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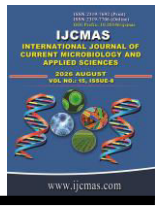

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Evaluation of the Anticandidal Activity of Total Extracts and Partitions of *Ganoderma lucidum* Collected in Côte d'Ivoire on the *invitro* Growth of Four Clinical Strains and One Reference Strain of *Candida* in Immunocompromised People

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A B S T R A C T

Candidiasis are fungal diseases caused by the genera *Candida*, which are yeasts that preferentially affect the skin and/or mucous membranes such as the mouth, vagina, and digestive tract. These conditions are becoming more and more recurrent due to the general decline in immunity and the emergence of resistance to conventional antifungals. Therefore, fighting against the failures of the treatment of candidiasis, and even better for these diseases, is essential. It is in this context that the present study is situated, which aims to evaluate the anticandidal activity of *Ganoderma lucidum* extracts (LUGA) on the *in vitro* growth of clinical strains and a reference strain of *Candida* in immunocompromised individuals in order to identify the most active extract. To do this, aqueous and hydroalcoholic extracts as well as partitioned extracts were prepared and their anticandidal potencies were tested on four clinical strains of *Candida* (*C. albicans, C. tropicalis, C. glabrata and C. parasislosis*) and a reference strain of *Candida albicans* ATCC 14053. The antifungal tests were carried out by the double dilution method in leaning tubes in solid medium. The results showed no inhibition of germ growth by LUGA aqueous extract; except on *Candida albicans* ATCC 14053 (reference strain) with a MIC=50 mg/mL. On the other hand, these results showed an inhibition of the growth of germs by the hydroethanolic extract and the acetae-water fraction from this LUGA extract. The minimum inhibitory concentrations (MICs) obtained from this fraction are: MIC (*Candida albicans* ATCC 14053) = 3.125 mg/mL; MIC (*Candida glabrata*) = 3.125 mg/mL; MIC (*Candida parapsilosis*) = 25 mg/mL; MIC (*Candida albicans*) = 25 mg/mL; MIC (*Candida tropicalis*) = 50 mg/mL. This study indicates that the acetate-water fraction from LUGA's hydroethanolic extract is the most active on the *Candida* strains studied among the two extracts evaluated and could constitute a source of effective molecules in the treatment of candidiasis.

Introduction

Candidiasis is a fungal infection called yeast infection. They are very frequent and caused by the exaggerated multiplication of yeasts belonging to the genus *Candida*. This infection usually affects the skin and/or mucous membranes such as the mouth, vagina, digestive tract of any immunocompromised person.

In addition, *Candida* is a commensal microscopic fungus that occurs naturally on the skin, mucous membranes (mouths, vagina, digestive tract) and internal organs. This becomes pathogenic when there is an imbalance in the microbial flora (Pujol, 2026).

Indeed, factors such as diabetes, HIV/AIDS, a decrease in immunity, environmental factors and the use of certain medications such as antibiotics and corticosteroids promote the appearance of candidiasis (Dereix, 2025).

Thus, studies have shown that there are treatments affiliated with these infections such as changing diet, taking antifungals, using plant extracts and certain spices (Dereix, 2025).

However, the inappropriate use of conventional antifungals has favored the appearance of resistant strains (Djohan *et al.,* 2012) which are responsible for therapeutic failure in the management of certain candidiasis mainly in immunocompromised people (Bolou *et al.,* 2022). Faced with this difficulty, research into new extracts and new classic molecules that contain effective antifungal properties against candidiasis resistant to existing molecules and that come from a commensal macroscopic fungus is necessary.

For example, the study of *Ganoderma lucidum* codified as Luga, a longevity fungus, appears to be a promising avenue for the discovery of effective drugs; given that this fungus is attracting growing scientific interest because of its potential beneficial effects on human health, particularly in the prevention of oxidative stress, aging, immune system disorders and certain cancers (Loyd *et al.,* 2018). It is with this in mind that the present study aims to evaluate the anticandidal activity of *Ganoderma lucidum* extracts on the *in vitro* growth of four clinical strains and one reference strain of *candida spp* in immunocompromised individuals in order to identify the most active extract. For the conduct of this study, aqueous and hydroalcoholic extracts as well as partitioned extracts were prepared and their anticandidal potencies were tested on four clinical strains of *Candida* (*C. albicans, C. tropicalis, C. glabrata and C. parasislosis*) and a reference strain of *Candida albicans* (ATCC 14053).

Materials and Methods

Material

Plant material

The plant material consisted of the macroscopic fungus called *Ganoderma lucidum* codified "LUGA". It was collected in the Lôh-Djiboua health region, more precisely in the Divo health district (190 km from Abidjan and 220 km from Daloa) in southwestern Côte d'Ivoire (Akoto *et al.,* 2026). This species was identified at the National Center of Floristics of the Felix Houphouet Boigny University in Abidjan.

Fungal strains

The germs tested are composed of four clinical strains of *Candida* and one reference strain of *Candida albicans* ATCC 14053. The resistance profiles of these strains are as follows:

Candida albicans ATCC 14053 (Amphotericine BR, FluconazoleR, ItraconazoleR, VoriconazoleR)
Candida albicans 479 (Amphotericine BS, FluconazoleR, ItraconazoleR, VoriconazoleR)
Candida glabrata 1224 (Amphotericine BS, FluconazoleI, ItraconazoleR, VoriconazoleS)
Candida tropicalis 1324 (Amphotericine BS, FluconazoleS, ItraconazoleS, VoriconazoleS)
Candida parapsilosis (Amphotericine BS, FluconazoleS, ItraconazoleS, VoriconazoleS)

Methods

Preparation of Ganoderma lucidum total extracts

Ganoderma lucidum has been cleaned and washed with distilled water to rid it of impurities. Then it was dried in the laboratory away from light at room temperature. After drying, the samples were crushed using an electric mill to obtain a homogeneous powder. This powder has been stored in airtight containers, away from moisture for later use. This very fine powder of *Ganoderma lucidum* (LUGA) obtained after spraying was used to prepare the

aqueous and ethanolic extracts according to the method described by Zirihi *et al.,* (2003) with a few modifications. Indeed, 100 g of vegetable powder was vigorously stirred in 1 L of solvents (distilled water or 70% ethanol) using an electric mixer for 5 turns of 60 seconds with a 5-second break after each turn. The mixture obtained is filtered through a sieve and then the residues are remixed in 500 mL of solvents (distilled water or 70% ethanol) at the same time and twice in a row. Another filtration is carried out, once on percale fabric and twice on hydrophilic cotton that is increasingly tight, in a funnel. The liquid extract obtained is evaporated in the oven at 50 °C for 24 hours for the ethanolic extract and 48 hours for the aqueous extract to obtain a dry extract.

Preparation of partitioned extracts of *Ganoderma lucidum*

The scores were made from the hydroethanolic extract. Indeed, 10 g of this extract was weighed and dissolved in 100 mL of solvent (hexane-water) or (ethyl acetate-water) at 50% under a magnetic stirrer at room temperature of 20° C at 1 revolution per min for 24 h for good homogenization.

After 24 hours of homogenization, the mixture was transferred to a decanting ampoule to observe the different phases of this partition. The two different phases observed were collected separately and brought to the VENTICELL ^{R} oven, for 24 h at 50° C, in order to obtain the different partitioned extracts (Ackah, 2009; Akoto *et al.,* 2026).

All these preparations were carried out at the Laboratory of Biotechnology and Valorisation of Natural Bioactive Substances (LBVSNB) of the National Centre for Floristics (CNF) of the University Félix Houphouet Boigny in Abidjan.

Extraction yield calculation

The extraction yield (ER) is defined as the ratio between the mass of hydroalcoholic or dry aqueous extract obtained (M') and the mass of the plant material (mushroom powder) used (M). This makes it possible to know the concentration of the molecules present in each extract. The return is expressed as a percentage. It was calculated by the following formula:

$$RE\ (\%) = \frac{M'}{M} \times 100$$

RE: Extraction yield in percentage %.

M': Mass of dry hydroalcoholic or aqueous extract obtained in grams (g).

M: Mass of plant matter (fungus) used in grams (g).

Evaluation of the anticandidal activities of LUGA's total extracts and scores

The antifungal activity is evaluated by the solid media dilution method and the antifungal parameters of the Minimum Inhibitory Concentration (MIC) and the Minimum Fungal Concentration (CMF) have been determined (Bolou *et al.,* 2022).

The incorporation of total and partitioned extracts of LUGA into Sabouraud + Chloramphenicol agar

The incorporation of the total and partitioned extracts of LUGA into the agar was carried out using the double dilution tube method with some modifications. Each series consisted of 10 test tubes, 8 of which contained the LUGA extract incorporated into the culture medium and 2 control tubes containing agar medium, one of which did not contain LUGA extract for germ growth control (TC) and the other without LUGA extract or germ for sterility control (TS) of the culture medium (Ahon *et al.,* 2011; Bolou *et al.,* 2022). The test tubes contained a range of decreasing concentrations of extract ranging from 100 mg/mL to 0.78125 mg/mL by describing a geometric sequence of 1/2 reason. To perform the double dilution, 1000 mg of LUGA extract was homogenized in 10 mL of Sabouraud + Liquefied Chloramphenicol agar in the T1 tube, giving a concentration of 100 mg/mL.

The remaining seven tubes contained 5 mL of Sabouraud + liquid Chloramphenicol agar. Then, 5 mL of the homogeneous mixture from the T1 tube was transferred to the next tube (T2), containing 5 mL of Sabouraud + Chloramphenicol agar, and this mixture was homogenized. This was repeated successively for the other tubes up to tube 8 (T8), containing the lowest concentration (0.78125 mg/mL). For this last tube, half of the content was thrown away to adjust the volumes.

The tubes thus prepared were sterilized at 121 °C by the autoclave for 15 minutes. Each tube containing the culture medium was tilted on the bench and then left at laboratory temperature to allow cooling and solidification of the agar.

Fungal inoculum preparation, seeding and incubation

The fungal inoculum was prepared from 24-h young colonies. For each strain, a perfectly isolated colony of *Candida* was suspended in 10 mL of sterile distilled water to give an estimated microbial suspension of 106 cfu/mL. A 1/10 dilution of this bacterial suspension was then performed to give our fungal inoculum estimated at 105 cfu/mL. Then, each of the tubes containing the sloping extract concentrations was seeded with 5 mm streaks with 5 µL of each inoculum. The inoculated tubes were incubated at 30°C for 48 h (Guédé-Guina *et al.,* 1997; Bolou *et al.,* 2022).

Determination of antifungal parameters (MIC and MFC)

After 48 h of incubation, germ growth was observed in the test tubes of each culture series. Thus, the minimum inhibitory concentration (MIC) on each of the different strains of Candida was determined for each extract of LUGA. This is the minimum concentration for which there has been no visible growth of the germ to the naked eye. The minimum fungicide concentration (MFC) was also determined. This is the smallest concentration of extract that resulted in at least 99.99% inhibition of germ growth, compared to growth control. In practice, the CMF was determined by a streak sterility test that showed no visible growth from the MIC after 48 h of incubation at 30°C. Transplants of the streaks without visible growth were carried out on a Petri dish containing new Sabouraud agar and containing no plant extract or antifungal substance. Indeed, the platinum loop was passed over the surface of each of the striations without visible microbial growth and then seeding was carried out, again by streaking, on a new agar. And after 48 h of incubation at 30°C more of these transplants, MFC was identified (Bolou *et al.,* 2022; Konan *et al.,* 2023).

As a result, the tube, which does not contain microbial growth, has been evaluated as MFC and the extract is said to be fungicidal. In the opposite case, the tube corresponds to the MFCs and the extract is said to be fungistatic (Kouassi *et al.,* 2026).

Results and Discussion

LUGA Total Extract Yields

The preparation of the total extracts (aqueous and hydroethanolic) from 100 g of *Ganoderma lucidum* powder (LUGA) yielded 15.12 g and 14.56 g of LUGA extract respectively, corresponding to 15.12% and 14.56% respectively (Figure 1). The analysis of this result shows that the aqueous extract has the best extraction yield compared to that of the hydroethanolic extract.

The evaluation of the antifungal potency of total extracts of *Ganoderma lucidum* (LUGA) *in vitro* on *Candida albicans* yielded the results reported in Table 1.

Evaluation of the anticandidal activities of total extracts of Ganoderma lucidum (LUGA)

These results show that the aqueous extract of LUGA showed no inhibition of *Candida albicans* 479 up to the maximum concentration used. On the other hand, the hydroethanolic extract of this same mushroom has significant inhibitory power with a MIC = 25 mg/mL and a CMF = 50 mg/mL on this strain of *Candida* (Figure 2). Therefore, the hydroethanol extract of LUGA is the most active on the strain of *Candida albicans479* studied and has a fungicidal effect.

Review of the antifungal potencies of total extracts of *Ganoderma lucidum* (LUGA) in vitro on Candida glabrata yielded the results presented in Table 2**.**

Figure.1 Total Extract Yields

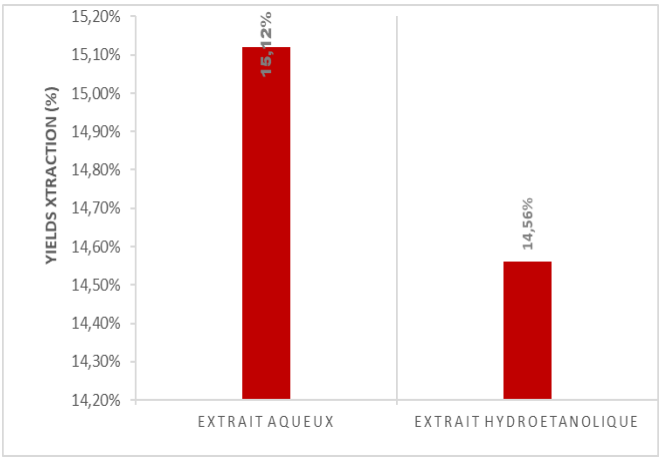


Table.1 Antifungal Parameters of Total Extracts on In Vitro Growth of Candida albicans 479

Total excerpts from *Ganoderma lucidum* (LUGA)	**Fungal strains**				
	Candida albicans		**Fungicide**	**Effect Report**	**Fungistatic**
	CMI	CMF	CMF/CMI	(CMF/CMI) ≤ 2	(CMF/CMI) > 2
Aqueous extract	>100	>100	1	YES	NO
Hydroethanolic extract	25	50	2	YES	NO

Figure.2 Determination of the MIC and MFC of the total extracts (XAq and X0) on *Candida albicans.*

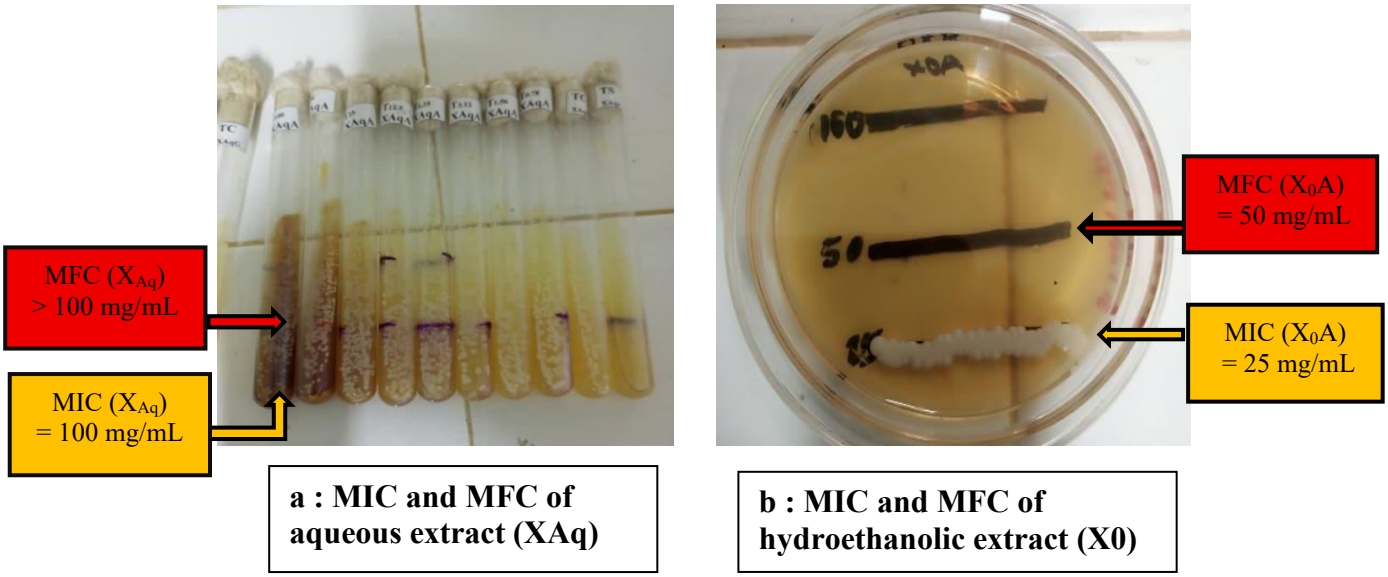
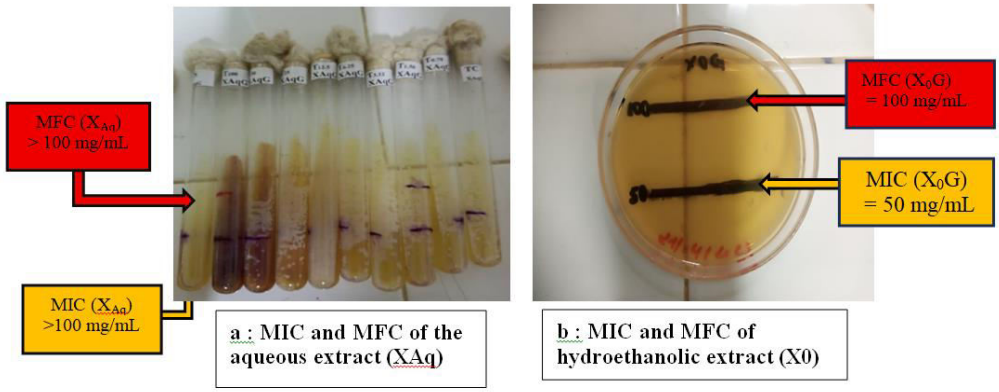


Table.2 Antifungal Parameters of Total Extracts on *In Vitro* Growth of *Candida glabrata*

Total excerpts from *Ganoderma lucidum* (LUGA)	Fungal strains				
	Candida glabrata		Effect Report	Fungicide	Fungistatic
	MIC	MFC	MFC/MIC	(MFC/MIC) ≤ 2	(MFC/MIC) >2
Aqueous extract >100 >	100	1	YES	NO	
Hydroethanolic extract	50	100	2	YES	NO

Figure.3 Determination of the MIC and MFC of the total extracts (XAq and X0) on *Candida glabrata.*



These results show that the aqueous extract of LUGA showed no inhibition of *Candida glabrata* up to the maximum concentration used. However, the hydroethanolic extract of this same mushroom has significant inhibitory power with a MIC = 50 mg/mL and an MFC = 100 mg/mL on this strain of *Candida* (Figure 3). Therefore, the hydroethanolic extract of LUGA appears to be the most active extract on the strain of *Candida glabrata* studied with a fungicidal effect.

L'évaluation of the antifungal potency of total extracts of *Ganoderma lucidum* (LUGA) *in vitro* on *Candida parapsilosis* yielded the results reported in Table 3.

These results show that the aqueous extract of LUGA showed no inhibition of *Candida parapsilosis* up to the maximum concentration used. On the other hand, the hydroethanolic extract of this same mushroom has significant inhibitory power with a MIC = 25 mg/mL and a MFC = 12.5 mg/mL on this strain of *Candida* (Figure 4). Therefore, the hydroethanol extract of LUGA is the most active on the strain of *candida parapsilosis* studied and has a fungicidal effect.

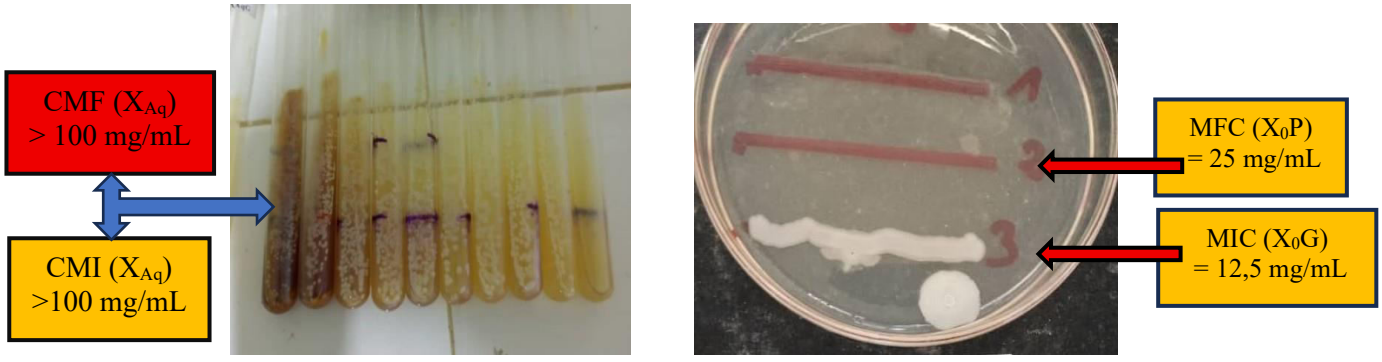
*Evaluation of the antifungal potency of total extracts of *Ganoderma lucidum* (LUGA) *in vitro* on *Candida tropicalis* yielded the results reported in Table 4.

These results show that the aqueous extract of LUGA showed no inhibition of *Candida tropicalis* up to the maximum concentration used. On the other hand, the hydroethanolic extract of this same mushroom has significant inhibitory power with a MIC = 50 mg/mL and a CMF = 100 mg/mL on this strain of *Candida* (Figure 5). Therefore, the hydroethanolic extract of LUGA is the most active on the strain of *Candida tropicalis* studied and has a fungicidal effect.

Table.3 Antifungal Parameters of Total Extracts on *in Vitro* Growth of *Candida parapsilosis*

Total excerpts from *Ganoderma lucidum* (LUGA)	**Fungal strain**				
	Candida parapsilosis		**Effect Report**	**Fungicide**	**Fungistatic**
	CMI	CMF	CMF/CMI	(CMF/CMI) ≤ 2	(CMF/CMI) > 2
Aqueous extract	**>100**	**>100**	**1**	**YES**	**NO**
Hydroethanolic extract	**12.5**	**25**	**2**	**YES**	**NO**

Figure.4 Determination of the MIC and MFC of the total extracts (X0 and XAq) on *Candida parapsilosis*



a : MIC and MFC of the aqueous extract (XAq)

b : MIC and MFC of hydroethanolic extract (X0)

Table.4 Antifungal Parameters of Total Extracts on *in Vitro* Growth of *Candida tropicalis*

Total excerpts from *Ganoderma lucidum* (LUGA)	Fungal strain				
	Candida tropicalis		Effect Report	Fungicide	Fungistatic
	MIC	MFC	MFC/MIC	(MFC/MIC) ≤ 2	(MFC/MIC) > 2
Aqueous extract	>100	>100	1	YES	NO
Hydroethanolic extract	25	50	2	YES	NO

The evaluation of the antifungal potency of total extracts of *Ganoderma lucidum* (LUGA) *in vitro* on *Candida albicans* ATCC 14053 yielded the results reported in Table 5.

These results show that the aqueous extract of LUGA showed inhibition of *Candida albicans* ATCC 14053 up to MIC = CMF = 50 mg/mL. Also, the hydroethanolic extract of this same mushroom showed significant inhibitory power with MIC = CMF = 3.125 mg/mL on this reference strain of *Candida* (Figure 6). So, the excerpt LUGA's hydroethanolic system is the most active on the strain of *Candida tropicalis* studied and has a fungicidal effect.

This study also shows that Ganoderma lucidum *hydroethanolic extract* (LUGA) is more active than LUGA's aqueous extract despite its lower extraction yield than the latter.

Figure.5 Determination of the MIC and MFC of the total extracts (XAq and X0) for *Candida tropicalis.*

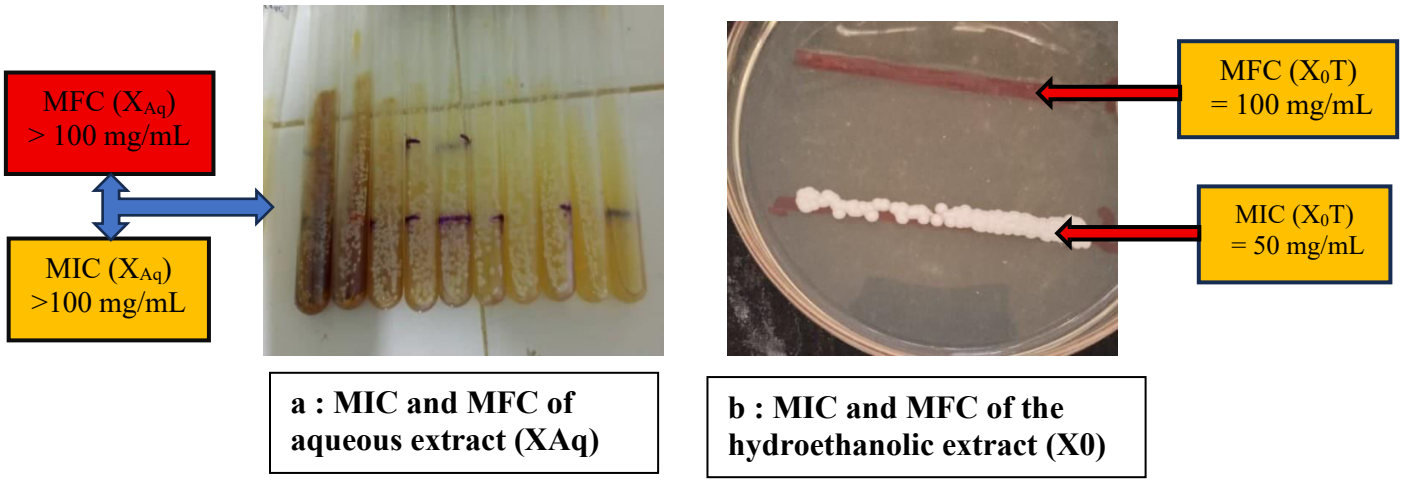


Table.5 Antifungal Parameters of Total *In Vitro* Growth Extracts of *Candida albicans* ATCC 14053

Total excerpts from *Ganoderma lucidum* (LUGA)	**Fungal strain**				
	***Candida* ATCC 14053**		**Effect Report**	**Fungicide**	**Fungistatic**
	MIC	MFC	MFC/MIC	(MFC/MIC) ≤ 2	(MFC/MIC) > 2
Aqueous extract	**50**	**50**	**1**	**YES**	**NO**
Hydroethanolic extract	**3.125**	**3.125**	**1**	**YES**	**NO**

Figure.6 Determination of the MIC and MFC of hydroethanolic extract (X0) on *Candida albicans* ATCC 14053.

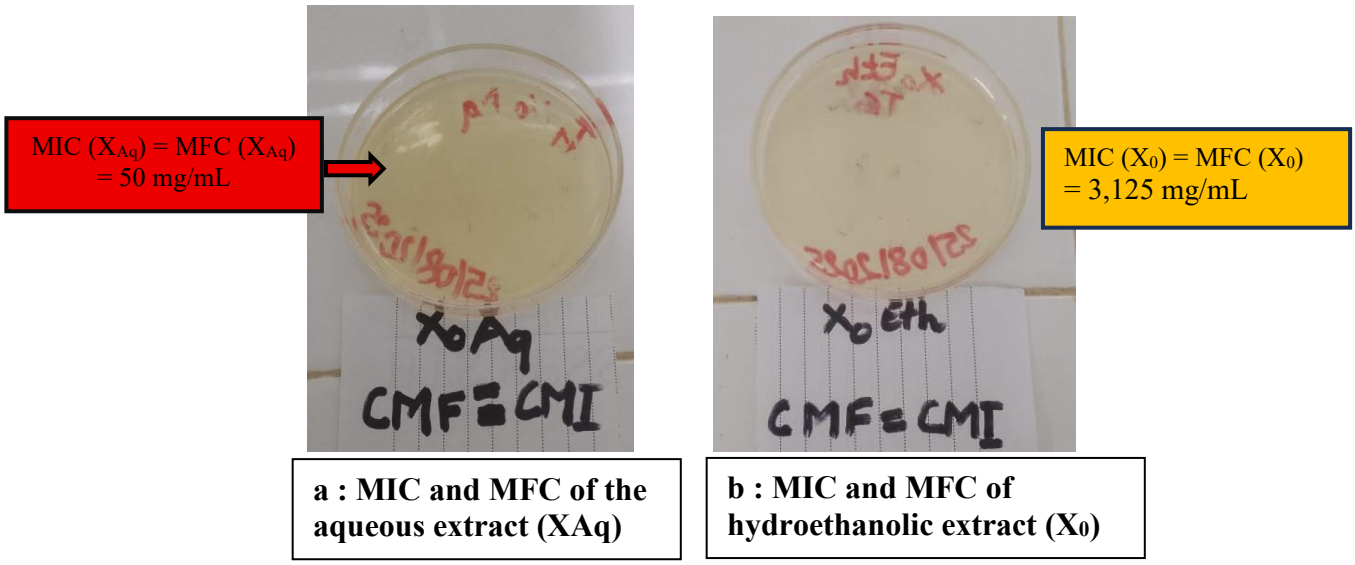


Figure.7 Partitioned Extract Yields

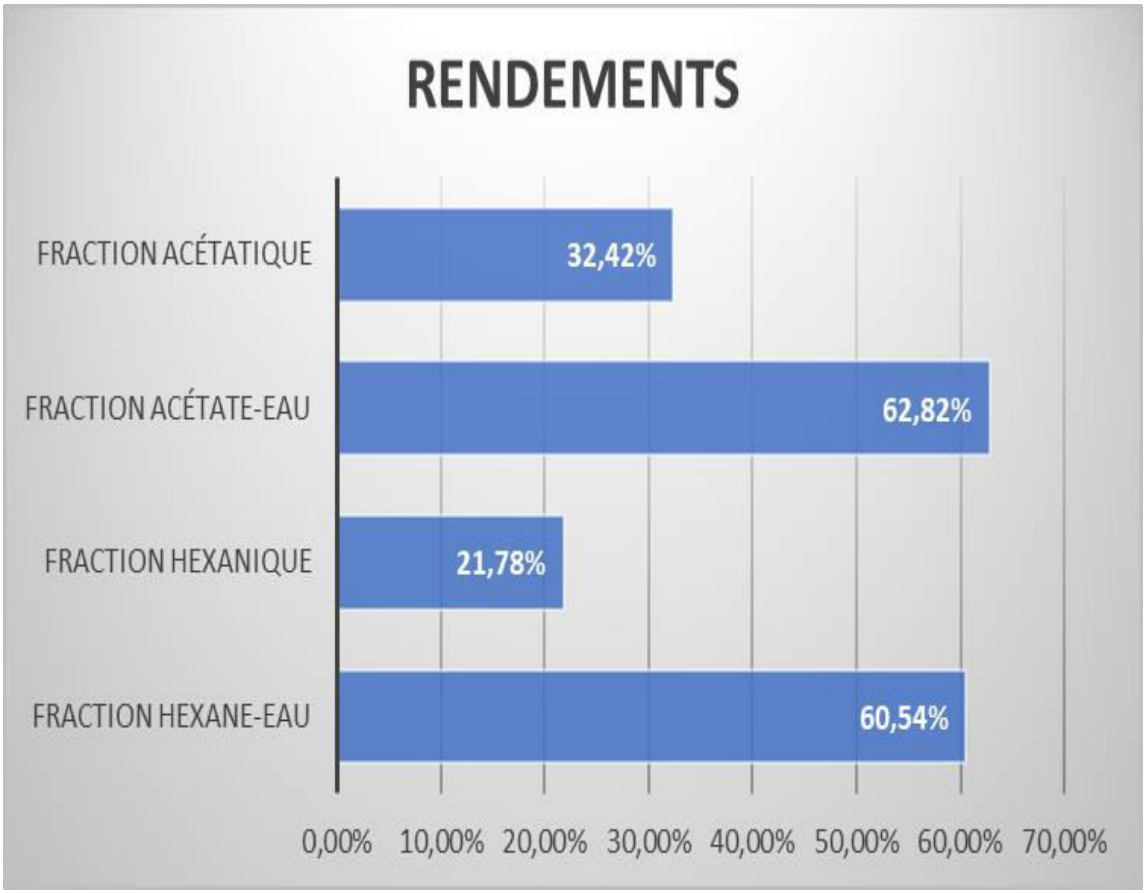


Table.6 Anticandidal Parameters of Partitioned Extracts of LUGA on the *In Vitro Growth* of *Candida albicans*

Partitioned excerpts from *Ganoderma lucidum* (LUGA)	Fungal strains				
	Candida albicans		Effect Report	Fungicide	Fungistatic
	CMI	CMF	CMF/CMI	(CMF/CMI) ≤ 2	(CMF/CMI) > 2
Acetal fraction (F1)	25	25	1	YES	NO
Acetate-water fraction (F2)	25	50	2	YES	NO
Hexanic fraction(F3)	25	50	2	YES	NO
Hexane-water fraction(F4)	25	50	2	YES	NO

Rendement des extraits partitionnés de *Ganoderma lucidum* (LUGA)

In view of the activity of the hydroethanolic extract, it was chosen to be partitioned with hexane and ethyl acetate from 10 g of this extract. This made it possible to obtain the following yields: the hexanic (21.78%) and acetan (32.42%) fractions, which showed low yields compared to those of the hexane-water (60.54%) and acetate-water (62.82%) fractions. The analysis of this result shows that the aqueous phases of the different partitions have the best extraction yield compared to that of the organic phases (Figure 7).

Evaluation of the anticandidal activities of LUGA partitioned extracts on the *in vitro* growth of the studied *Candida* strains

These scores obtained were evaluated on the *in vitro growth* of *Candida albicans*, *Candida tropicalis, Candida glabrata, Candida parapsilosis* and *Candida albicans* ATCC 14053 (the reference strain). The results are shown in tables 6, 7, 8, 9 and 10 and figures 8, 9, 10, 11 and 12.

Evaluation of the anticandidal activities of partitioned LUGA extracts on the *in vitro growth* of *Candida* albicans

The results of this evaluation show that all LUGA fractions have an inhibition on the in vitro growth of the different strains of *Candida albicans*, with a MIC= 25 mg/mL and an MFC= 50 mg/mL each. Except for the acetan fraction which showed MIC=MFC=25 mg/mL (Table 6 and Figure 8).

Effect reports for *Candida albicans*:
-MFC X_0 /MFC F_1= 50/25= 2
- MFC X_0 /MFC F_2= 50/50= 1
- MFC X_0 /MFC F_3= 50/50= 1
-MFC X_0 /MFC F_4= 50/50= 1

From the comparison of the fractions F1, F2, F_3 and F4 on the basis of the ratios of its MFC value, it appears that the F1 fraction is twice as active as the other fractions. Moreover, when this value of MFC is compared to that of the extract used as the basis for its preparation (X0), it is noted that it is 2 times more active than the other fractions on the germ studied.

Evaluation of the anticandidal activities of partitioned LUGA extracts on the *in vitro growth* of *Candida glabrata*

The results of this evaluation show that all LUGA fractions showed inhibition on the in vitro growth of *Candida glabrata*, with MIC F1= 25 mg/mL, MIC F2= 6.25 mg/mL, MIC F3 = 50 mg/mL, MIC F4= 12.5 mg/mL. But the aqueous fractions F2 and F4 are more active this Candida than the organic fractions F1 and F3. (Table 7 and Figure 9)

Effect reports for *Candida glabrata*:
-MFC X0 /MFC F1= 100/50= 2
- MFC X0 /MFC F2= 100/12,5= 8
- MFC X0 /MFC F3= 100/100= 1
-MFC X0 /MFC F4= 100/25= 4

From the comparison of the fractions F1, F2, F_3 and F4 on the basis of the ratios of its MFC value, it appears that the fractions F2 and F4 are respectively 8 and 4 times more active than F1 and F3. Moreover, when this MFC value is compared with that of the extract used as the basis for its preparation (X0), it is noted that F2 is 8 times more active than the other fractions on the germ studied. Here the acetate-water fraction (F2) is the most active.

Figure.8 Determination of the MIC and CFM of partitioned LUGA extracts (F1, F2, F3 and F4) on *Candida albicans.*

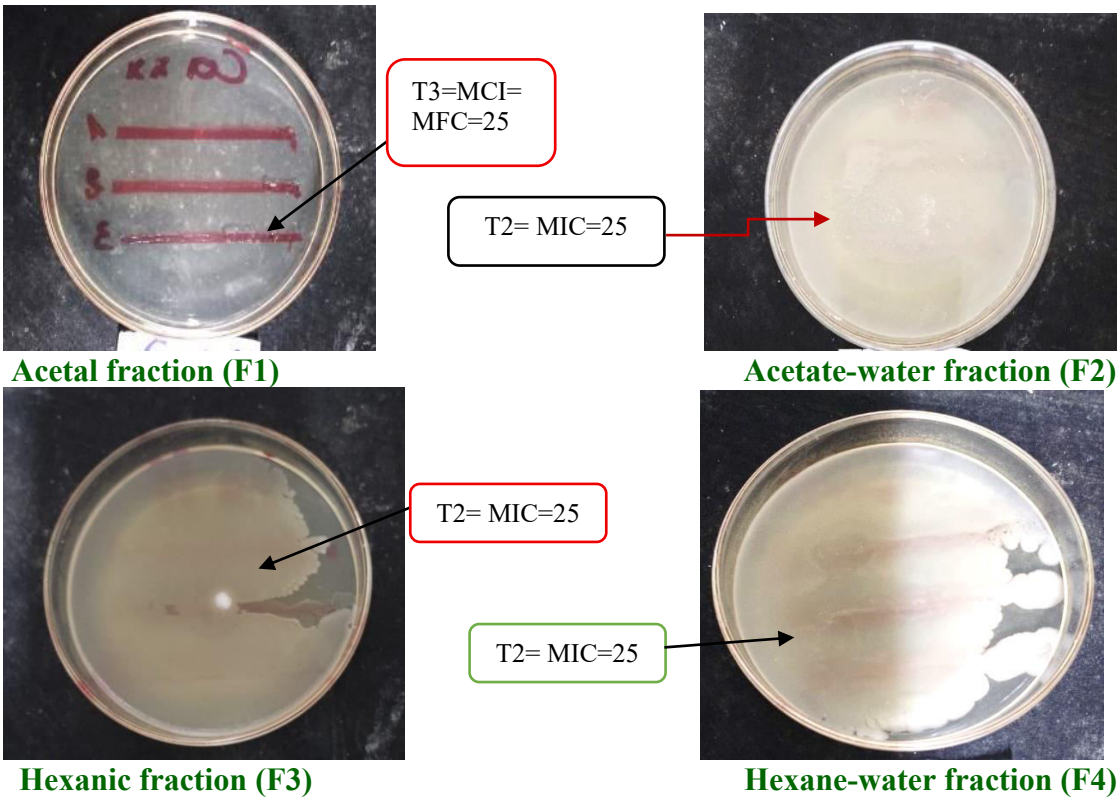


Table.7 Antifungal Parameters of Partitioned Extracts on the *In Vitro Growth* of *Candida glabrata*

Partitioned excerpts from *Ganoderma lucidum* (LUGA)	**Fungal strain**				
	Candida glabrata		**Effect Report**	**Fungicide**	**Fungistatic**
	MIC	MFC	MFC/MIC	(MFC/MIC) ≤ 2	(MFC/MIC) > 2
Acetal fraction (F1)	25	50	2	YES	NO
Acetate-water fraction (F2)	6.25	12.5	2	YES	NO
Hexanic fraction(F3)	50	100	2	YES	NO
Hexane-water fraction(F4)	12.5	25	2	YES	NO

Table.8 Antifungal parameters of partitioned extracts on the *in vitro growth* of *Candida tropicalis*

Partitioned excerpts from *Ganoderma lucidum* (LUGA)	**Fungal strain**				
	Candida tropicalis		**Effect Report**	**Fungicide**	**Fungistatic**
	MIC	MFC	MFC/MIC	(MFC/MIC) ≤ 2	(MFC/MIC) > 2
Acetan fraction (F1)	100	>100	1	YES	NO
Acetate-water fraction (F2)	50	50	1	YES	NO
Hexanic fraction(F3)	100	>100	1	YES	NO
Hexane-water fraction(F4)	100	>100	1	YES	NO

Figure.9 Determination of the MIC and MFC of LUGA partitioned extracts (F1, F2, F3 and F4) on *Candida glabrata.*

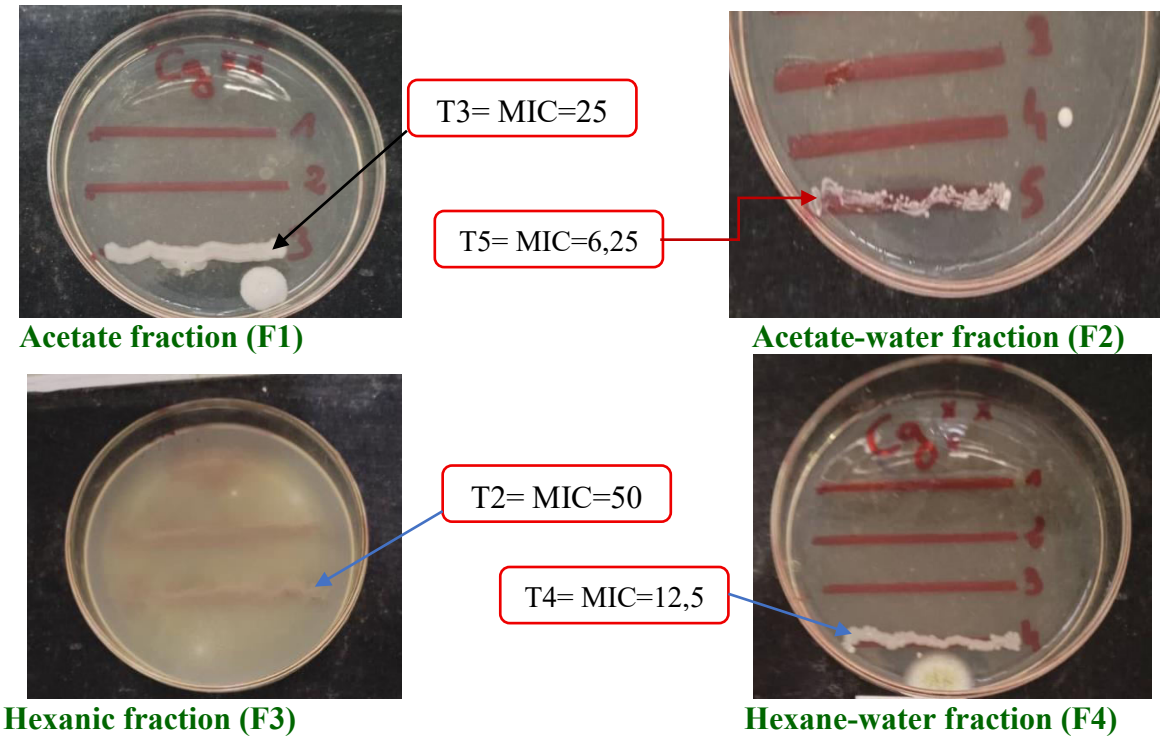


Figure.10 Determination of the MIC and MFC of partitioned LUGA extracts (F1, F2, F3 and F4) on *Candida tropicalis.*

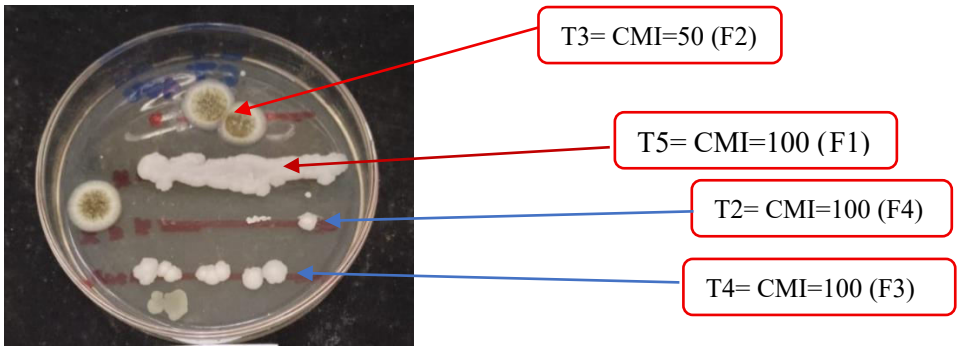


Table.9 Antifungal Parameters of Partitioned Extracts on in *Vitro Growth* of *Candida parapsilosis*

Partitioned excerpts from *Ganoderma lucidum* (LUGA)	**Fungal strain**				
	Candida parapsilosis		**Effect Report**	**Fungicide**	**Fungistatic**
	CMI	CMF	CMF/CMI	(CMF/CMI) ≤ 2	(CMF/CMI) > 2
Acetal fraction (F1)	25	50	2	YES	NO
Acetate-water fraction (F2)	50	100	2	YES	NO
Hexanic fraction(F3)	25	50	2	YES	NO
Hexane-water fraction(F4)	50	100	2	YES	NO

Figure.11 Determination of the MIC and CMF of partitioned LUGA extracts (F1, F2, F3 and F4) on *Candida parasilosis.*

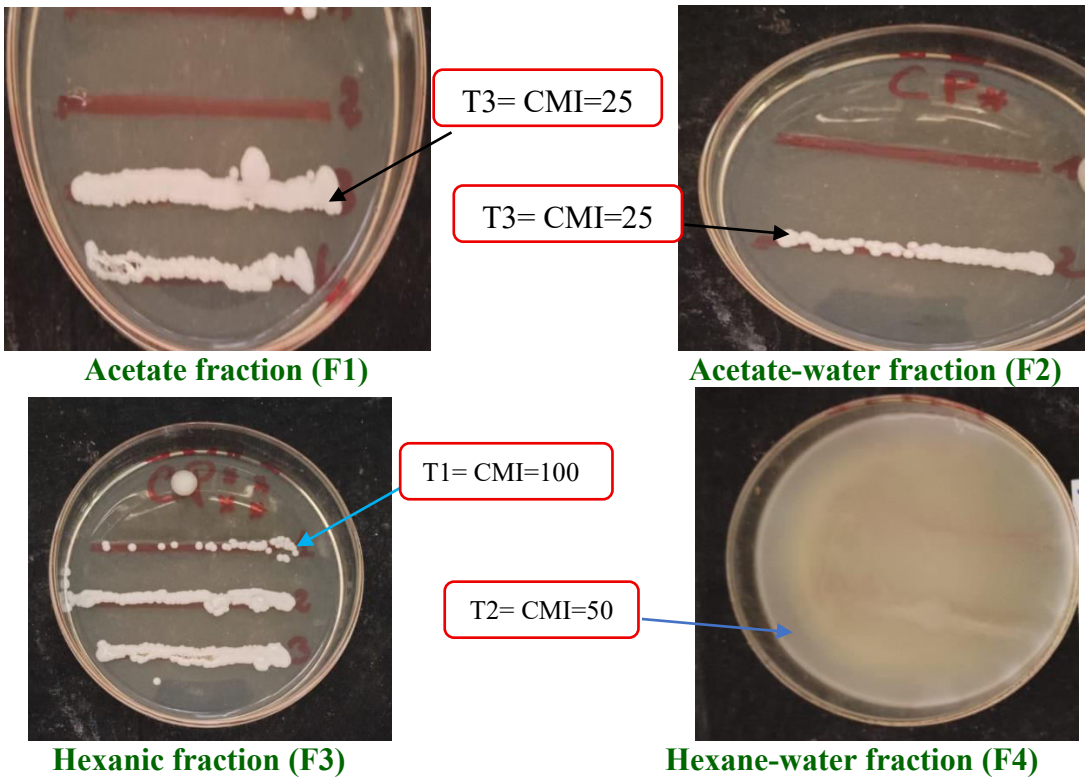
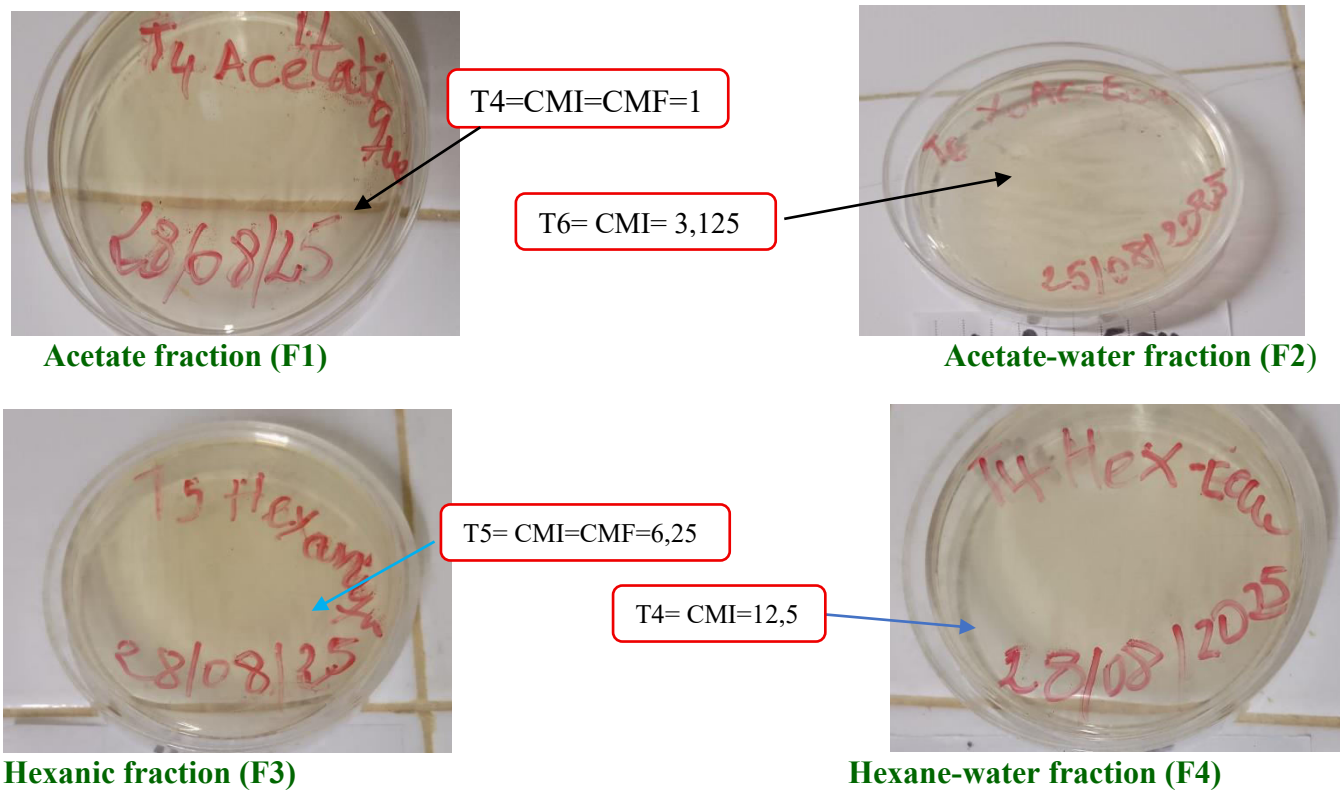


Table.10 Antifungal Parameters of Partitioned Extracts on the In *Vitro Growth* of *Candida albicans (*ATCC 14053)

Partitioned excerpts from *Ganoderma lucidum* (LUGA)	**Fungal strain**				
	***Candida albicans* (ATCC 14053)**		**Effect Report**	**Fungicide**	**Fungistatic**
	CMI	CMF	CMF/CMI	(CMF/CMI) ≤ 2	(CMF/CMI) > 2
Acetan fraction (F1)	12.5	12.5	1	YES	NO
Acetate-water fraction (F2)	3.125	3.125	1	YES	NO
Hexanic fraction(F3)	6.25	6.25	1	YES	NO
Hexane-water fraction(F4)	12.5	25	2	YES	NO

Figure.13 Determination of the MIC and CMF of partitioned LUGA extracts (F1, F2, F3 and F4) on *Candida albicans* (ATCC 14053).



Evaluation of the anticandidal activities of partitioned LUGA extracts on the *in vitro growth* of *Candida tropicalis*

The results of this evaluation show that all LUGA fractions showed no inhibition on the in vitro growth of *Candida tropicalis*, with MIC = 100 mg/mL and CMF=100 mg/mL. Except for the F2 fraction which showed inhibition on this germ with a MIC=CMF= 50 mg/mL.

Effect reports for *Candida tropicalis*:
-MFC X0 /MFC F1= 100/100= 1
-MFC X0 /MFC F2= 100/50= 2
-MFC X0 /MFC F3= 100/100= 1
-MFC X0 /MFC F4= 100/100= 1

From the comparison of the fractions F1, F2, F_3 and F4 on the basis of the ratios of its MFC value, it appears that the fractions F2 is 2 times more active than F1, F3 and F4. Moreover, when this MFC value is compared to that of the extract used as the basis for its preparation (X0), it is noted that F2 is twice as active as the other fractions on the germ studied. Here the acetate-water fraction (F2) is the most active.

Evaluation of the anticandidal activities of partitioned LUGA extracts on the *in vitro growth* of *Candida parapsilosis*

The results of this review show that all LUGA fractions expressed inhibition on the in *vitro growth* of *Candida parapsilosis*, with MIC F1 = 25 mg/mL, MIC F2 = 50 mg/mL, MIC F3 = 100 mg/mL, MIC F4 = 50 mg/mL. But the organic fraction F1 is the most active on this *Candida* than the F2 and F4 fractions which showed the same MIC = 50 mg/mL and the same MFC = 100 mg/mL. F1 presented the same results for the base extract (X0). (Table 9 and figure 11)

Effect reports for *Candida parapsilosis*:
-MFC X0 /MFC F1= 25/50= 0,5
- MFC X0 /MFC F2= 25/100= 0,25
- MFC X0 /MFC F3= 25/100= 0,25
-MFC X0 /MFC F4= 25/100= 0,25

From the comparison of the fractions F1, F2, F $_3$ and F4 on the basis of the ratios of its value of MFC, it appears that the fractions F1 is more active than F2, F3 and F4. Moreover, when we compare this value of MFC to that of the extract used as the basis for its preparation (X0), we notice that F1 has the same ICMs and MFCs as the base extract.

It is more active than the other fractions on the germ studied. Here the acetal fraction (F2) is the most active.

Evaluation of the anticandidal activities of partitioned LUGA extracts on the *in vitro growth* of *Candida albicans* ATCC 14053

The results of this experiment show that all LUGA fractions expressed inhibition on the in vitro growth of *Candida albicans* (ATCC 14053) with MIC F1= 12.5 mg/mL, MIC F2=3.125mg/mL, MIC F3 = 6.25 mg/mL, MIC F4= 12.5 mg/mL. But the most active fractions are F2 and F3. (Table 10 and Figure 12)

Effect reports for *Candida albicans* ATCC 14053:
-CMF X0 /CMF F1= 3,125/12,5= 0,25
-CMF X0 /CMF F2= 3,125/6,25= 0,5
-CMF X0 /CMF F3= 3,125/6,25= 0,5
-CMF X0 /CMF F4= 3,125/25= 0,125

From the comparison of the fractions F1, F2, F $_3$ and F4 on the basis of the ratios of its CMF value, it appears that the fractions F2 and F3 are more active than F1 and F4. Moreover, when this CMF value is compared with that of the extract used as the basis for its preparation (X0), it is noted that F2 is more active than the other fractions on the germ studied. Because F2 has the lowest MIC = 3.125 mg/mL. Here the acetate-water fraction (F2) is the most active.

Analysis of the extraction yield result of total extracts of *Ganoderma lucidum* (LUGA) shows that the aqueous extract has the best extraction yield compared to that of the hydroethanolic extract. This is in agreement with the work of (Akoto *et al.,* 2026) who achieved such a high yield with LUGA's aqueous extract (Ext-Aq). This result means that LUGA is relatively more concentrated in secondary metabolites extractable by the water solvent and also by the ethanol-water solvent (70/30, v/v). Because the return on this is not negligible. For this reason, the evaluation of the anticandidal powers of these total LUGA extracts on the *in vitro* growth *of Candida albicans, Candida glabrata, Candida tropicalis, Candida parapsilosis and Candida alabicans* ATCC 14053 has shown that the hydroethanolic extract of this mushroom is the most active extract and has a fungicidal effect. This is because it has a significant inhibitory power on the different strains of *Candida* studied. From these results, it can be deduced that LUGA hydroethanolic extract is more active than reference molecules such as amphotericin B, fluconazole, itraconazole and voriconazole and accepted in the treatment of candidiasis in immunocompromised people.

Based on these facts, we can conclude that LUGA is highly concentrated in anticandidal active ingredients. This observation is in agreement with the extraction yields obtained. So the active ingredients of LUGA could replace the classic molecules and cure the various cases of resistant candidiasis while boosting the immune system in immunocompromised people. These results are in agreement with those of Angaman *et al.,* (2020); Bolou *et al.,* (2022); Yapo *et al.,* (2023) who showed that when extracts from a plant inhibit fungal strains of Candida, it appears that this plant has antifungal powers**.**

Analysis of the results of the partitioned extracts shows that the aqueous phases of these different partitions have the best extraction yield compared to that of the organic phases (Figure 7). These results are consistent with those of (Akoto *et al.,* 2026) who obtained the same yields with the partitions of LUGA harvested in Côte d'Ivoire. But, these yields are very high compared to those obtained by Ryu *et al.,* (2020), this research team in South Korea found that the yield values of *Ganoderma lucidum* extracts are for n-hexane 0.25%, ethyl acetate 2.10% and methanolic 4.25% and by Kebaili *et al.,* (2021); Merghid and Halimi (2025) who showed the following values for extracts of ethyl acetate 0.63% and aqueous 5.78% of *Ganoderma lucidum* in Algeria. This could be explained by several factors such as the extraction methods used and the nature of the solvents used. (Khatua *et al.,* 2019; Ghimire *et al.,* 2021; Villalobos-Pezos *et al.,* 2024).

All these results indicate the presence of significant amounts of polar compounds as well a non-polar compounds in LUGA extracts. In addition, the evaluation of he anticandidal activities of these fractions on the *in vitro* growth *of Candida albicans, Candida glabrata, Candida tropicalis, Candida parapsilosis and Candida alabicans* ATCC 14053.

Revealed that all these fractions showed inhibition on the *in vitro* growth of *the Candida* studied. Except for the acetate moiety which showed MIC=MFC=25 mg/mL on the *in vitro growth* of *Candida albicans*. Our results are superior to those of Ackah *et al.,* 2008 who found MIC = MFC = 390 µg/mL for *Candida albicans* with hexanic extracts and MIC=MFC=40 µg/mL with hexane-water, MIC = MFC = 190 µg/mL acetate extract and MIC = MFC = 90 µg/mL with acetate-water extract of *Terminalia catappa.*

Also, the aqueous fractions F2 and F4 of this fungus demonstrated their strong activity, especially the F2 fraction (acetate-water fraction) on these Candida than the organic fractions F1 and F3. Our results are consistent with those of Agré *et al.,* 2014 who showed that the aqueous phases of partitions have a high activity than organic phases.

This indicates that these germs are more sensitive to aqueous fractions than to organic fractions. All these anticadidotic activities are confirmed by the anticandidal activity of these fractions on the reference strain ATCC 14053 which showed for the acetate-water fraction (F2) with a MIC = 3.125 mg/mL. Our results are endorsed by those of Yayé *et al.,* 2013 who expressed that the acetate-water phase (F2) has a high activity than the other phases. This indicates that this *Candida albicans* (ATCC 14053) has a higher sensitivity for the acetate-water fraction.

In view of these results, it should be noted that the best performance is observed with the acetate-water fraction (F2). In addition, this extract has a fungicidal action like all other extracts.

Therefore, the acetate-water fraction (F2) would have started the purification of the total hydro-ethanol extract by improving the antifungal activity of the latter. Hence the acetate-water fraction would be retained for the rest of the work.

This study, carried out on *Ganoderma lucidum* (LUGA) collected in Côte d'Ivoire, evaluated the potential for inhibition of total extracts and partitions of this fungus on four clinical strains of *Candida* and a reference strain of *Candida albicans* ATCC 14053.

It appears that LUGA's hydroethanolic extract is more active than its total aqueous extract. In addition, the most active fraction from the hydroethanolic extract is the acetate-water fraction. So LUGA collected in Côte d'Ivoire is a promising mushroom and could be used to prepare mushroom-based drugs or to extract new antifungal or anticandidal molecules capable of inhibiting reference molecules and effectively curing candidiasis. Also, this study revealed the importance of the selection of extraction solvents.

Author Contributions

Affou Rosine AKOTO: conceived the original idea, designed the model, wrote the manuscript and managed the analysis and interpretation of the study. Abba Pacôme OBOUAYEBA: Designed the model and the computational framework and analysed the data. Moustapha KAMAGATE: Managed the analyses of the study. Agohi Meidji Francisqua N'DRI: Managed literature searches. Gbê Kouakou N'dri Ange KONAN: Managed literature searches. Jean David N'GUESSAN: Read and approved the final manuscript and the orientation. Tanoh Hilaire KOUAKOU: Read and approved the final manuscript and the orientation during this work.

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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