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 kruiset* 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

**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 species. 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.

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). The identified 5g samples were extracted in Soxhlet extractor for about 6hours at 50°C with methanol (MeOH) and dichloromethane (DCM) (Gerhardt EV14). The obtained extracts were concentrated with a rotary evaporator (Heidolph Laborota 4000Rotary 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. 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
Antioxidant and antimicrobial capacities of *Ganoderma lucidum* and *G. lucidum* - ATCC 10231, 22 - 100 and *C. glabrata* 1.56 - 100 and *E. coli* - 100 - 200 and ATCC 27853, 3.12 100 and C. krusei 1.56 1.56 - 100 200 - OSI 3.12 3.12 10.177±0.116 50 aqueous *E. faecalis* 3.12 1.56 - - - - 3.12 3.12 200, 3.12 50 *C. krusei* 1.56 and 3.12 *C. albicans* 3.12 3.12 100 3.12 100 1.56 - - - - - - - 1.230μmol/L, respectively, and TOs values were 23.910, 17.760, 24.357, 10.797, 21.109 and 7.533μmol/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 TAS value of *G. lucidum* was a lower when compared to *L*. leucothites, *A*. auricula, *T*. versicolor, *L*. crista, *C*. cylindracea and *P*. involutus mushrooms. 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. crista, 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.

### Table 1. *G. lucidum* TAS, TOs and OSI values

|       | TAS      | TOs      | OSI       |
|-------|----------|----------|-----------|
| G. lucidum | 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 values of *S. aureus* MRSA, *E. faecalis*, *E. coli*, *P. aeruginosa*, *A. baumannii*, *C. albicans*, *C. glabrata* and *C. krusei*. 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, Leptota cristata, Leucoagaricus leucothites*, *Cyclopye cylindracea* and *Paxillus involutus* mushrooms were 1.010, 0.820, 2.210, 8.291, 4.325 and 1.230μmol/L, respectively, and TOs values were 23.910, 17.760, 24.357, 10.797, 21.109 and 7.533μmol/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 TAS value of *G. lucidum* was a lower when compared to *L*. leucothites, *A*. auricula, *T*. versicolor, *L*. cristata, *C. cylindracea* and *P. involutus* mushrooms. 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. crista, 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.

| S. aureus | S. aureus MRSA | E. faecalis | E. coli | P. aeruginosa | A. baumannii | C. albicans | C. glabrata | C. krusei |
|----------|----------------|------------|--------|---------------|--------------|-------------|-------------|-----------|
| DCM      | 200            | 200        | 100    | 200           | 100          | 100         | 100         | 100       |
| MeOH     | 200            | 200        | 100    | 100           | 200          | 100         | 50          | 100       |
| Amoxiciln| 1.56           | 3.12       | 1.56   | 3.12          | -            | -           | -           | -         |
| Amikacin | -              | -          | 1.56   | 3.12          | 3.12         | -           | -           | -         |
| Ciprifloxacin | 1.56         | 3.12       | 1.56   | 3.12          | 3.12         | -           | -           | -         |
| Flunokzole | -            | -          | -      | -             | -            | -           | 3.12        | 3.12      |
| Amphiotecin | -            | -          | -      | -             | -            | 3.12        | 3.12        | 3.12      |

It was determined that mushroom MeOH extracts were effective on test microorganisms at 50-200μg/mL concentrations. Furthermore, it was found that mushroom DCM extracts were effective on test microorganisms at concentrations of 100-200μg/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. 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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