

# Phytochemical Screening, Total Phenolics, Flavonoids Contents, Total Antioxidant Capacity and Antifungal Activity of *Cymbopogon giganteus* Extracts from Burkina Faso

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## Abstract

Extracts obtained from roots, stems, leaves and flowers of *Cymbopogon giganteus* using hexane, dichloromethane (DCM), ethyl acetate and methanol were screened for their phytochemicals, total phenolics content, (TPC), total flavonoids content (TFC), total antioxidant content (TAC) and for their antifungal activity. Tannins, flavonoids, phenolic acids and alkaloids were mainly found in extracts, depending of the solvent used for extraction.

TAC were evaluated using Ferric Reducing Antioxidant Power (FRAP) and DPPH radical scavenging assays. Results from FRAP assay showed that methanolic flower extracts had highest TAC ( $112.94 \pm 2.4 \mu\text{g TE/mg}$  of extracts), followed by leaves ( $68.56 \pm 7.53 \mu\text{g TE/mg}$  of extract), roots ( $45.17 \pm 4.28 \mu\text{g TE/mg}$  of extracts) and stems ( $39.21 \pm 2.34 \mu\text{g TE/mg}$  of extract). The highest TPC were found in methanolic flowers extracts ( $171.17 \pm 1.42 \text{ GAE/mg}$  of extract) whereas DCM and ethyl acetate roots extracts exhibited the best TFC with respectively  $348.34 \pm 12.48$  and  $323.86 \pm 31.55 \mu\text{g of QE/mg}$  of extract.

Only methanolic extracts of *C. giganteus* different parts were tested at 10 mg/mL on four local fungi. Results showed that methanolic roots extracts had an inhibitory effect of 16.16%, 19.15% and 10.79% respectively on the radial growth of *Fusarium moniliforme*, *Phoma sorghina* and *Aspergillus flavius*. Methanolic flowers extracts only inhibited *Fusarium moniliforme* radial growth at 19.4171% and *Aspergillus flavius* at 7.11%. None of plant parts extracts showed an inhibitory effect on *Byopolaris orezae*.

**Keywords:** *Cymbopogon giganteus*; Phenolics; Flavonoids; Antioxydant; Antifungal

## Introduction

Fungi are responsible for agricultural losses, both while crops are growing and when they are later stored. During storage, fungi can make food crops unfit for consumption, by changing the nutritional value of seeds or producing mycotoxins that are harmful for human and animal health [1]. Many fungi are known to be indirectly responsible for allergic or toxic disorders among consumers because of the production of mycotoxins or allergens.

*Phoma sorghina*, *Fusarium moniliforme*, *Aspergillus flavus*, *Byopolaris oryzae* are common fungi that cause alterations during development stages including post-harvest of some of local plant such as sorghum, maize, millet, rice. Generally these phytopathogenic fungi are controlled by synthetic fungicides; however the use of these fungicides is increasingly restricted due the harmful effect of pesticides on human health and the environment [2]. The main toxic effect are carcinogenicity, genotoxicity, hepatotoxicity, reproductive disorders and immunosuppression [3,4]. A sizeable portion of world population living below poverty line in the developing countries are suffering from health problem associated with consuming mycotoxin contaminated grains or cereals [5]. Even though effective and efficient control of seed borne fungi of seeds can be achieved by the use of the synthetic chemical fungicides, the same cannot be applied to grains for reasons of toxicity [2]. Thus, there is a need to search for alternative approaches to store grains/cereals for human consumption without toxicity problems.

Plants extracts have been reported to exhibit antibacterial, antifungal and insecticidal properties [6,7]. Furthermore, many plants are known to contain a number of secondary metabolites like phenols, flavonoids, quinines, essential oils, alkaloids, saponins and steroids. Previous works showed that there is an important link between phenolic compounds, mainly flavonoids and most of the biological activities such as antioxidant, anti-inflammatory and antifungal activities [8,9]. On the other hand, several works demonstrated in laboratory trials that plant parts, such as roots, leaves, seeds, stems and flowers possess inhibitory properties against bacteria, fungi and insects [10]. The present work aimed to investigate for antifungal biological activity of extracts from different parts of *Cymbopogon giganteus* from Burkina Faso. This plant was selected according to reported data on its biological activities [11]. *Cymbopogon giganteus* is used in local African medicine to cure diseases such as rheumatism, fever, cough, skin disorders (decoctions of leaves and flowers) and arterial hypertension [12]. Furthermore, previous works only focused on essential oil (volatile compounds) of *Cymbopogon giganteus* [11] from Burkina Faso, but no study has been undertaken on non-volatile compounds in our knowledge. Because of the possible link between phenolic compounds and biological activities, all the extracts obtained from roots, leaves, stems and flowers of this plant were first screened for their phytochemicals, phenolics, flavonoids and total antioxidant contents; subsequently, the most potent extracts were tested for their antifungal activity.

## Materials and Methods

### Materials

**Plant material:** Plant material (roots, stems, leaves and flowers) of *Cymbopogon giganteus* were collected in 2015, in an experimental field, at Applied Science and Technology Research Institute, Natural Products Department (Ouagadougou, Burkina Faso). Plant has been identified and described by the Laboratory of Vegetal Biology and Ecology of University of Ouagadougou, where a specimen was filed. All the samples were shade dried for 15 days. After drying, plant materials were crushed.

**Biological material:** Four fungi (*Phoma sorghina*, *Fusarium moniliforme*, *Bipolaris oryzae* and *Aspergillus flavus*) were produced from grains or leaves of sorghum, maize, millet and rice collected in Burkina Faso. Once infested grains identified, each fungus was removed using a needle and placed in a petri dish containing a culture medium (malt agar). The petri dish was then incubated at 25°C under a UV lamp light, for at least 5 days. The fungi were identified and isolated by the laboratory of Phytopathology of Nazi Boni University of Bobo.

## Methods

**Preparation of plant extracts:** 50 g of each plant part were successively extracted (three times) with 300 mL of hexane, dichloromethane, ethyl acetate and methanol by cold maceration under magnetic stirring for 24 h. The solutions were filtered, concentrated under reduced pressure to yield hexane extract (HE), dichloromethane extract (DCME), ethyl acetate extract (EAE) and methanol extract (ME). Thus, sixteen extracts were prepared.

**Phytochemical screening:** All the extracts prepared were screened for several chemical groups: tannins, alkaloids, flavonoids, saponins, anthracenosids, phenolic acids, using the methods described by Wagner et al. [13]

**Determination of total phenolics content (TPC):** Total phenolics content was determined by the Folin-Ciocalteu method as described by Nihal et al. [14]. Gallic acid was used as standard. A calibration curve was first established using gallic acid solutions at concentrations ranging from 0, 25 µg/mL, 50 µg/mL, 75 µg/mL and 100 µg/mL. Then 60 µL of the Folin-ciocalteu reagent (FC-R 1:10 dilution), were added to the solutions of gallic acid. The mixtures were left to stand at room temperature for 8 min and then, 120 µL of sodium carbonate solution (Na<sub>2</sub>CO<sub>3</sub>), 7.5% were added to neutralize the residual reagent. The absorbance was recorded at 700 nm after incubation for 30 min at 37°C. After that, 60 µL of each extract dissolved in DMSO, suitably diluted and were added to 60 µL of FC-R, instead of gallic acid. The total phenolics contents, determined from the equation of the calibration curve, were expressed as µg of gallic acid equivalent/mg extract (µg GAE/mg).

**Total flavonoids content (TFC) measurement:** Total flavonoids content was measured using aluminum chloride colorimetric assay as described by Zhishen J et al. [15] with slight modifications (adapted for microplates). A calibration curve was established using different concentrations (0, 25 µg/L, 50 µg/L, 75 µg/L and 100 µg/L) of Quercetin solutions. Briefly, 25 µL of plant extracts (properly diluted) or standard solution of Quercetin at different concentration was added to 150 µL of distilled water. Then 10 µL of 5% NaNO<sub>2</sub> was added. After 5 min, 10 µL of 10% AlCl<sub>3</sub> were added. After 6 min, 50 µL of NaOH 1 M were added. After incubation for 30 min at 37°C, absorbance of the mixture was recorded at 415 nm. Tests were carried out in triplicates and results were expressed as µg of Quercetin equivalent/mg of extract (µg QE/mg).

**Evaluation of total antioxidant content (TAC):** TAC of extracts were determined using two (02) methods: 2, 2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging assay and Ferric Reducing Antioxidant Power (FRAP). Trolox was used as reference. All the tests were carried out using a microplate reader (spectrophotometer MP96, SAFAS) and were performed in triplicates.

**DPPH radical scavenging test:** This test was performed according to the method described by Lamien-Meda et al. [16] with slight modifications and adapted for microplates. A calibration curve was first established using standard solutions of Trolox at different concentrations (10 µg/mL to 50 µg/mL). For this purpose, briefly, 200 µL of DPPH solution  $10^{-4}$  M were added to 50 µL of Trolox solutions. The mixtures were allowed to stand for 10 min in the dark at room temperature and then, absorbance was recorded at 517 nm.

After that, 50 µL of each extract suitably diluted were mixed with 200 µL of DPPH solution. The absorbance was recorded at 517 nm, 10 min after the start of the reaction. Total antioxidant capacity was determined from the equation of calibration curve and results were expressed as µg of Trolox equivalents/mg extract (µg TE/mg).

**Ferric Reducing Antioxidant Power (FRAP) assay:** In this method, 2, 4, 6-Tripyridyl-s-Triazine (TPTZ) was used as oxidant substratum [17]. The FRAP reagent was prepared by mixing 1 mL TPTZ (10 mM), 10 mL of sodium acetate buffer (pH=3.6) and 1 ml of solution of ferric (III) chloride, 20 mM. As in DPPH scavenging assay, a calibration curve was established using Trolox solutions at different concentrations (10 µg/mL to 50 µg/mL). Then, 200 µL of FRAP reagent were added to 50 µL of each of the previous solutions of Trolox, followed by 30 µL of distilled water. The absorbance of the intense blue color mixture was read after 10 min at 595 nm.

For the extract, 50 µL of each sample properly diluted was used instead of Trolox. Total antioxidant capacity was determined from the equation of calibration curve and results were expressed as µg of Trolox equivalents/mg extract (µg TE/mg).

**Antifungal activity of the extracts:** This test was performed using the method described by Bonzi et al [1]. Growing fungi and their isolation: Fungi to be tested were grown in a fresh malt agar medium contained in petri dishes of 9 cm diameter. From a 10 days-old colony four mycelium explants of identical size (5 mm) were placed in the center of a petri dish containing culture media with or without extract to be tested. All the extracts were dissolved in DMSO 1% and tested at 10 mg/mL. Calcio C was used as positive control and was tested at 1 mg/mL. The inoculated plates were incubated in the heat chamber at 28°C and keep in the dark for 10 days (Bonzi et al., 2012).

**Evaluation of antifungal activity:** The evaluation of the radial growth involved tracing on the lid of the petri dish two perpendicular lines through the center of the explant. The diameters of the mycelium colonies (in cm) were measured every two (02) days for 10 days after incubation. The tests were performed in triplicate. The percentage inhibition of each sample is calculated using the following formula:

$$\% \text{ of inhibition} = \frac{R_b - R_{ext}}{R_b} \times 100$$

Where,  $R_b$ : radius of the blank (without extract);

$R_{ext}$ : radius of the extract.

## Results and Discussion

### Phytochemical screening

Results are presented in TABLE 1; the presence or absence of chemical groups depends on the plant tissue and the solvent used for extraction.

Flower extracts, whatever the solvents used, did not contain saponins. Tannins and anthracenosides were rather present in methanol extract. However, flavonoids, alkaloids and phenolic acids were all present in hexane, ethyl acetate and methanol extracts. Thus, except sponins, *C. giganteus* flower extracts contain most of the chemical groups screened.

Results from ethyl acetate leaves extracts did not show the presence of any chemical groups while most of the chemical groups were found in methanol extracts. Saponins were found only in DCM extract. Methanol seems to be the suitable solvent to obtain these chemical from *C. giganteus* leaves.

Methanol stems extracts are rich in tannins, flavonoids, anthracenosides and phenolic acids but did not contain alkaloids and saponins. No chemical group could be found in hexane and DCM stems extracts, except alkaloids and saponins.

Anthracenosides, alkaloids and saponins were highly present in roots extracts. Tannins and flavonoids could be found only in methanol roots extracts. *C. giganteus* roots extracts did not contain phenolic acids.

So many chemicals could be found in *C. giganteus* different parts, depending on the type of solvent used for the extraction. This plant might certainly have a broad use against many diseases.

TABLE 1. Chemical groups in different tissues of *C. giganteus* extracts.

	Extracts	Tannins	Flavonoids	Alkaloids	Anthracenosides	Saponins	Phenolic acids
<b>Flowers</b>	Hexane	-	+	+	-	-	+
	DCM	-	-	-	-	-	-
	Eth. Ac.	-	+	+	+	-	+
	MeOH	+	+	+	+	-	+
<b>Leaves</b>	Hexane	-	+	+	-	-	+
	DCM	-	-	-	-	+	-
	Eth. Ac.	-	-	-	-	-	-
	MeOH	+	+	-	+	+	+
<b>Stems</b>	Hexane	-	-	+	-	-	-
	DCM	-	-	+	-	+	-
	Eth. Ac.	-	+	-	+	-	-
	MeOH	+	+	-	+	-	+
<b>Roots</b>	Hexane	-	-	+	-	-	-
	DCM	-	-	+	+	+	-
	Eth. Ac.	-	-	-	+	-	-
	MeOH	+	+	-	+	+	+
+: presence; -: absence; Eth. Ac.: Ethyl Acetate; DCM: Dichloromethane; MeOH: Methanol							

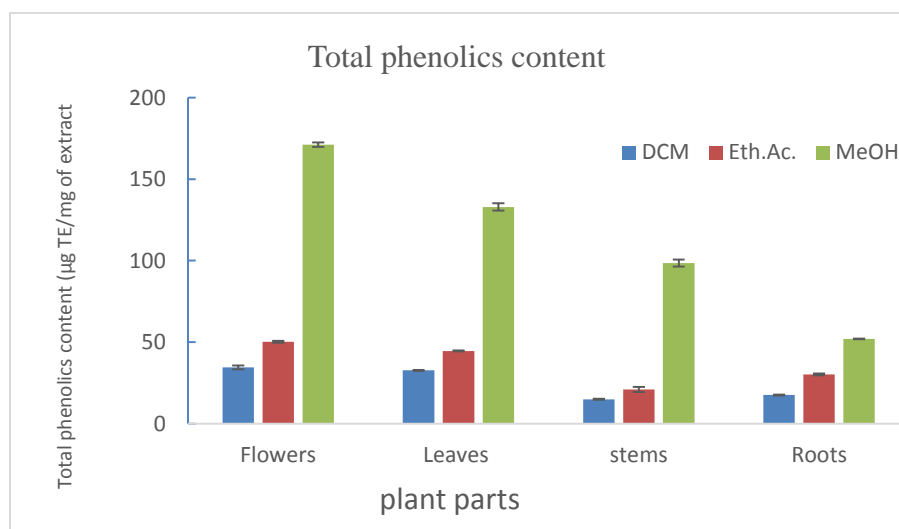
**Total phenolic content (TPC)**TABLE 2. Total phenolic content in different parts of *C. giganteus* extracts.

Extracts	Total phenolic content ( $\mu\text{g GAE/mg}$ of extract)			
	Flowers	Leaves	Stems	Roots
DCM	$34.44 \pm 1.21$	$32.63 \pm 0.33$	$14.94 \pm 0.32$	$17.52 \pm 0.34$
Eth. Ac.	$50.17 \pm 0.60$	$44.57 \pm 0.24$	$20.95 \pm 1.56$	$30.17 \pm 0.52$
MeOH	$171.17 \pm 1.42$	$132.95 \pm 2.20$	$98.55 \pm 2.14$	$51.93 \pm 0.17$

TPC in different parts of *C. giganteus* varied from  $14.94 \mu\text{g GAE/mg}$  of dried extract for DCM stems extract to up to  $171.17 \mu\text{g GAE/mg}$  of dried extract for Methanol flowers extract. Flowers possessed highest TPC compared to others different parts. Total phenolics contents in flowers are  $34.44 \mu\text{g GAE/mg}$ ,  $50.17 \mu\text{g GAE/mg}$  and  $171.17 \mu\text{g GAE/mg}$  of extract respectively in DCM, ethyl acetate and methanol extracts. On the other hand, methanol extracts had highest TPC ( $51.93$  to  $171.17 \mu\text{g GAE/mg}$  of extract), followed ethyl acetate extracts ( $20.95 \mu\text{g GAE/mg}$  to  $50.17 \mu\text{g GAE/mg}$  of extract) and DCM extract ( $14.94$  to  $34.44$ ), as it's clearly shown in FIG. 1. Methanol, as well as ethanol, is suitable solvents to extract phenolic compounds but methanol might extract many other compounds that are not phenolics. These results are matched with phytochemical results which showed that methanol extract contained many chemical groups.

These TPC are largely higher than those reported in *Lippia muliflora* leaves extracts according to our previous works [9]. Furthermore, the methanol extracts of *C. giganteus* flowers and leaves contained higher TPC than those reported by Kouassi et al [18] in *C. citratus* methanol leaves extracts from Ivory Coast ( $118.14 \text{ mg GAE/g}$  of extract). DCM extracts showed the lowest TPC but these values are higher compared to TPC reported by Karanga et al. [19] in different extracts of *Euphorbia hirta* from Burkina Faso.

*C. giganteus* different parts extracts, whatever the solvent used, contained strong phenolic contents, so this plant could be used as natural source of phenolic compounds.

FIG. 1. Total phenolic content in different parts of *C. giganteus* extracts.

**Total flavonoids content (TFC)**

Total flavonoids contents (TFC), expressed as  $\mu\text{g}$  of Quercetin equivalent/mg of extract, are gathered in TABLE 3.

Results showed that:

1. Using DCM as extraction solvent, roots had the highest TFC, followed by stems, leaves and flowers. TFC values in these different plant parts are respectively 348.34 ; 207.2, 147.55 and 93.91  $\mu\text{g}$  QE/mg of extract;
2. In ethyl acetate extracts, roots presented the highest TFC (323.86  $\mu\text{g}$  QE/mg of extract) compared to leaves (270.4  $\mu\text{g}$  QE/mg of extract);
3. In methanol extracts, the highest TFC were found in flowers (250.12  $\mu\text{g}$  QE/mg of extract) and the lowest were noted in stems extracts.

Results also showed that the type of solvent used to extract phenolics and flavonoids plays an important role. Indeed, phenolic compounds were easily extracted by methanol whereas ethyl acetate and sometimes, DCM are appropriate to extract flavonoids (FIG. 2). Although *C. giganteus* flowers are rich in phenolic compound, its roots remain the plant part with highest TFC, whatever the solvent used for extraction (TABLE 3).

TABLE 3. Total flavonoids content of different parts of *C. giganteus* extracts.

Extracts	Total flavonoids content ( $\mu\text{g}$ QE)/mg of extract)			
	Flowers	Leaves	Stems	Roots
<b>DCM</b>	93.91 $\pm$ 2.83	147.55 $\pm$ 23.24	207.20 $\pm$ 4.60	348.34 $\pm$ 12.48
<b>Eth. Ac</b>	132.49 $\pm$ 4.701	270.41 $\pm$ 32.20	189.38 $\pm$ 11.62	323.86 $\pm$ 31.55
<b>MeOH</b>	250.12 $\pm$ 14.94	134.23 $\pm$ 4.051	58.31 $\pm$ 8.01	159.02 $\pm$ 28.41

QE: Quercetine Equivalent

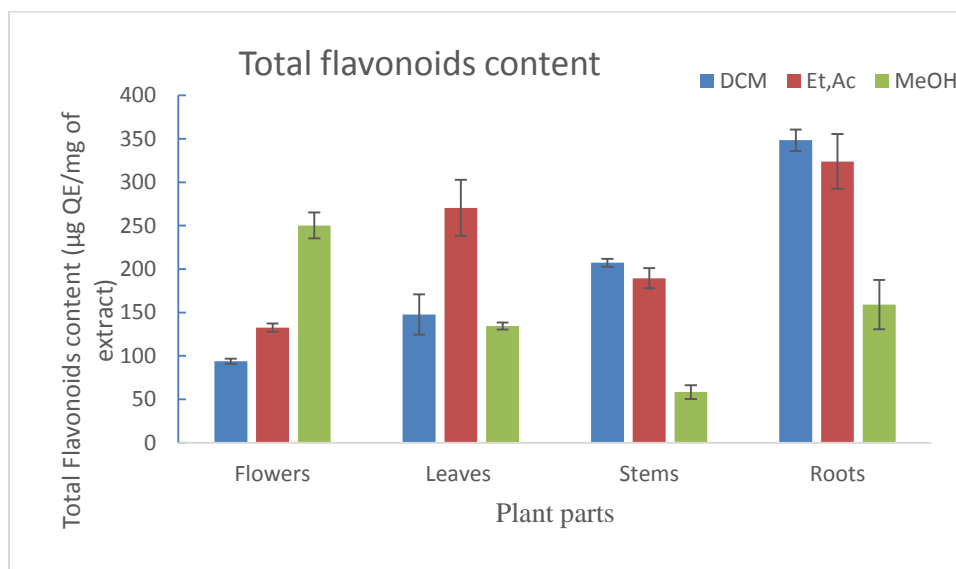


FIG. 2. Total flavonoids content in different parts of *C. giganteus* extracts and using different extraction solvents.

**Total antioxidant content (TAC) of different parts of *C. giganteus* extracts**

TAC were measured using two different methods: DPPH radical scavenging test and Ferric Reducing Antioxidant Power (FRAP) assay. Results are presented in TABLE 4. We note that *C. giganteus* different parts possessed significant TAC. Using DPPH test, the highest TAC could be found in flowers (12.52 µg of TE/mg to 100.40 µg of TE/mg of extract), then in leaves (17.63 µg of TE/mg to 57.15 µg of TE/mg of extract) and stems (16.74 µg of TE/mg to 39.21 µg of TE/mg of extract) and at last, in roots (9.33 µg of TE/mg to 38.68 µg of TE/mg of extract). Results also showed that for each plant part, methanol extracts exhibited the highest TAC compared to ethyl acetate and DCM extracts. For flowers extracts for example, 100 µg of TE/mg of extract were found in methanol extract, about three times the TAC in ethyl acetate extract and ten times in DCM extract. Results obtained by FRAP method were similar to those found with DPPH test, even if sometimes, FRAP assay seems to overestimate TAC in extracts.

It is well known that extracts with strong TPC and TFC generally present higher TAC [20]. In this work, methanolic extracts of flowers, leaves, stems and roots of *C. giganteus* were found to possess, in most of cases, highest TPC, TFC and TAC. So methanol extracts of different parts of this plant were tested for their antifungal activity.

TABLE 4. Total antioxidant content (TAC) *C. in giganteus* different parts extracts.

Total antioxidant content (µg TE/mg of extract)			
	Extracts	DPPH	FRAP
Flowers	DCM	12.52 ± 0.3	14.89 ± 1.47
	Eth. Ac	37.96 ± 4.02	38.2 ± 3.2
	MeOH	100.40 ± 8.41	112.94 ± 2.34
Leaves	DCM	20.14 ± 0.05	20.30 ± 1.50
	Eth. Ac	17.63 ± 1.67	19.67 ± 4.08
	MeOH	57.15 ± 6.47	68.56 ± 7.53
Stems	DCM	16.74 ± 0.00	18.16 ± 2.38
	Eth. Ac	27.47 ± 2.55	36.73 ± 0.91
	MeOH	39.21 ± 2.34	31.46 ± 6.52
Roots	DCM	9.33 ± 1.79	7.60 ± 8.45
	Eth. Ac	16.17 ± 3.27	13.77 ± 2.44
	MeOH	38.68 ± 2.63	45.17 ± 4.28
TE: Trolox Equivalent			

**Antifungal activity**

The percentage of inhibition of each methanol extract, tested at 10 mg/mL on the four fungi, was calculated every two days up to ten days; results are gathered in TABLE 5.



TABLE 5. Percentage of inhibition of methanol extracts of *C. giganteus* different parts on *Fusarium moniliforme*, *Phoma sorghina*, *Aspergillus flavus* and *Byopolaris orezae*.

% of inhibition of methanol extracts					
Plant parts	Duration	<i>Fusarium moniliforme</i>	<i>Phoma sorghina</i>	<i>Aspergillus Flavus</i>	<i>Byopolaris orezae</i>
Flowers	2 <sup>nd</sup> day	22.31 ± 5.36a	-2.39 ± 15.55a	10.56 ± 6.9a	-34.49 ± 11.72c
	4 <sup>th</sup> day	16.23 ± 4.17a	-9.13 ± 13.95a	8.33 ± 8.3a	-85.18 ± 11.95b
	6 <sup>th</sup> day	13.66 ± 12.80a	-26.47 ± 18.6a	2.36 ± 0.01a	-114.05 ± 15.6b
	8 <sup>th</sup> day	25.87 ± 5.60a	-3.47 ± 0.6a	1.27 ± 0.54a	-168.35 ± 21.04a
	10 <sup>th</sup> day	19.00 ± 6.39a	ND	13.04 ± 2.4a	-182.4 ± 16.75a
Leaves	2 <sup>nd</sup> day	18.160 ± 4.77b	-11.81 ± 15.77a	ND	ND
	4 <sup>th</sup> day	3.865 ± 4.64ab	-38.27 ± 21.4a	ND	ND
	6 <sup>th</sup> day	1.610 ± 6.70ab	-55.43 ± 18.8a	ND	ND
	8 <sup>th</sup> day	2.197 ± 6.29ab	-25.00 ± 0a	ND	ND
	10 <sup>th</sup> day	-1.839 ± 3.18 a	ND	ND	ND
Stems	2 <sup>nd</sup> day	9.857 ± 6.72a	-3.99 ± 2.55a	-9.86 ± 6.3a	-55.8 ± 9.0c
	4 <sup>th</sup> day	1.018 ± 11.24a	-23.72 ± 3.22a	-1.81 ± 0.8a	-122.5 ± 19.01bc
	6 <sup>th</sup> day	4.659 ± 4.20a	-33.61 ± 1.18a	-3.53 ± 5.18a	-144.0 ± 35.03ab
	8 <sup>th</sup> day	5.814 ± 5.89a	-12.96 ± 9.4a	-6.98 ± 1.4a	-202.7 ± 35.76a
	10 <sup>th</sup> day	10.321 ± 5.58a	ND	2.56 ± 5.7a	-186.1 ± 25.7ab
Roots	2 <sup>nd</sup> day	20.16 ± 4.49a	21.11 ± 4.32a	8.9a ± 2.76	-45.00 ± 18.02b
	4 <sup>th</sup> day	17.30 ± 4.4a	20.81 ± 4.23a	9.09 ± 2.14	-64.46 ± 24.32ab
	6 <sup>th</sup> day	9.17 ± 8.05a	16.17 ± 6.77a	12.45 ± 5.9	-81.17 ± 10.08ab
	8 <sup>th</sup> day	15.20 ± 3.46a	19.68 ± 4.62a	10.15 ± 0.5	-102.74 ± 22.64a
	10 <sup>th</sup> day	19.00 ± 8.27a	18.01 ± 1.32	13.4 ± 5.6	-93.85 ± 33.36ab
ND: Not Determined					

Positive values mean that extract has inhibitory effect on fungi; negative values mean that either extract has no inhibitory effect or extract stimulates fungus radial growth. Means (positive) values of inhibition percentage are presented in TABLE 6.

TABLE 6. Mean values of percentage of inhibition of each extract on *Fusarium moniliforme*, *Phoma sorghina*, *Aspergillus flavus* and *Byopolaris orezae*.

Fungi	Percentage of inhibition of extracts (%)				
	Flowers	Leaves	Stems	Roots	Calcio C*
<i>Fusarium moniliforme</i>	19.41	6.45	6.33	16.16	100
<i>Phoma sorghina</i>	NIE	NIE	NIE	19.15	100
<i>Aspergillus Flavus</i>	7.11	NIE	NIE	10.79	100
<i>Byopolaris orezae</i>	NIE	NIE	NIE	NIE	85.02
NIE: No inhibitory effect; Calcio C* was tested at 1 mg/mL					

Results showed that all the extracts inhibited the radial growth of *F. moniliforme*. Methanol flowers extract had the highest antifungal activity (19.41%), followed by roots (16.16%), leaves (6.45%) and stems extract (6.33%) (TABLE 6). These values are weak, compared to those reported by Karanga et al. [19]. Indeed, these authors found that *F. moniliforme* was sensitive to ethanol-water crude extracts, ethyl acetate and butanol extracts of *E. hirta* L. At a concentration of 5 mg/mL, they recorded percentages of inhibition of 47.00%; 58.33% and 57.00% respectively.

In contrario, none of extracts exhibited an inhibitory effect on *Byopolaris orezae*. Indeed this fungus seems to be hardly controlled by natural extract; even calcio C, a potent antifungal product, did not fully control its radial growth.

For *Phoma sorghina*, only roots extracts had an inhibitory effect on its radial growth. This inhibitory effect was low (19.15%) compared to the values reported by Karanga et al. [19] who found that *E. hirta* extracts, at 5 mg/mL, showed percentages of inhibition on this fungus ranged from 22.00% to 44.46%.

*Aspergillus flavus* was weakly sensitive to flowers extract (7.11%) and roots extracts (10.79%) but no inhibitory effect was observed for leaves and stems extracts. Pane et al. [21] also tested *Hyptis spicigera*, *C. giganteus* and *C. citratus* extracts on several strains of *Aspergillus*. They found that at concentration of 10 mg/mL, *C. giganteus* essential oil showed a slight inhibitory effect on *Aspergillus* strains but no inhibitory could be observed for *Hyptis spicigera* essential oil and organic extracts. To our knowledge, antifungal activity of the organic extracts of *C. giganteus* plant parts has been carried out for the first time. Roots and flowers of this plant might contain bioactive compound with broad action on several fungi at once.

*Phoma sorghina* as well as *Aspergillus flavus* are generally less sensitive to several plant extracts as reported in many previous works [1,21,22]. Certainly, plant extracts might behave like nutritive substances for these kind of fungi; they enrich the culture medium and produce greater mycelium growth than the control. On the other hand, the weak inhibitory effect of our extracts on fungi could be explained by their poor diffusion in the culture medium. Indeed, phytochemical results showed that methanol extracts contained many chemical groups which can interfere, resulting in a weak diffusion. So further fractionation of the extracts might reduce their complexity and each fraction could be tested again for its antifungal activity. Further studies could be focused on *C. giganteus* roots and flowers extracts regarding their high TPC, TFC and antifungal activity.

## Conclusion

The results obtained from this work showed that *C. giganteus* flowers, leaves, stems and roots contained several phytochemicals, particularly phenolic and flavonoids. All the different plant parts were more or less rich in phenolic and flavonoids compounds but flowers and roots were found to exhibit highest total phenolic, flavonoids and total antioxidant contents. Furthermore, methanolic extracts of flowers and roots both had an inhibitory effect on mycelium growth of *Fusarium moniliforme* and *Aspergillus flavus* but roots extracts also inhibited *Phoma sorghina* mycelium growth, a dangerous fungus which is generally hardly controlled by natural antifungal. *C. giganteus* roots and flowers extracts could be a natural source of antifungal as well as antioxidants. Further studies are need to determine the chemical compounds that are responsible for interested activities.

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