 **Comparative study of the concentrations of mineral elements present in Curcumas in 2014 and 2020**

2014									2020			
	Concentration (mg/kg)									Concentration (mg/kg)		
Element	Mandritsara[1]	Ambatondrazaka[2]	Anivorano[3]	Brickaville[3]	Moramanga[2]	Anjiro[2]	Tolongoina[4]	Tech	Element	Anivorano[3]	Manjakandriana[5]	Tech
Ca	1112,1 ± 54,5	1051,8 ± 71,5	941,4 ± 63,9	929,2 ± 60,9	1142,4 ± 85,6	966,6 ± 68,1	1037,1 ± 44,4	SAAF	Ca	1196,0 ± 95,7	1236,5 ± 111,3	DEXRF
Cr	< 9,3	< 9,3	< 9,3	< 9,3	< 9,3	< 9,3	< 9,3	TXRF	Cr	1,2 ± 0,1	3,2 ± 0,3	DEXRF
Fe	34,8 ± 2,9	55,4 ± 3,2	80,1 ± 5,4	51,1 ± 3,3	49,3 ± 3,5	53,3 ± 4,5	51,3 ± 2,5	SAAF	Fe	294,6 ± 23,6	1102,0 ± 110,2	DEXRF
Co	< 6,8	< 6,8	< 6,8	< 6,8	< 6,8	< 6,8	< 6,8	TXRF	Co	< 3,0	< 3,0	DEXRF
Ni	< 5,9	< 5,9	< 5,9	< 5,9	< 5,9	< 5,9	< 5,9	TXRF	Ni	1,3 ± 0,1	2,0 ± 0,2	DEXRF
Cu	18,5 ± 0,6	21,9 ± 1,4	16,5 ± 1,1	18,3 ± 1,1	23,3 ± 1,7	20,1 ± 1,6	19,7 ± 0,7	SAAF	Cu	8,8 ± 0,7	8,8 ± 0,7	DEXRF
Zn	11,4 ± 0,7	14,1 ± 0,1	19,8 ± 0,3	14,7 ± 0,6	13,2 ± 1,0	24,3 ± 1,8	23,4 ± 1,5	TXRF	Zn	65,0 ± 5,9	76,7 ± 6,9	DEXRF
As	< 3,7	< 3,7	< 3,7	< 3,7	< 3,7	< 3,7	< 3,7	TXRF	As	< 0,5	< 0,5	DEXRF
Br	< 7,6	< 7,6	< 7,6	< 7,6	< 7,6	< 7,6	< 7,6	TXRF	Br	3,5 ± 0,3	3,3 ± 0,3	DEXRF
Rb	28,9 ± 2,7	42,8 ± 0,7	38,7 ± 2,7	28,7 ± 2,2	38,7 ± 1,6	39,1 ± 5,5	29,5 ± 2,6	TXRF	Rb	55,0 ± 5,0	90,7 ± 9,1	DEXRF
Pb	< 0,9	< 0,9	< 0,9	< 0,9	< 0,9	< 0,9	< 0,9	SAAF	Pb	< 0,1	2,3 ± 0,2	DEXRF

DEXRF : Direct Excitation X-Ray Fluorescence
TXRF : Total reflection X-Ray Fluorescence
SAAF : Spectrométrie d'Absorption Atomique en Flamme
Tech : Technique

[1]: Region of SOFIA
[2]: Region of ATSINANANA
[3]: Region of ALAOTRA MANGORO
[4]: Region of VATOVAVY-FITOVINANY
[5]: Region of ANALAMANGA

birth and an increase in birthweight. There is no increased risk of kidney stones.[32]

It is also noted that the iron content of the sample from Manjakandriana is considerable (1102.0 ± 110.2 mg/kg) compared to the other samples. Iron is not only an element necessary for hemoglobin production but is also an important component of at least 200 cellular enzymes that are essential for normal cellular functions.[58] Therefore, iron is essential for oxygen transport and storage and for many other metabolic functions related to growth, immunity, muscular activity, bone strength and the nervous system.[4] Moreover, iron deficiency anaemia has been shown to be associated with an increased risk of 30-day morbidity and mortality in patients undergoing major non-cardiac surgery.[33]

Determination of the essential oil chemical composition

The spectra of the three essential oil samples are given in figures 1, 2 and 3.

The essential oil chemical composition of the *Curcuma* of different studies is summarized in table 2.

The major chemical component of the samples analyzed is Ar-Turmerone. It shows potent hypoglycemic activity against α-glucosidase and α-amylase.[39] Ar-Turmerone effectively inhibits copper-mediated oxidation of LDL.[40] Oxidation of LDL plays an important role in the development of atherosclerosis. Atherosclerosis is defined as the build-up of cholesterol (plaque) on the walls of the arteries, which causes blockage of blood flow. The plaques can break off and cause an acute occlusion of the artery with a clot. Atherosclerosis is often asymptomatic until plaque breaks off or the buildup is large enough to block the flow of blood. This too has shown a neuroprotective effect by inhibiting the activation of microglia, increasing the proliferation of stem cells and promoting neuronal differentiation.[41] Ar-Turmerone, isolated from turmeric essential oil, has shown potent cytotoxic activity against several cell lines, including HeLa.[42] It is also

Table 2 **Comparative study of the essential oil chemical composition of the Curcumas**

	Sample 1	Sample 2	Sample 3	Limit values found at the Pesticide Control Laboratory (PCL)	Lahatsaravita[34]	Guimarães, et al.[35]	Le et al.[36]	Sahoo et al.[37]	Zhang et al.[38]
					Vangaindrano Atsimo-Atsiinanana	Brazil	Vietnam	India (8 samples)	China (20 samples)
Ar-Turmerone (%)	42,41	47,32	42,19	25,80-41,30	43,10	31,31	09,93	39,5-45,50	00,92–42,85
β-Turmerone (%)	09,63	07,26	07,75	07,53-26,70	-	20,73		09,8-11,70	05,13–42,54
α-Turmerone (%)	16,78	17,59	17,11	11,40-17,60	12,60	22,41	10,28	-	-
β-caryophyllene (%)	00,61	00,56	02,25	00,30-00,50	06,30	-	trace	00,30-00,56	00,00-01,53
α-zingiberene (%)	03,95	3,88	02,19	00,50-03,50	-	-	26,38	-	00,50-15,70

T1: Floramad (high plateau and coast); T2: Floribis (north-east coast and high plateau); T3: Mab (east-north coast)

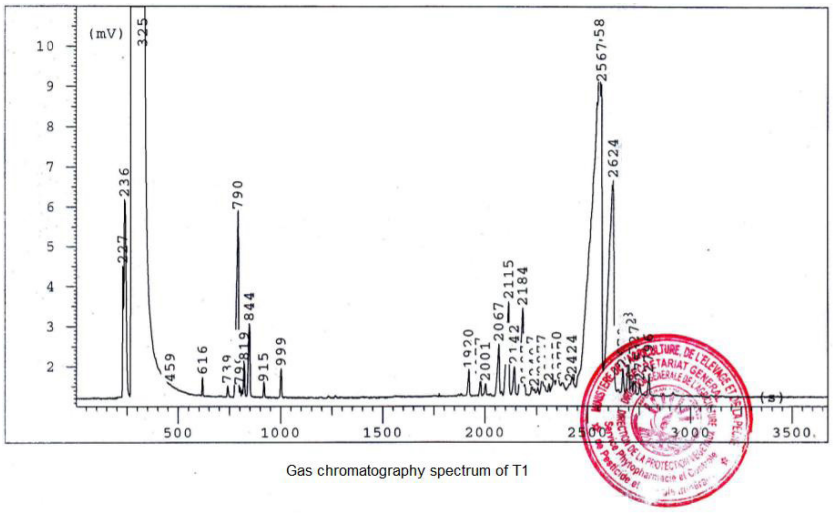

Figure 1 Chromatogram of sample T1

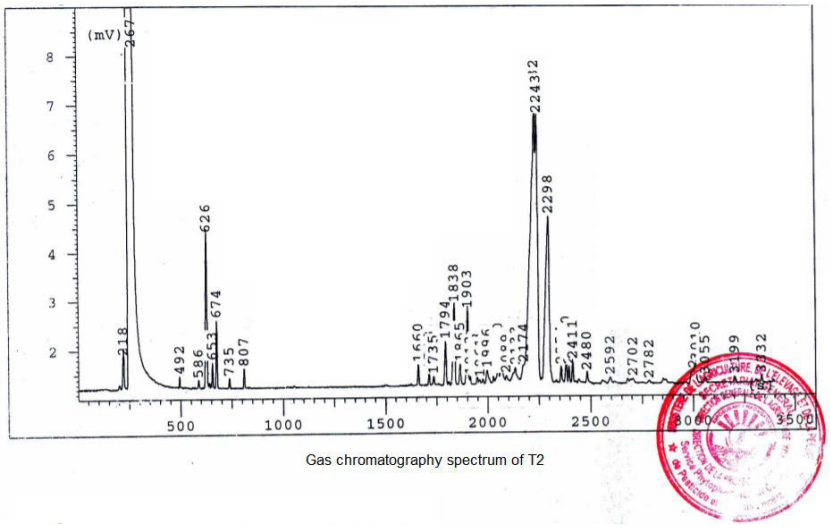

Figure 2 Chromatogram of sample T2

a powerful anti-inflammatory agent; it inhibits the production of inflammatory cytokines.[43] The study by Yue and et al. evaluated the anti-proliferative activities of isolated compounds (three curcuminoids and two Turmerones) from *Curcuma longa*, using human cancer cell lines HepG2, MCF-7 and MDA-MB-231. The immunomodulatory activities of Turmerones (alpha and aromatic) isolated from *Curcuma longa* was also examined using human peripheral blood mononuclear cells (PBMC). The results showed that curcuminoids (curcumin, demethoxycurcumin and bisdemethoxycurcumin) and alpha-Turmerone significantly inhibited the proliferation of cancer cells in a dose-dependent manner.[44] It also had strong antifungal activity against *Aspergillus flavus*.[45] No acute toxicity was found for ar-Turmerone, but it could be non-toxic, similar to turmeric petroleum rhizome. However, ar-tumone has been classified as possibly causing an allergic skin reaction (H317) and eye irritation (H319).[46]

A study was undertaken to assess the anti-depressive activity of Turmerone after one week of administration using a mouse forced swim test and a tail hang test. After one week of administration, the Turmerone produced antidepressant-like effects. The mechanisms of action of the anti-depressive effect of Turmerone seem to involve an increase in the level of monoamine reducing the MAO-A activity and the stress of mice.[47]

The variation of the levels of Ar-Turmerone, β-Turmerone and a-Turmerone in the three samples is uniform. They are respectively between 47.32 to 42.19; 9.63 to 7.26; 17.59 to 16.78. This is due to the confirmation of the existence and accuracy of its conforming chemical properties. We see the maximum value of Ar-Turmerone in T1.

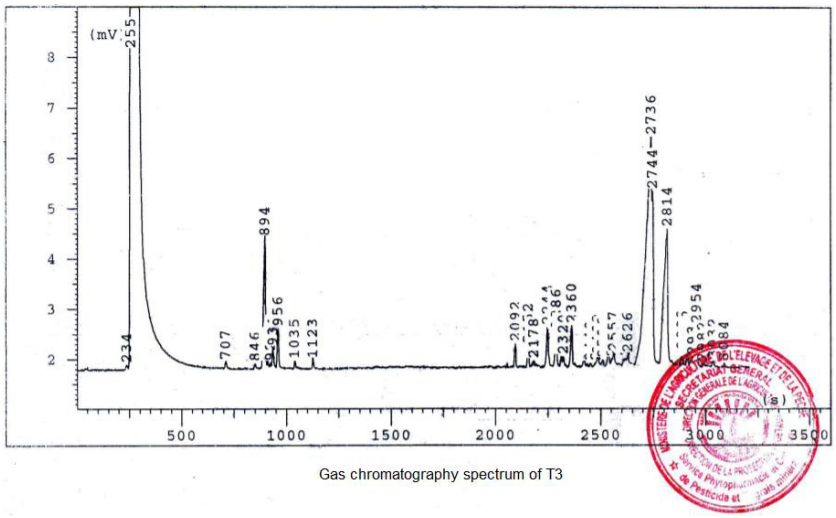

Figure 3 Chromatogram of sample T3

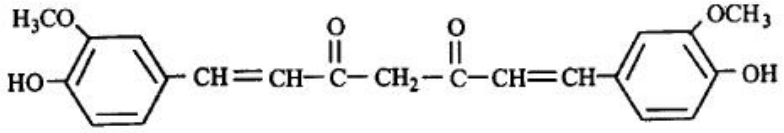

Figure 4 Chemical structure of the curcumin molecule[51]

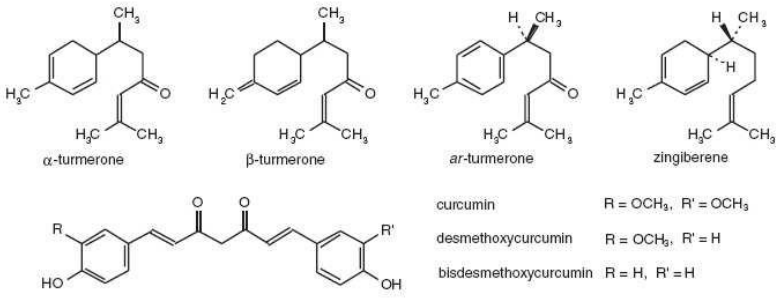

Figure 5 Chemical structures of the main compounds in longa turmeric powder[51]

This could be due to the traceability of the product, from the quality of the cultivation of the raw materials to the processing and packaging of the products. Rainfall in the highlands; place of culture compared to that of the east coast which certainly affects the quality. Thus, the hot and humid microclimate of the high plateau-eastern part is favorable to the plant (rainfall, soil quality and temperature), among others.

Obtaining Ar-Turmerone, the main active ingredient at industrial level, requires know-how and experience in the field. Indeed, the concept of product traceability upstream (cultivation, collection) requires technical expertise on the part of the operator (product maturity, adulteration, degree of drying, etc.). Mastery of processing alone with the latest technology equipment does not give the assurance of a standardized product.

The maximum value of β-Turmerone in T2 (9.63) compared to T1 (7.26) and T3 (7.75) could be due to a problem of maturity of the treated materials. Indeed; to reach a maximum value of Ar-Turmerone, intermediate formulas such as β-Turmerone cannot reach their peak due to the lack of necessary conditions such as maturation time (early collection time).

The percentages of β-caryophyllene terpenes previously found at the PCL laboratory are between 0.3 and 0.5 - The value of the three samples exceeds the limit value (0.56 - 0.61 and 2.25). The more the terpenes increase, the more the quantities of active ingredients decrease. One of the reasons for this increase is the quality of the materials to be processed (humidity level, immaturity, etc.). This could also be due to the humidity due to the rainy climate of the eastern and eastern coastal regions. By comparing the 3 samples, sample T3 has the maximum value of β-caryophyllene which is 2.25. This explains the establishment of the crop in the rainy zone almost all year round. Consequently, the humidity level is far from being optimized. A simple drying system or method at farmer level could improve the quality of the product obtained by using, for example, traditional racks with Ravinala leaf roofing. This would not only allow the air and heat to combine their effects to better establish the drying, but it will also improve the level of Ar-Turmerone..

The level of α-zingiberene exceeds the limit of the usual values found at the PCL laboratory. This could be due to unintentional adulteration with the ginger. The farmers cultivate these two products at the same time. The tonnage sourcing of raw materials does not exclude the existence of this turmeric family.

The quantities of ar-Turmerone contained in the 3 samples are of the same order of magnitude as that of the study by Lahatsaravita et *al.*[34] and the maximum values of ar-Turmerone of that of Sahoo et *al.*[37] and Zhang et *al.*[38] The amounts of β-Turmerone contained in the 3 samples are low compared to that of Brazil and very low compared to the maximum value of the sample of Zhang et *al.*[38] As for α-Turmerone, the 3 samples have lower values compared to that of Brazil, but the quantities are higher compared to samples from Vangaindrano and Vietnam.

As we see in the table above, the chemical composition of essential oils is variable. Indeed, this depends on several factors, in particular: the age of the plant, ecological factors, climatic factors, pedological factors, storage effects (exposure to light, air, and high temperature).[48]

During storage, essential oils may undergo qualitative deterioration. However, in some cases,

Table 3 **Composition of minerals in the rhizome of Curcuma longa L. (Source auteur)**

Elements	Concentration (mg/kg)
Sodium (Na)	< 100,0
Magnesium (Mg)	1298,5 ± 116,9
Aluminium (Al)	1467,5 ± 146,8
Silicon (Si)	2881,5 ± 288,2
Phosphorus (P)	2434,0 ± 243,4
Sulfur (S)	1409,0 ± 126,8
Chlorine (Cl)	2930,0 ± 293,0
Potassium (K)	28000,0 ± 280,0
Calcium (Ca)	1236,5 ± 111,3
Titanium (Ti)	132,9 ± 12,0
Chromium (Cr)	3,2 ± 0,3
Manganese (Mn)	233,6 ± 21,0
Iron (Fe)	1102,0 ± 110,2
Cobalt (Co)	< 3,0
Nickel (Ni)	2,0 ± 0,2
Copper (Cu)	8,8 ± 0,7
Zinc (Zn)	76,7 ± 6,9
Arsenic (As)	< 0,5
Selenium (Se)	< 0,1
Bromine (Br)	3,3 ± 0,3
Rubidium (Rb)	90,7 ± 9,1
Strontium (Sr)	13,8 ± 1,2
Lead (Pb)	2,3 ± 0,2
Mercury (Hg)	5,1 ± 0,4

the scent quality improves with aging (essences of patchouli and vetiver). In these oils which have undergone aging, the presence of secondary products formed by oxidation, dehydration and / or polymerization is noted.

Nutraceutical effect of the active ingredients of Curcuma longa L.

This study focused mainly on the phytochemical characterization of turmeric *longa* L. extract obtained by the treatment of the underground parts favoring the release of bio-functional molecules. Turmeric extracts were isolated and then identified by analysis using the X-ray fluorescence of SPECTRO X-Lab Pro. The interest of this work is to explore the therapeutic potential of medicinal plants known for their nutraceutical virtues. In this perspective, the present work aims to evaluate the nutraceutical and bio-functional properties of turmeric *longa* L. According to the analysis by atomic absorption spectrophotometry, it would be expected that turmeric *longa* L. has a significant nutraceutical potential. Atomic Absorption Spectrophotometry is essentially a quantitative analytical method which is much better suitable for the determination of traces than for the determination of major components. In this study, we found that turmeric *longa* L. has a wide variety of phytochemical and nutraceutical elements and the plant possess wide range of medicinal, nutraceutical and bio-functional properties to be valorized. By definition, photochemistry refers to the first or second metabolites. The first refer to macronutrients. And the second ones concern the derivatives of the first ones and have ecological roles.[49] Secondly, nutraceuticals are substances that make up a food or part of a food and can provide medical, therapeutic effects to prevent or treat a disease. The nutraceutical elements contained in turmeric correspond to phytochemical elements: proteins, carbohydrates, antioxidants, vitamins, minerals.[50] Thus, each constituent element of turmeric *longa* L. presented above can be used as a nutraceutical.

According to Jayaprakasha et *al*.,[50] nutraceuticals are obtained by: isolating nutrients. Thus, according to other searcher,[51] the proposed nutraceutical forms for *longa* L. turmeric are:

- Rhizome-derived powders, fleshy, branched, are the part used as a food spice, preservative, and coloring agent in food and textiles;
- Locally applied turmeric paste treats eye infections, burns, wounds and snake bites;
- The dried alcoholic extract of the rhizomes in powder form to actively provide the plant's cancer-fighting and hypoglycemic effects. The nutraceutical can be presented in tablet or capsule form.
- Arabo-Persian medicine recommends the use of powders to treat ulcers, digestive disorders, and scabies and as a stimulant;
- In Chinese medicine, it is indicated to reduce blood stasis, stimulate menstruation and relieve pain;
- The rhizome contains the non-volatile fraction called curcuminoids that give the yellow coloring: curcumin, desmethoxycurcumin and bisdemethoxycurcumin. These are the main active ingredients. Among these curcuminoids, curcumin, isolated for the first time in 1815, is the most abundant and most studied molecule. It is an antioxidant and anti-inflammatory substance;
- Essential oils of *Curcuma longa* can also be proposed to provide the benefits of the various volatile compounds of the plant. Ar Turmerone, beta-Turmerone, alpha Turmerone are the main active ingredients abundant in the varieties studied.

Curciminoids contain active ingredients from turmeric extra. They can be extracted with solvents. Among them, curcumin is the major element with a broad spectrum of activity in turmeric.[51] Curcumin is a lipophilic polyphenol, soluble in ethanol, alkalis, ketones, acetic acid and chloroform, insoluble in water and fairly stable at acidic pH like that of the stomach.[52]

Turmeric rhizome is rich in starch (45-55%), fiber (2-7%) and carbohydrates (60-70%) in total. It also contains proteins, 6-8% including turmerine, a water-soluble peptide,[53] and lipids up to about 5%. The ground powder of *longa* L. turmeric possesses minerals (3-7%)[54] which are very beneficial for the strengthening of metabolic activities and immunity in humans. The results of analyses by X-ray fluorescence spectrophotometry show, among others, the abundant supply of Potassium (K) 19g/kg dry matter. Potassium contributes to the maintenance of normal blood pressure, fluid and electrolyte balance. It also plays an important role in nerve and cervical functions and muscle development. Potassium deficiency is manifested by diarrhea and vomiting or urine loss.[55] Ground turmeric is a source of iron with an iron content of 1.102g as determined by X-ray fluorescence analysis. Every cell in the body contains iron. This mineral is essential for the transport of oxygen and the formation of red blood cells in the blood. It also plays a role in the production of new cells, hormones and neurotransmitters (messengers in nerve impulses). It should be noted that the iron contained in foods of plant origin (such as turmeric) is less well absorbed by the body than the iron contained in foods of animal origin. However, the absorption of iron from plants is enhanced when it is consumed with certain nutrients, such as vitamin C.[55] As a result, the antioxidant effect of curcumin suggests a protective effect against diseases related to oxidative stress (such as cardiovascular disease and Alzheimer's disease).[56] Curcumin also has anti-inflammatory properties and may be involved in cancer prevention at several stages of its development.[56] Curcumin, alone and in combination with other therapeutic agents, has been shown to be effective against different forms of cancer such as multiple myeloma, colon and rectal cancer, pancreatic cancer, prostate cancer, osteosarcoma, oral mucositis in children on chemotherapy and familiar adenomatous polyposis.[54] Curcumin's antioxidant and anti-inflammatory properties may be responsible for its anticancer effects.[52] Some authors hypothesize that the consumption of 1 teaspoon (5 ml) of *Curcuma* per day could provide the amount of curcumin necessary to exert a preventive effect against cancer. The research conducted by Tilak J. C.[57] and supported by Frautschy et *al.*[58] shows that curcumin consumption improved cognitive deficits related to Alzheimer's disease, by mechanisms that are still little known. Probably the different properties of curcumin (such as antioxidant, anti-inflammatory and cholesterol-lowering properties) could be associated with this effect.

More in-depth studies have demonstrated the effectiveness of a turmeric extract in preventing the oxidation of LDL-cholesterol ("bad" cholesterol) as well as in lowering total cholesterol in animals.[53,59] It is becoming increasingly clear that curcumin and its metabolites (obtained during the conversion of curcumin into other compounds in the body) are partly responsible for these effects.[30,53,59] These results suggest that *Curcuma* may prevent the development of atherosclerosis and other risk factors for cardiovascular disease, but more human studies are needed.[53]

CONCLUSION

Curcuma longa L. is among the inseparable products of the daily life for to increase the immune and well-being of human. The present study revealed that the major compounds of Turmeric from Madagascar were respectively between 42,19 and 47,32% for Ar-Turmerone, 07,26 to 09,63% for β-Turmerone and 16,78 to 17,59% for α-Turmerone. While, the major mineral elements *Curcuma longa* L. rhizome powder was Magnesium (28000,0 ± 280,0), Calcium (1236,5 ± 111,3 mg/kg) and Iron (1102,0 ± 110,2) from Manjakandriana. It is thus desirable that the chemical composition of Malagasy turmeric from vrarious place in Madagascar would be compared to those from African continent.

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