

Antioxidant and antimicrobial capacities of *Ganoderma lucidum*

Abstract

The present study aimed to determine the total antioxidant status (TAS), total oxidant status (TOS), oxidative stress index (OSI) and antimicrobial activities of *Ganoderma lucidum* mushroom collected in Oguzeli region (Gaziantep province, Turkey). Rel Assay Diagnostics kits were used to determine TAS, TOS and OSI levels. Antimicrobial activity was determined using 9 different bacteria and fungi (*Staphylococcus aureus*, *S. aureus* MRSA, *Enterococcus faecalis*, *Escherichia coli*, *Pseudomonas aeruginosa*, *Acinetobacter baumannii*, *Candida albicans*, *Candida krusei* and *Candida glabrata*) using modified agar dilution method. The study findings demonstrated that *G. lucidum* had high antioxidant potential. Antimicrobial activity of the mushroom was also found to be normal. Thus, the consumption of *G. lucidum* as a natural source of antioxidants and an antimicrobial resource could be suggested.

Keywords: *Ganoderma lucidum*, medicinal mushroom, antioxidant, oxidant, antimicrobial

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Introduction

Mushrooms, one of the functional nutrients consumed for centuries, were always among the natural material rich in fiber, proteins, vitamins and minerals. In addition to their property as functional nutrients, several mushroom species possess natural pharmacological potential. Only a few studies were conducted on important pharmaceutical mushrooms even today, despite the fact that these studies reported ant proliferative, antimicrobial, and antioxidant, antitumor, antiallergic, hypoglycemic, anti-inflammatory and immune-enhancing properties of the investigated mushroom specie.¹⁻⁵ Thus, it is not surprising that the interest in investigating the medicinal properties of wild mushrooms has increased over time.

Ganoderma lucidum, a cosmopolitan mushroom species, is a polypore rack mushroom that changes its color during growth until maturity from orange-white to bright red. There are both historical and contemporary research that supported the use of *G. lucidum* in various conditions including chronic inflammation and cancer. Its potent anti-oxidant and liver protective properties help slow the aging process, thus it is known as the “mushroom of immortality”. The anti-cancer properties act as a powerful supplement in several malignancies, especially breast cancer and lymphoma, and recent studies demonstrated surprising safety profile in these cases.⁶⁻⁹

The present study aimed to determine the total antioxidant status, total oxidant status and oxidative stress index of *Ganoderma lucidum* (Curtis) P. Karst mushroom collected in Gaziantep province Oguzeli region (Turkey) in order to identify the antioxidant capacity of the mushroom.

Material and Method

G. lucidum mushrooms were collected in Gaziantep province (Oguzeli region) in Turkey (Figure 1). The samples were transported to the laboratory environment under adequate conditions and extracted with methanol (MeOH) and dichloromethane (DCM) in Soxhlet extractor (Gerhardt EV14). The extracts were concentrated in a rotary evaporator (Heidolph Laborota 4000 Rotary Evaporator).



Figure 1 *Ganoderma lucidum* (Curtis) P. Karst.

The identified 30 g samples were extracted in Soxhlet extractor for about 6 hours at 50°C with methanol (MeOH) and dichloromethane (DCM) (Gerhardt EV14). The obtained extracts were concentrated with a rotary evaporator (Heidolph Laborota 4000 Rotary Evaporator).

TAS, TOS and OSI tests

Rel Assay brand commercial kits were used to determine *G. lucidum* mushroom TAS, TOS and OSI levels. Trolox was used as the calibrator in the TAS tests and hydrogen peroxide was used as the calibrator in TOS tests.^{10,11} When calculating the OSI value, TAS and TOS units were equalized and the proportion of the two values was calculated. Thus, the OSI percentage value was calculated.¹¹

Antimicrobial Activity Tests

Antimicrobial activity assays on mushroom MeOH and DCM extracts were conducted with the agar dilution method as recommended by the Clinical and Laboratory Standards Institute (CLSI) and the European Committee on Antimicrobial Susceptibility Testing (EUCAST). Minimal inhibitory concentrations (MIC) for

each extract were tested against standard bacterial and fungal strains. *Staphylococcus aureus* ATCC 29213, *Staphylococcus aureus* MRSA ATCC 43300, *Enterococcus faecalis* ATCC 29212, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, *Klebsiella pneumoniae* ATCC 700603, *Acinetobacter baumannii* ATCC 19606, *Candida albicans* ATCC 10231, *Candida krusei* ATCC 34135 ATCC 13803, and *Candida glabrata* ATCC 90030 were used as test microorganisms. Bacterial strains were pre-cultured in Muller Hinton Broth medium and fungal strains were pre-cultured in RPMI 1640 Broth medium. The turbidity of bacteria and fungi was prepared according to McFarland 0.5 scale to obtain a standard inoculum. All extracts were tested at 800-12.5 µg/ml concentrations and all dilutions were conducted with distilled water. The solvents used in the extracts were tested for antimicrobial activity. Fluconazole and amphotericin were used as reference drugs for B fungi and Amikacin, Ampicillin and Ciprofloxacin were used as reference drugs for bacteria. The lowest dilution that inhibited the propagation of bacteria and fungi was determined as the minimal inhibitory concentration (MIC).¹²⁻¹⁷

Results and discussion

TAS, TOS, and OSI

In the present study, *G. lucidum* mushroom TAS, TOS and OSI values were determined for the first time in literature. The findings are presented in Table 1.

Table 1 *G. lucidum* TAS, TOS and OSI values

	TAS	TOS	OSI
<i>G. lucidum</i>	5.509±0.198	10.177±0.116	0.185±0.008

No data are available in the literature for the TAS, TOS and OSI

Table 2 Antimicrobial Activity of *G. lucidum*

	<i>S. aureus</i>	<i>S. aureus</i> MRSA	<i>E. faecalis</i>	<i>E. coli</i>	<i>P. aeruginosa</i>	<i>A. baumannii</i>	<i>C. albicans</i>	<i>C. glabrata</i>	<i>C. krusei</i>
DCM	200	200	100	200	200	100	100	100	100
MeOH	200	200	100	100	200	100	50	100	50
Ampicillin	1.56	3.12	1.56	3.12	3.12	-	-	-	-
Amikacin	-	-	-	1.56	3.12	3.12	-	-	-
Ciprofloxacin	1.56	3.12	1.56	1.56	3.12	3.12	-	-	-
Fluconazole	-	-	-	-	-	-	3.12	3.12	-
Amphotericin B	-	-	-	-	-	-	3.12	3.12	3.12

The MIC values are presented in units of µg/mL.

It was determined that mushroom MeOH extracts were effective on test microorganisms at 50-200 µg/mL concentrations. Furthermore, it was found that mushroom DCM extracts were effective on test microorganisms at concentrations of 100-200 µg/mL. Previous studies demonstrated that different concentrations of *G. lucidum* aqueous extracts were effective on *Bacillus anthracis*, *B. cereus*, *B. subtilis*, *Micrococcus luteus*, *Staphylococcus aureus*, *Escherichia coli*, *Klebsiella oxytoca*, *K. pneumoniae*, *Proteus vulgaris*, *Salmonella tomson*, *S. typhi*, *S. typhimurium* and *Serratia marcescens*.²² It was reported that different concentrations of *G. lucidum* MeOH extracts were effective on *S. aureus*, *B. cereus*, *Listeria monocytogenes*, *Micrococcus flavus*, *P. aeruginosa*, *E. coli*, *S. typhimurium* and *Enterobacter cloacae*. In the present study, MeOH and DCM extracts of *G. lucidum* were used. It was determined that the extracts exhibited antimicrobial effects in different concentrations on *S. aureus*, *S.*

values of *G. lucidum* mushroom. However, in studies conducted on the TAS, TOS and OSI values with different mushroom species, it was determined that the TAS values of *Auricularia auricula*, *Trametes versicolor*, *Lepiota cristata*, *Leucoagaricus leucothites*, *Cyclocybe cylindracea* and *Paxillus involutus* mushrooms were 1.010, 0.820, 2.210, 8.291, 4.325 and 1.230 mmol/L, respectively, and TOS values were 23.910, 17.760, 24.357, 10.797, 21.109 and 7.533 µmol/L and OSI values were reported as 2.367, 2.166, 1.103, 0.130, 0.488 and 0.613, respectively.^{4,18-21} Compared to the above-mentioned studies, it was determined that the TAS value of *G. lucidum* was lower when compared to *L. leucothites* mushroom and higher when compared to that of *A. auricula*, *T. versicolor*, *L. cristata*, *C. cylindracea* and *P. involutus* mushrooms. It was determined that the TOS value of *G. lucidum* was a lower when compared to *L. leucothites*, *A. auricula*, *T. versicolor*, *L. cristata* and *C. cylindracea* mushrooms and higher when compared to *P. involutus* mushroom. It was determined that the OSI value of *G. lucidum* was higher when compared to *L. leucothites* mushroom and lower when compared to that of *A. auricula*, *T. versicolor*, *L. cristata*, *C. cylindracea* and *P. involutus* mushrooms.

It was suggested that the above-mentioned differences in TAS, TOS and OSI values were due to differences among mushroom species and environmental and inherent factors such as differences between the habitats and the substrates the mushrooms utilize. Thus, it was determined that *G. lucidum* has a high antioxidant potential and can be consumed as a natural antioxidant source.

Antimicrobial Activity Tests

In the present study, the lowest extract concentrations that prevented the proliferation of test microorganisms were determined and the findings are presented in Table 2.

aureus MRSA, *E. faecalis*, *E. coli*, *P. aeruginosa*, *A. baumannii*, *C. albicans*, *C. glabrata* and *C. krusei* test microorganisms. Thus, it was concluded that *G. lucidum* was a natural antimicrobial agent against tested microorganisms.

Conclusion

In the present study, antioxidant and antimicrobial activities of wild *G. lucidum* mushroom were determined. In conclusion, it was determined that the mushroom exhibited high antioxidant activity. It could also be consumed as a good antimicrobial agent against tested microorganisms.

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Conflicts of Interest

No conflict of interest was declared by the authors.

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