Int. J. Pharm. Investigation, 2025; 15(4):1380-1387.
https://www.jpionline.org

Original Article

Antibacterial, Antioxidant and Anti-Inflammatory Effect with GC-MS Profile of Edible Mushroom Fermented by LAB

Jamith Basha Abdul Wahid*, Mohameed Aljuwayd, Muhannad Alruwaili, Wesam Nofal

Department of Medical Laboratory Technology, Faculty of Applied Medical Sciences, Northern Border University 91431, Arar, SAUDI ARABIA.

ABSTRACT

Background: Nutritional modifications arise from an enhanced understanding of the importance of food and its impact on human well-being. **Objectives:** This study investigates the fermentation-based preservation of edible mushrooms using Lactobacillus sp. Methods: The research examines the effects of LAB-mediated fermentation on edible mushrooms and evaluates their bioactive potential. **Results:** The findings indicate that the extract of Agaricus bisporus exhibits superior properties compared to Coriolus versicolor. Nevertheless, both fermented mushrooms displayed significantly lower metal chelating capacity than DPPH radical inhibition efficiency. *Agaricus bisporus* showed greater antioxidant activity than *Calocybe indica*, but exhibited lower anti-inflammatory properties. The analyzed LAB effectively fermented Agaricus bisporus, preserving the mushroom and sustaining its biological activity, as evidenced by the identification of more than 30 different volatile compounds through gas chromatography. **Conclusion:** The results suggest that LAB-dependent fermentation of Agaricus bisporus holds promising medicinal value, exhibiting higher antioxidants, antibacterial, and anti-inflammatory properties compared to non-fermented mushrooms. This study highlights the potential of edible mushrooms as sources of antibacterial, antioxidant, and anti-inflammatory compounds, indicating the necessity for further assays to evaluate fermented fungal compounds as safe alternatives to combat antibiotic resistance.

Keywords: Fungi, antioxidant, Lactobacillus, Mushroom, Phenol, DPPH.

Correspondence:
Dr. Jamith Basha Abdul Wahid
Department of Medical Laboratory Technology, Faculty of Applied Medical Sciences, Northern Border University, SAUDI ARABIA.
Email: jamithbasha@gmail.com

Received: 12-03-2025;
Revised: 09-04-2025;
Accepted: 23-06-2025.

INTRODUCTION

Around the world, people create and eat fermented food, with probiotic bacteria probably the most prevalent type of fermentation. Because of their distinct flavor and its universal recognition as a cuisine marvel, mushrooms are used all over the world (Bakratsas *et al*., 2021). In addition to their organoleptic quality, therapeutic qualities, and socioeconomic relevance, mushrooms are regarded as a delicacy with high nutritional and functional value and are also recognized as nutraceutical foods. In recognition of its anticancer properties, lactic fermentation has long been utilized in many parts of the world for maintaining the fruiting bodies of edible mushrooms (Atila *et al*., 2021). The Agaricus bisporus mushroom is among the most widely grown in the globe (Ramos *et al*., 2019). Diverse antimicrobial substances, primarily secondary metabolites along with certain primary metabolites as oxalicacid, peptides, and proteins, may be found in mushrooms. The most extensively researched species, Lentinus edodesis, appears to exhibit antibacterial properties against both bacteria and fungi (Ergonul *et al*., 2013). They also guard towards inflammation and the growth of tumors. The most significant polysaccharide in contemporary medicine is glucan, a highly well-known and adaptable metabolite with a broad range of biological activities (Alves *et al*., 2012). In addition to a variety of amino acids, dietary mushrooms are a good source of riboflavin (vitamin B2), niacin, folates and trace amounts of vitamin C, B1, B12, D, and E. (Pereira *et al*., 2012) Strong immune boosters have been discovered in a protein from *A. polytricha* and a lectin from *A. bisporus*. It has been demonstrated that *A. bisporus* extract stops breast cancer cells from proliferating (Ferreira *et al*., 2010; Jabłońska *et al*., 2019). Although lactic acid fermentation of mushrooms is common in Southeast Asia and Eastern Europe, it is not commonly used in industry. Therefore, the purpose of this work is to investigate the *in vitro* antioxidant and antibacterial activity of the acetone and methanol extract of the *Russula cyanoxanth, Lactarius piperatus, Amanita rubescens*, and *Cantharellus cibarius* mushrooms (Kosanić *et al*., 2016).

OPEN ACCESS

Manuscript TECHNOMEDIA

DOI: 10.5530/ijpi.20250304

MATERIALS AND METHODS

Raw material processing

Experimental study on preservation of produced edible mushrooms has focused on improving the procedure thoroughly

using curd samples. Commercially procured *Agaricus bisporus* and *Calocybe indica* were the two types of mushrooms used in these investigations. Typically, only the mushroom caps are utilized for lactic fermentation; the stems are thrown away. The edible parts of the mushrooms used in this study were chopped into short pieces, measuring between 3.5 and 4.5 cm and then blanched in boiling water for 60 sec. For fermentation, just about 25 g of stems and fruiting bodies were used. When a washing procedure is done correctly, dirt can be removed during dry cleaning, and surface microorganisms can be partially reduced (Liu *et al*., 2016).

Starter cultures

The majority of investigations on fermented mushrooms used starter cultures of Lactic Acid Bacteria (LAB), which are obtained from curd samples on MRS agar, to carry out lactic fermentation. The curd sample was serially diluted and plated on MRS agar and subsequently subcultured on MRS broth. The cell pellet was collected by centrifugation and the OD at 600 nm was adjusted to 1 using phosphate buffer.

Fermentation

In a sterile vial, 50 g of edible mushroom parts are combined with 5 mL of LAB at $1x10^{-8}$ CFU sample and thoroughly mixed. It is advised to use the raw material in a 1:2 ratio to the brine that contains 2% salt and 1% sucrose in this about 25 mL sterilized brine solution. The samples, which were stored at 30°C for 25 days (Bernas and Jaworska, 2012).

Extraction

10 mL of the sample were obtained, and it went through a centrifuge for 15 min at 10,000 rpm. After 3 hr, the clear aqueous phase was gathered and extracted using 10 mL of ethanol. Following a 10-min centrifugation at 5000 rpm, the supernatant was filtered through Whatman filter paper No. 2, dried in a Rotary Evaporator, and then reconstituted in 1 mg/mL of double-distilled water.

Total Antioxidant activity

The antioxidant capability of the isolated biological compound assessed using 1,1-Diphenyl-2-Picrylhydrazyl (DPPH) at a concentration of 1 mg/mL. A 100 µg quantity of ascorbic acid served as the evaluation's standard. 0.2 mL of DPPH reagent was incorporated to 2 mL of ethanol solution in a test tube, and everything was thoroughly mixed. The reaction tube filled with 0.1 mL of the fermented aqueous sample. After that, the tube was covered with aluminum foil and allowed to sit at room temperature for 20 min and OD recorded at 517 nm, absorbance was measured against ethanol blank. The percentage was calculated by equation 1

Eq1. DPPH scavenging=(OD of control-OD of test/OD of control)x100

Metal Chelating Activity

Metal chelating activity carried out on the extract's by mixing 1mL of ethanol with 100 µL of the recovered fermented mushroom with 50 µL of 2 mM ferrous chloride, 0.2 mL of 5 mM ferrozine was added to initiate the reaction. After 10 min in a dark environment, absorbance at 562 nm was then measured. EDTA is used as standard. For the control, distilled water was utilized. The equation that follows was used to determine the metal chelating efficiency.

Eq2. Inhibition (%)=(1-A562(extract)/A562(control))×100

The anti-inflammatory protein denaturation

The extract's anti-inflammatory properties were investigated using the protein denaturation prevention technique at a concentration of 1 mg/mL. 0.1 mL of egg albumin, 2.8 mL of phosphate buffered saline (pH: 6.4), and 0.1 mL of fermented extracts at different concentration was prepared. PBS used as a negative control and dichlofenac used as standard drug. After 15 min of incubation at 37±2°C, the mixtures were heated to 70 °C for 5 min. After cooling, the vehicle was used as a blank to measure their absorbance at 660 nm. The following formula was used to determine the percentage inhibition of protein denaturation.

Eq3. Percentage of anti-inflammatory=(OD of Control-OD of sample/OD of Control)x100

Antibacterial activity

100 µg of both fermented and crude mushroom extracts were placed onto a sterile disk after being dissolved in the vehicle for 30 min at room temperature. The disc had been placed on over the MH agar plates that had been inoculated with the test pathogen for 24 hr. The bacterial lawn agar Petri plates were coated with 30 µg of ofloxacin. The regions of inhibition surrounding each disc were measured in millimeters to assess sensitivity to either antibiotics or mushroom extracts.

GC-MS analysis

The GC Clarus 500 Perkin-Elmer apparatus with an autosampler (AOC-20i) and Gas Chromatograph interfaced to a Mass Spectrometer (GC-MS) were the instruments used to perform the GC-MS analysis of these extracts. The temperature was set at 250°C for the injector and 280°C for the transfer line. The oven temperature was programmed to rise by 10°C every min from 60°C to 280°C, with a 9 min isothermal at 280°C. Software for handling mass spectra and chromatograms is called Turbo Mass Ver. 5.0. The HP 5973 mass detector's settings included scan mode, ion ass/charge ratio, and 30-550 m/z. Every mass spectrum was compared to the NIST library.

RESULTS

Antioxidant DPPH activity of fermented mushroom

The LAB is used for fermentation of two different edible mushroom kept for 21 days changed into dark brown colour during fermentation and the pH is sustained 6 to 7. Acidification reached and pH is gradually decreased to 6.6, 6.4 and 6.2 during 7th, 14th and 21st day of fermentation. During fermentation the LAB grown well and produced large filamentous like vegetative cells (Figure 1). Both the metal chelating assay and the DPPH radical inhibition assay were used to measure antioxidant effects. Comparison of the rate of probiotic fermented mushroom and raw mushroom on DPPH was given in Table 1. The DPPH antioxidant activity of raw mushroom and fermented mushroom was given in Figure 2. The percentage of free radical was 51.46±0.503% on *Agaricus bisporus* and 55.6±0.529% in *Calocybe indica*. Compare to LAB fermented *Agaricus bisporus* have 69.866±0.503% and significant *p* value was 0.000177. Likewise, *Calocybe indica* LAB showed 62.266±0.305% significant with *p* value 0.001394. The percentage of DPPH antioxidant activity of ascorbic acid was 78.46±0.416. The independent DPPH of sample and standard was significant $p<0.05$ except fermented sample ($p>0.05$).

Metal chelating activity

The Metal chelating antioxidant activity of non-fermented mushroom is and fermented mushroom activity given in Figure 3 as percentage of inhibition. The data represent that both the fermented mushroom have greater activity than raw mushroom. The maximum activity of 72.33±0.305 was recorded in fermented *Agaricus bisporus* whereas non fermentred extract have 57.86±0.41%. The activity of fermented *Calocybe indica* was 68.4±0.2% and non-fermented sample have 54.3±0.1%. The dependent *t*-test among *Agaricus bisporus* ($p=0.0002$) was significant at $p<0.05$ and *Calocybe indica* was not significant ($p=2.5$). The independent *t* test among sample and standard shows except fermented *Agaricus bisporus* ($p=0.027$) all other activities were not significant $p>0.05$(Table 2).

Anti-inflammatory activity

Figure 4 represent the results indeed verified the *in vitro* anti-inflammatory activities of LAB+ *Agaricus bisporus* stem reveals greatest anti-inflammatory (74%) Similarly in the albumin denaturation inhibition assay (plate 4), LAB+*Calocybe indica* stem extract had shown the good inhibition capacity with 70% inhibition. *LAB+Agaricus bisporus* FB have less significant activity compare to stem and recorded as 15-20% Similarly in the albumin denaturation inhibition assay, of non-fermented *Calocybe indica* extract had shown the less significant inhibition capacity with 30% inhibition and 56% by non-fermented *Agaricus bisporus* at 21st day (Table 3).

Antibacterial activity of fermented mushroom

The antibacterial activity of ethanol extract of LAB fermented fruiting body and stem of basidiomycete *Coriolus versicolor* and *Agaricus bisporus* were examined by well diffusion method against test pathogens. The zone of inhibition against tested pathogens were given in Table 4 data reveals fermented Button mushroom-stem showed significantly greater antibacterial effect against all tested pathogens and the zone of inhibition 15.66±0.57,15.66±0.57, 15±0, 17.33±0.57 mm against *Escherichia coli, P. aeruginosa, K. pneumonia, E. faecalis* were recorded on *Agaricus bisporus* fermented by *LAB+*. The non-fermented crude extract showed <10 mm to be less significant. The antibacterial activity of fermented *Calocybe indica* were found to be moderately effective and less significant zone of inhibition on *E. coli* (12.33±0.57), *P. aeruginosa* (14±0) and *E. faecalis* (12.33±0.57) whereas not active on *K. pneumoniae* (4.6±0.57). Similarly, the raw extract of *Calocybe indica* failed to exhibit antibacterial activity. The *p* value of dependent *t* test of *Agaricus* sp. was 0.000467007 and *Calocybe indica was* 0.010124591 found to be significant. In case of the independent *t* test of sample of fermented *Agaricus* sp. and standard 0.02 ($p<0.05$) and non-fermented *p* value 0.20 ($p>0.05$). The independent *p* value of fermented *Calocybe indica*

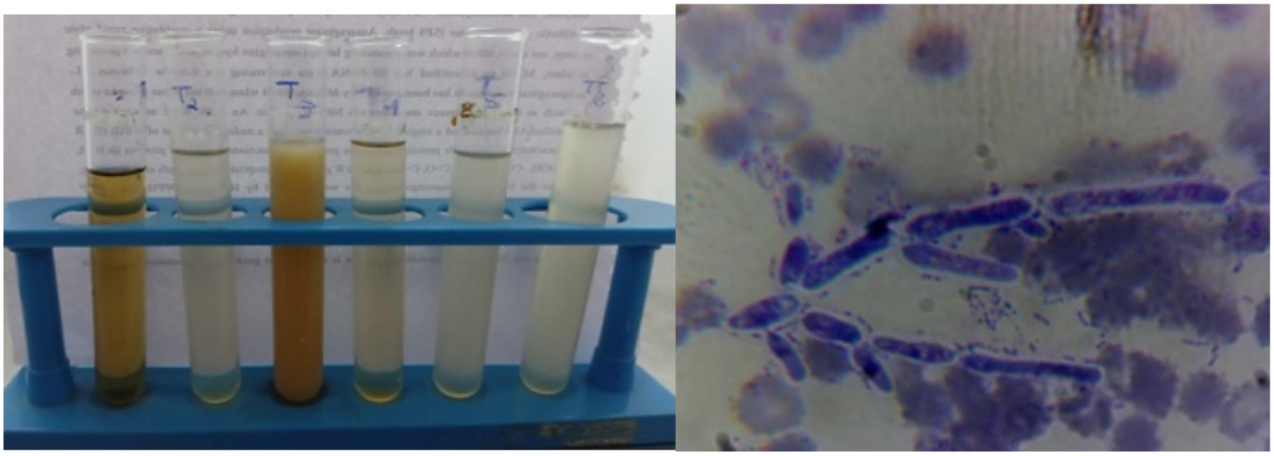

Figure 1: LAB mediated Fermentation.

Table 1: **Antioxidant Activity of Lab Fermented Mushroom.**

Sample	T1	T2	T3	Mean	SD	Dependent	Independent
Agaricus bisporus LAB	69.8	69.4	70.4	69.866	0.503	0.000177	0.0010781
Agaricus Bisporus	52	51	51.4	51.466	0.503		0.0001919
Calocybe indica LAB	62	62.2	62.6	62.266	0.305	0.001394	7.61905
Calocybe indica	56	55	55.8	55.6	0.529		0.00025
Ascorbic	78	78.8	78.6	78.46	0.416		

Table 2: **Metal Chelating Activity of Lab Fermented Mushroom.**

Sample	T1	T2	T3	Mean	SD	Dependent	Independent
Agaricus bisporus LAB	72	72.4	72.6	72.33	0.305	0.0002	0.027
Agaricus bisporus	58	57.4	58.2	57.86	0.41		6.51
Calocybe indica LAB	68.4	68.6	68.2	68.4	0.2	2.51	5.06
Calocybe indica	54.4	54.3	54.2	54.3	0.1		3.909
EDTA	72	71.4	71.6	71.66	0.30		

Table 3: **Anti-inflammatory Activity of Lab Fermented Mushroom.**

Sample	T1	T2	T3	Mean	SD	Dependent	Independent
Agaricus bisporus LAB	51	52	51	51.33	0.577	0.00016	0.00030
Agaricus bisporus	24	23.6	24.2	23.93	0.3055		1.858
Calocybe indica LAB	62	62.6	63.4	62.66	0.702	1.9652	0.006536
Calocybe indica	20	19.8	20.6	20.13	0.416		3.0486
Dichlofenac	68	67.6	67.4	67.66	0.305		

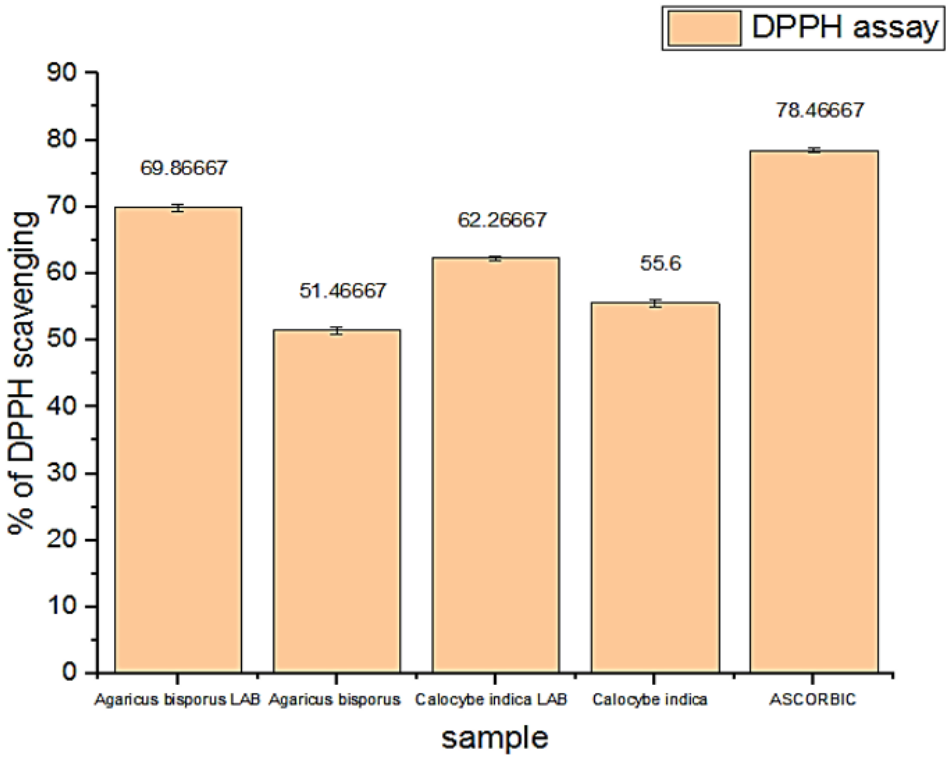

Figure 2: Percentage of DPPH antioxidant activity of mushroom Samples.

and standard was 0.00025 and crude was 0.001049 indicates both are significant ($p<0.05$).

Mass spectrum anaylsis of LAB femented *Agaricus bisporus*

GC MS analysis of fermented Button mushroom reveals the presence of 35 peaks (Figure 5) and 32 diffeent compounds. All the detected compounds are enlisted on Table 5. The maximum detected compounds are n-Hexadecanoic acid (14.33%), 4.87% of 2-Piperidinone (RT 11.288). Dibutyl phthalate (9.7%), 3.93% of 1,2-Benzenediol (RT 11.432),4.24% of 2-Methoxy-4-Vinylphenol and 6.32% Hydrocinnamic acid. In addition to fatty acid methylesters, spectrum shows presence of Phenylpropanoic acid or hydrocinnamic acid is a carboxylic acid and 1-Nonadecene alkenes were identified from the fermented sample. Piperidin-2-one is a delta-lactam that is piperidine with an oxo group at position 2, according to a Pub chem investigation. It has a role as L-glutamate gamma-semialdehyde dehydrogenase inhibitor. Presence of 11-octadecenoic acid, phenolic acids. *A. bisporus* extracts suggest that there may be several bioactive compounds that inhibit the growth of both Gram-positive and Gram negative pathogens.

DISCUSSION

The sensory results of fermented edible mushroom such as odour, consistency was acceptable, except for the texture and colour found to be dark and juicy. All the parameters were triplicated and the bioassay pH was maintained at 6.5. Bello and Akinyele proposed an identical pattern in the use of fermenting mushroom medicinal value using fruiting bodies (Bello and Akinyele, 2007). Free radical scavenging of crude edible mushroom was lower than fermented mushroom. Both metal chelation and DPPH activity was concentration dependent. Significant protein denaturation inhibition was recorded and found to be close to standard. Bai *et al.*, (2013) have reported that presence of phenolics aid in scavenging of 2,2-diphenyl-1-picrylhydrazyl (DPPH) and hydroxyl (OH) radicals. The application of the LAB starter as fermenter also act as preservative in the food industry and enhance the use of the industrial fermentation and production of more health-oriented foods (Beganovic *et al.*, 2014). Ascorbic acid equitant antioxidant activities of extracts of five edible mushrooms was previously reported by (Boonsong *et al.*, 2016). Metal chelation potential of mushroom *Pleurotus ostreatus* was previously reported by (Oluwamodupe *et al.*, 2013). Mushroom components like phenolics and flavonoids and ascorbic acid promotes the antioxidant potential (Nakamura *et al.*, 2019). The data is correlates the study of (Nataraj *et al.*, 2022) who reported metal chelating capacity of mushrooms lower than EDTA. The β-glucan-rich preparation from mushrooms has cytotoxic in nature antioxidant effects that are controlled by glucan. Its anti-inflammatory effects are achieved by inhibiting Cyclooxygenase (COX) and Nitric Oxide Synthase (NOS) inhibition. According literature survey it was reported that *C. indica* significantly showed anti-inflammatory, antioxidant and antimicrobial activity (Meghna *et al.*, 2022). A number of studies showed that mushrooms extracts express a higher antimicrobial activity against pathogenic bacteria. Recently (Jankov *et al.*, 2024) have reported the antibacterial and Synergistic activities of *Agaricus bisporus* against *S. aureus, E. coli, B. subtilis.* According to

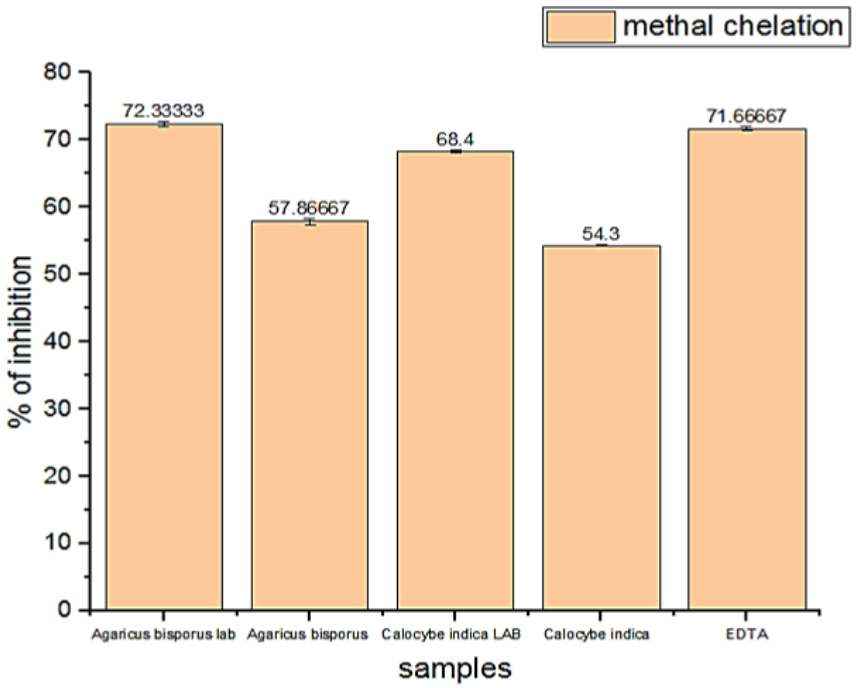

Figure 3: Percentage of Metal Chelating Activity.

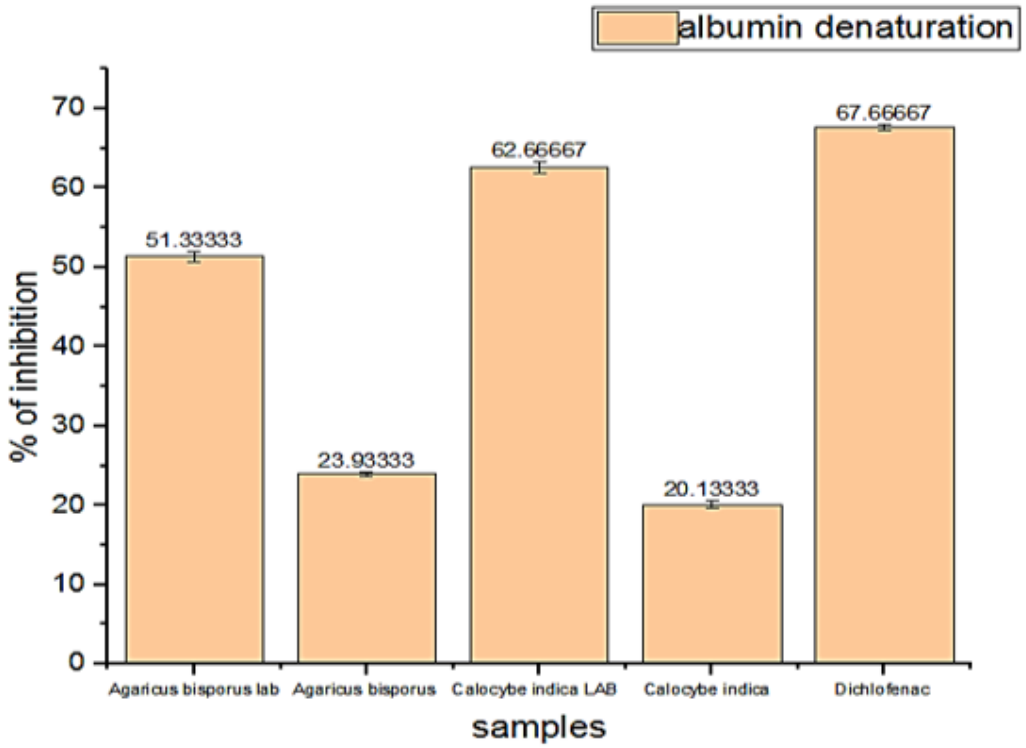

Figure 4: Percentage of anti-inflammatory activity.

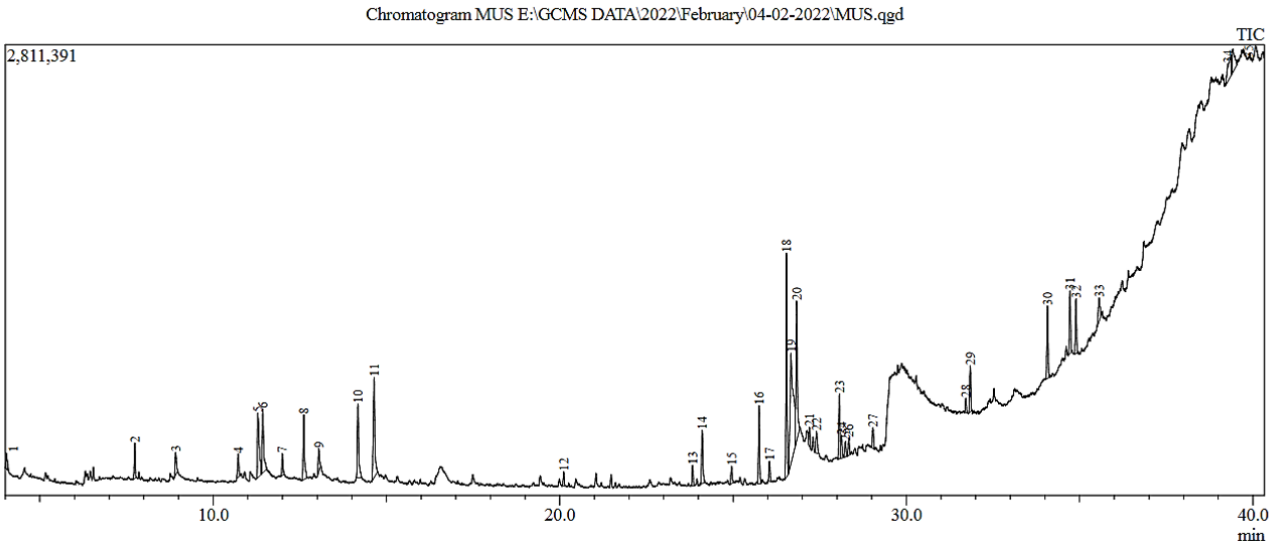

Figure 5: GCMS spectrum of fermented *Agaricus bisporous* (Button mushroom).

Table 4: Antibacterial activity of fermented and raw edible mushroom.

Sample 1 mg/mL	EC		PA		KP		EF	
	Mm	SD	Mm	SD	Mm	SD	Mm	SD
LAB *Agaricus bisporus*	15.66	0.57	15.66	0.57	15	0	17.33	0.57
LAB *Calocybe indica*	12.33	0.57	14	0	4.6	0.57	12.33	0.57
Agaricus bisporus	5.66	0.57	6.66	1.15	7.33	1.15	6.33	0.57
Calocybe indica	4.66	1.15	0	0	0	0	0	0
Standard	13.33	1.154	12.66	0.57	14.33	0.57	12.33	0.57

EC-E. coli, PA-P. aeruginosa, KP-K. pneumoniae, EF-E. faecalis.

Table 5: NIST library matched GCMS eluted active compounds.

Peak	Retention time	Area %	Name
1	4.035	0.76	Butanoic acid, 2-methyl-
2	7.737	1.57	Benzyl alcohol
3	8.919	1.29	Phenol, 2-methoxy-
4	10.725	1.12	Benzenepropanal
5	11.288	4.87	2-Piperidinone
6	11.432	3.93	1,2-benzenediol
7	11.996	1.01	2,3-dihydro-benzofuran
8	12.613	3.54	4-phenyl-2-butanone
9	13.045	1.25	Phenol, 4-amino-
10	14.176	4.24	2-Methoxy-4-vinylphenol
11	14.644	6.32	Hydrocinnamic acid
12	20.111	0.6	1-Nonadecene
13	23.833	0.92	1-Nonadecene
14	24.108	2.91	3-Buten-2-one, 4-(4-hydroxy-3-methoxyphenyl)-
15	24.956	0.85	1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester
16	25.747	3.56	1,2-benzenedicarboxylic acid, bis(2-methylpropyl) ester
17	26.048	1.01	1,2-Benzenedicarboxylic acid, bis(2-methylpropyl) ester
18	26.541	9.79	Dibutyl phthalate
19	26.67	14.33	n-Hexadecanoic acid
20	26.837	7.95	Phthalic acid, butyl 2-pentyl ester
21	27.204	0.86	n-Nonadecanol-1
22	27.405	1.33	1,2-benzenedicarboxylic acid, butyl octyl ESTER
23	28.069	3.01	Dibutyl phthalate
24	28.127	1.22	9,12-Octadecadien-1-ol, (Z,Z)-
25	28.241	0.82	1,2-Benzenedicarboxylic acid, butyl octyl ester
26	28.339	0.76	Diamyl phthalate
27	29.035	1.04	1,2-benzenedicarboxylic acid, dibutyl ester
28	31.712	0.59	Glycidyl palmitate
29	31.841	2.18	1H-Imidazole, 4,5-dihydro-2-(phenylmethyl)-
30	34.075	3.36	Bicyclo[10.1.0]tridec-1-ene
31	34.722	3	6h-benzofuro[3,2-c][1]benzopyran, 6a,11a-dihydro-3,9-dimethoxy-, (6ar-cis)-
32	34.895	2.59	Bis(2-ethylhexyl) phthalate
33	35.56	1.66	Hexacontane
34	39.275	3.15	Phytyl dodecanoate
35	39.426	2.6	1,1,3,3-Tetraallyl-1,3-disilacyclobutane

(Bartkiene *et al.*, 2023) during fermentation A. bisporus showed decreased 1-Octen-3-ol content while benzyl alcohol, acetoin, and 2,3-butanediol increased in most fermented sample. Another study shows the FA profile of *A. bisporus* comprises stearic acid, palmitic, linoleic, caprylic, oleic, erucic, and eicosanoic acid (Saiqa *et al.*, 2008). It was also reporte that Linoleic acid is converted to 13-hydroxy-9-octadecenoic acid or the antifungal 10-hydroxy-12-octadecenoic acid (Ogawa *et al.*, 2001).

CONCLUSION

This study yielded useful data that can be used to produce fermented mushrooms on a large-scale. Additionally, a broader range of LAB for *A. bisporus* fermentation can be investigated in the future to suggest the most suitable LAB strains for the mushroom fermentation sector as well as the healthiest and most palatable outcome for the end user.

ACKNOWLEDGEMENT

The authors thank to Helikem Biotek Industrial Research Pvt. Ltd., Tiruchirappalli, Tamil Nadu, India for providing assistance on GC-MS analysis.

FUNDING

The authors extend their appreciation to the Deanship of Scientific Research at Northern Border University, Arar, KSA for funding this research work through the project number "NBU-FFR-2025-1329-03".

CONFLICT OF INTEREST

The study was carried out without any financial or commercial ties that might be interpreted as a conflict of interest, agreed to the authors.

ABBREVIATIONS

FA: Fatty acid; **FB:** Fruiting bodies; **OD:** Optical density; **LAB:** Lacticacid bacillus; **Mm:** millimole.

SUMMARY

In addition to increasing phytochmical during fermentation with LAB strain altered the physical characteristics of *A. bisporus* and *Calocybe indica. A. bisporus* showed the highest degree of bioactivity. The primary volatile substances found in the samples of mushrooms were hydrocinnamic acid, nonadecanol-2-peridinone, hexadecanoic acid, and 2-methyl-4-vinylphenol. The general acceptance of fermented and non-fermented mushrooms was comparable. The *A. bisporus* variety and the LAB strain employed for fermentation were important contributors to the majority of biomedical application.

REFERENCES

Alves, M. J., Ferreira, I. C. F. R., Dias, J., Teixeira, V., Martins, A., & Pintado, M. (2012). A review on antimicrobial activity of mushroom (Basidiomycetes) extracts and isolated compounds. Planta Medica, 78(16), 1707-1718. https://doi.org/10.1055/s-0032-1315370

Atila, F., Owaid, M. N., & Shariat, M. A. (2021). The Nutritional and Medical Benefits of *Agaricus bisporus*: A review. Journal of Microbiology, Biotechnology and Food Sciences, 281-286.

Bai, M.-S., Wang, C., Zong, S.-C., Lei, M., & Gao, J.-M. (2013). Antioxidant polyketide phenolic metabolites from the edible mushroom *Cortinarius purpurascens*. Food Chemistry, 141(4), 3424-3427. https://doi.org/10.1016/j.foodchem.2013.05.099

Bakratsas, G., Polydera, A., Katapodis, P., & Stamatis, H. (2021). Recent trends in submerged cultivation of mushrooms and their application as a source of nutraceuticals and food additives. Future Foods, 4, Article 100086. https://doi.org/10.1016/j.fufo.2021.100086

Bartkiene, E., Zarovaite, P., Starkute, V., Mockus, E., Zokaityte, E., Zokaityte, G., Rocha, J. M., Ruibys, R., & Klupsaite, D. (2023). Changes in Lacto-Fermented Agaricus bisporus (White and Brown Varieties) Mushroom Characteristics, including Biogenic Amine and Volatile Compound Formation. Foods, 12(13), 2441. https://doi.org/10.3390/foods12132441

Beganović, J., Kos, B., Leboš Pavunc, A., Uroić, K., Jokić, M., & Šušković, J. (2014). Traditionally produced sauerkraut as source of autochthonous functional starter cultures. Microbiological Research, 169(7-8), 623-632. https://doi.org/10.1016/j.micres.2013.09.015

Bello, B. K. B., & Akinyele, B. J. A. (2007). Effect of fermentation on the microbiology and mineral composition of an edible mushroom *Termitomyces robustus* (Fries). International Journal of Biological Chemistry, 1(4), 237-243. https://doi.org/10.3923/ijbc.2007.237.243

Bernaś, E., & Jaworska, G. (2012). Effect of preservation method on amino acid content in selected species of edible mushroom. LWT- Food Science and Technology, 48(2), 242-247. https://doi.org/10.1016/j.lwt.2012.03.020

Boonsong, S., Klaypradit, W., & Wilaipun, P. (2016). Antioxidant activities of extracts from five edible mushrooms using different extractants. Agriculture and Natural Resources, 50(2), 89-97. https://doi.org/10.1016/j.anres.2015.07.002

Ergonul, P. G., Akata, I., Kalyoncu, F., & Ergonul, B. (2013). Fatty acid compositions of six wild edible mushroom species. The Scientific World Journal, 4, 21-27.

Ferreira, I. C. F. R., Vaz, J. A., Vasconcelos, M. H., & Martins, A. (2010). Compounds from wild mushrooms with antitumor potential. Anti-Cancer Agents in Medicinal Chemistry, 10(5), 424-436. https://doi.org/10.2174/1871520611009050424

Jabłońska-Ryś, E., Skrzypczak, K., Sławińska, A., Radzki, W., & Gustaw, W. (2019). Lactic acid fermentation of edible mushrooms: Tradition, technology, current state of research: A review. Comprehensive Reviews in Food Science and Food Safety, 18(3), 655-669. https://doi.org/10.1111/1541-4337.12425

Jankov, M., Léguillier, V., Gašić, U., Anba-Mondoloni, J., Ristivojević, M. K., Radoičić, A., Dimkić, I., Ristivojević, P., & Vidic, J. (2024). Antibacterial activities of *Agaricus bisporus* Extracts and Their Synergistic Effects with the anti staphylococcal Drug AFN-1252. Foods, 13(11), 1715. https://doi.org/10.3390/foods13111715

Kosanić, M., Ranković, B., Rančić, A., & Stanojković, T. (2016). Evaluation of metal concentration and antioxidant, antimicrobial, and anticancer potentials of two edible mushrooms *Lactarius* deliciosus and *Macrolepiota procera*. Journal of Food and Drug Analysis, 24(3), 477-484. https://doi.org/10.1016/j.jfda.2016.01.008

Liu, Y., Xie, X.-X., Ibrahim, S. A., GulKhaskheli, S., & Yang, H. (2016). Yan-fengWang, Wen Huang. Characterization of*Lactobacillus pentosus* as a starter culture for the fermentation of edible oyster mushrooms (*Pleurotus* spp.). LWT-Food Science and Technology, 68, 21-26.

Nakamura, A., Zhu, Q., Yokoyama, Y., Kitamura, N., Uchida, S., Kumadaki, K., Tsubota, K., & Watanabe, M. (2019). *Agaricus brasiliensis* KA21 may prevent diet-induced Nash through its antioxidant, anti-inflammatory, and anti-fibrotic activities in the liver. Foods, 8(11), 546. https://doi.org/10.3390/foods8110546

Nataraj, A., Govindan, S., Ramani, P., Subbaiah, K. A., Sathianarayanan, S., Venkidasamy, B., Thiruvengadam, M., Rebezov, M., Shariati, M. A., Lorenzo, J. M., & Pateiro, M. (2022). Antioxidant, anti-tumour, and anticoagulant activities of polysaccharide from *Calocybe indica* (APK2). Antioxidants, 11(9), 1694. https://doi.org/10.3390/antiox11091694

Ogawa, J., Matsumura, K., Kishino, S., Omura, Y., & Shimizu, S. (2001). Conjugated linoleic acid accumulation via 10-hydroxy-12-octadecaenoic acid during microaerobic transformation of linoleic acid by *Lactobacillus acidophilus*. Applied and Environment Microbiology, 67l, 1246-1252.

Oluwamodupe, C., Akinmoladun, A., Elekofehinti, O., & Olaleye, T. (2013). Antioxidant profile of four selected wild edible mushrooms in Nigeria. Journal of Chemical and Pharmaceutical Research, 5, 286-295.

Pereira, E., Barros, L., Martins, A., & Ferreira, I. C. F. R. (2012). Towards chemical and nutritional inventory of Portuguese wild edible mushrooms in different habitats. Food Chemistry, 130(2), 394-403. https://doi.org/10.1016/j.foodchem.2011.07.057

Ramos, M., Burgos, N., Barnard, A., Evans, G., Preece, J., Graz, M., Ruthes, A. C., Jiménez-Quero, A., Martínez-Abad, A., Vilaplana, F., Ngoc, L. P., Brouwer, A., van der Burg, B., Del Carmen Garrigós, M., & Jiménez, A. (2019). *Agaricus bisporus* and Its By-Products as a Source of Valuable Extracts and Bioactive compounds. Food Chemistry, 292, 176-187. https://doi.org/10.1016/j.foodchem.2019.04.035

Saiqa, S., Haq, N. B., Muhammad, A. H., Muhammad, A. A., & Rehman, A. (2008). Studies on chemical composition and nutritive evaluation of wild edible mushrooms. Iranian Journal of Chemistry and Chemical Engineering, 27, 151-154.

Shashikant, M., Bains, A., Chawla, P., Sharma, M., Kaushik, R., Kandi, S., & Kuhad, R. C. (2022). *In vitro* antimicrobial and anti-inflammatory activity of modified solvent evaporated ethanolic extract of Calocybe indica: GCMS and HPLC characterization. International Journal of Food Microbiology, 376, Article 109741. https://doi.org/10.1016/j.ijfoodmicro.2022.109741.

Cite this article: Wahid JBA, Aljuwayd M. Antibacterial, Antioxidant and Anti-Inflammatory Effect with GCMS Profile of Edible Mushroom Fermented by LAB. Int. J. Pharm. Investigation. 2025;15(4):1380-7.