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Mushroom being Natural Antimicrobials: A Review

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ABSTRACT: Multidrug antimicrobials resistance become a emerging threat and become serious issue day by day majorly in developing countries. Infectious diseases become major cause of mortality and morbidity all over the world and in this devastating situation antimicrobial resistance act as a fuel. Pathogen resists themselves against these synthetic and semisynthetic drugs which deplete the effectiveness of these drugs. Economically we also losses. To eradicate this problem an alternate method of selecting natural extract of plant and fungi as medicine or as natural antimicrobial agent has been targeted. Recent studies and research, mushroom and their extract which consist bioactive compounds is in trends as an alternative of natural antimicrobial against different type of bacterial species. Mushroom is not only known for their nutritional value or as food source but also for their therapeutics values like antimicrobial, antitumor, antioxidant activity. In this review paper we studied about AMR, their mechanism, about mushroom antibacterial nature and their mechanism.

KEYWORDS: AMR (antimicrobial resistance), Mushroom, Antimicrobial activity, Natural Extract.

I. INTRODUCTION

A. Antimicrobial resistance:

Antimicrobial resistance means microbes are capable themselves to resist against these antimicrobial drugs [1]. Antimicrobial resistance occurs naturally but due to mishandling we make possible this cause early by continuous and inappropriate use of medicines, low quality medicines, poor in prevention against diseases, improper facilitating of antibiotics create difficulty in treating diseases.[2].

A.1 Mechanism of Antimicrobial Resistance:

This occurs when microbes evolve mechanism that protects them from the effect of antimicrobials agents. There are two main ways for bacteria to withstand the effect of antibiotics. First, to stop the antibiotics from reaching its target at a high enough concentration. To modify the target that the antibiotics act on [3]. Another mechanism of resistance is that several bacterial enzymes that can inactivate the function of antibiotics. A synthetic antibiotic like penicillin has a beta-lactam ring component destroyed by beta-lactamase [4]. There is a mechanism called pumping out the antibiotics in which pump is fixed by bacteria in their cell membrane called efflux pump and through this pump, it throws out the antibiotics. Mutation in bacterial DNA produce more pumps [5].

The increasing burden of AMR all over the world still not resolved properly [6]. The widely use of antimicrobials by humans gives opportunity to microorganism to produce immense response of resistance against antibiotics. The current situation of AMR will probably long lasting if we do not find the alternate of this situation [7].

A.2 Mushroom as an Antimicrobial Agent:

In recent years natural antimicrobial like plants or fungi renewed interest towards their various properties and antimicrobial activity is one of them because of their non harmful impact and most effective against microbials [8]. Mushroom is a macro fungus having large edible fruiting bodies with stalk and caps. Popularity of these mushroom is due to colourful appearance, great flavours and aromas along with nutritional and therapeutics value like high protein content, fat rich, carbohydrates and vitamin D and utilization as medicines respectively [9]. In fight against antimicrobials resistance challenge mushroom is a great alternative represent as antimicrobial agent which show promising effect against bacteria and to treat diseases [10]. Both edible, wild mushroom have great potential of nutraceuticals which facilitates medical and health benefit. Study on different mushroom bioactive resources reveals their antibacterial activity. Gram positive and gram-negative bacteria are selected to find their effect [11]. So utilization of different type pf mushroom and their extract having bio metabolites assist in this threatening situation [12].

A.3 Biometabolite or Extract of different Mushroom act on different Bacterial Species:

Secondary metabolites such as therapeutic proteins and peptides which is a major source of bioactive components which is produced by different type of mushrooms [13]. An edible mushroom *Agaricus bisporus* commonly known as white button mushroom and most extensively cultivated in India, Europe and North mushroom. Their texture consists brownish or white cap dark brown gills and stalk [14]. *Agaricus bisporus* show antibacterial activity by their stipes and total protein extract and silver nanoparticles (AgNPs) which is a biosynthesis product of white button mushroom shows antibacterial activity specifically against *Staphylococcus aureus* [15]. Medicinal mushroom *Ganoderma lucidum* commonly known as Reishi mostly grown on living and dead wood of deciduous species. This mushroom develops fruiting bodies containing cap which is kidney or rounded in shape with red, shiny and reddish-brown colour [16]. Study regarding antibacterial property of three mushroom *Ganoderma lucidum*, *Phellinus rimosus* and *Navesporus floccosa* occur in south India. These all three mushrooms consist methanol extract having polyphenols with class quinones in *P. rimosus*, terpenes in *G. lucidum* and flavonoids. Human pathogenic bacteria include Gram positive bacteria (*S. Aureus*) and Gram negative bacteria (*E. coli*, *B. subtilis*, *S. typhimurium*) give best response of sensitivity against methanol extract [17]. *Pleurotus ostreatus* locally known as oyster mushroom mostly cultivated in tropical and subtropical sides. Their texture colour is white to grey or dark brown having broad, fan shape [18]. Oyster mushroom consist non polar solvent extract petroleum ether which show antibacterial property against gram negative and gram positive bacteria in compare to this polar solvent ethanol extract comprise finer activity against microorganism [19]. Grey oyster mushroom is a general name of *P. sajor-caju* because of their appearance like to be oyster shell. Mostly cultivated in tropical and subtropical region [20]. *P. sajor-caju* mushroom contain methanolic extract which inhibit microbes growth or show antibacterial activity against *S. typhi* strain [21]. Study of *Ganoderma pfeifferi* reveal that it consist bioactive compound called farnesylhydroquinones named ganomycins and triterpenoids and in this Ganomycins A and B show antibacterial activity mainly included gram-positive bacteria [22]. Medicinal mushroom *Schizophyllum commune* known as "split fold". The habitat of this mushroom is mainly in light, sunny, dry places of forest having texture like small, thin, flexible, whitish in colour and grown in layer which are overlapped on each other [23]. *Schizophyllum commune* mushroom having four bioactive compounds namely methanol, dichloromethane, ethyl acetate and water and check their inhibitory effect on gram positive bacteria including *Bacillus cereus*, *Bacillus subtilis*, *Enterobacter faecalis* and *Staphylococcus aureus* and these type of bacteria are most responsive to these several extract. Gram negative microbes are also included like *Plesiomonas shigelloides*, *Pseudomonas aeruginosa*, *Proteus vulgaris*, *Salmonella* species, *S. typhi*, *Shigella* species, *S. flexneri*, *Streptococcus mitis*, *S. mutans*, *S. sanguis*. Among all the extract of *Schizophyllum commune* extract show best result having higher range of antimicrobial activity [24]. A medicinal mushroom *Termetes versicolor* also known as *Coriolus versicolor* or turkey tail white rot fungi, mainly found on different trees like prunus and oak and on different conifers like fir or pine trees [25]. *Coriolus versicolor* contain four extract methanol's, ethyl acetate, dichloromethane and acetone extract. In which *S. aureus* is inhibited by all four extract while *Bacillus* species and *S. enteritidis* was responsive to methanol extract, another bacteria *P. aeruginosa* was sensitive to acetone extract. The chemical composition of methanol extracts which include high number of polyphenols having high amount which show high antibacterial activity [26]. *Auricularia auricular* is an edible mushroom also known as jelly mushroom. Mostly grown on woods logs, dead trees, and root of woody plants. Its fruiting body is generally dividing into two parts upper sterile portion and lower fertile portion [27]. Study of *Auricularia auricular* extract and their antibacterial properties like polysaccharide and protein complex. In this total ethyl acetate fraction of *A. auricular* give best response against *S. aureus* [28]. *Volvarella volvacea* is counting as an edible mushroom, their distribution in tropical, subtropical and temperate region of eastern and western hemisphere. It is also known as paddy straw. Their texture like pink coloured spores, free lamellae and velvate base [29]. *Volvarella volvacea* which is basidiomycetes fungi used for research and study screening for antimicrobial activity and it is effectively work against *E. coli* [30]. Mushroom *Stereum ostrea* also called "false turkey tail" which acts exact similar to *Trametes versicolor*. Saprobic fungi on dead wood of hardwood, growing densely, this consist shape like fuzzy cup which have different colour zones like brown, red, oranges, buff [31]. In research and study of *Stereum osterus* there are two components first is methanol extract and second is crude cultural filtrate. Methanol extracts showing inhibitory effect highest in *Micrococcus* species and lowest in *Klebsiella pneumonia*. The antimicrobial activity of crude cultural filtrate shows activity against highest in *Bacillus subtilis* followed by *Micrococcus*, *Pseudomonas aeruginosa* and lowest in *Klebsiella* species. These result of antibacterial activity of both extracts are compared with ampicillin which is semi synthetic antibiotic at concentration of 50ppm. Result determines that ampicillin is not effective and does not show any antibacterial effect against *Klebsiella pneumonia* [32]. *Calocybe indica* known as milky white mushroom or in local "Dhuth chatta" originated from India distributed in west Bengal or eastern Indian state side. This is counting as tropical edible mushroom having high nutritional value with high quality protein [33]. Study of Solvent extract of *Calocybe indica* named petroleum ether show antimicrobial activity against *Staphylococcus aureus*, *Streptococcus pyogenes*, and *Pseudomonas aeruginosa* [34]. *Pleurotus eryngii* also called king oyster mushroom, which, is widely distributed and used in North

africa, Europe and Asia because of nutritional and medicinal qualities [35]. *P. eryngii* determine antimicrobial activity by the formation of chitosan nanoparticles by their extract. Nanoparticles show vast activity and emerged as driving force in area of scientific interest in world. These nanoparticles inhibit *E. coli*, *B. subtilis*, *C. Albicans*. There are different compounds like Chitosan nanoparticles show inhibitory effect against *S. aureus*, *Bacillus cereus*, *E. coli*, *Pseudomonas aeruginosa*. Turmeric chitosan nanoparticles show antimicrobial activity against *Trychophyton metagrophyte*, *Fusarium oxysporum*. [36]. *Lenntiula edodes* also known as shiitake mushroom or Japanese wood mushroom considered as an edible mushroom having medicinal property [37]. *Lentinula edodes* consist chloroform extract which determine antimicrobial activity and inhibit *Streptococcus mutans* and *Prevotella intermedia* [38]. *Lactarius* species are also called saffron milk cap mushroom having good texture, delicious taste with aromas. This is an ectomycorrhizal fungus and mostly grown in coniferous woodland under pines [39]. These wild edible portuguese *Lactarius* species mushroom one is *Lactarius deliciosus* and *L. piperatus* and gram positive species (*B. cereus*, *B. subtilis*, *S. aureus*) and gram negative species (*E. coli*, *P. aeruginosa*, *K. pneumoniae*) included to study. These both species of mushroom having different bioactive compounds like flavonoids, phenol, ascorbic acid, β -carotene, lycopene. *L. piperatus* inhibits the activity of *E. coli*. *L. deliciosus* determines antimicrobial activity against *K. pneumonia* [40]. *Cordeyceps sinensis* is traditional medicine of china having enormous pharmaceuticals properties [41]. Study of medicinal mushroom *Cordeyceps sinensis* consist flavonoids compounds which is a class of polyphenolic. In this major class, there are 6 subgroup name chalcones, flavonol, flavanone, flavone, anthocyanins and isoflavanoids these subcompounds have apotential effect of antimicrobial activity against *E. coli*, *P. aeruginosa* and *B. subtilis*. These sensitivity or their activity depends on genotype of strain [42]. There are two wild edible mushrooms taking from west region of turkey for study name *Clitocybe alexandri* (gill), *Rhizopogon roseolus* (corda). Methanol extract of *C. alexandri* inhibit *Bacillus subtilis*, *Escherichia coli* and most effective against *Micrococcus*, *n-hexane* and water extract inhibit *Bacillus cereus*. Diethyl ether, methanol, water effective against *Enterobacter aerogenes*. Study of extract of fruiting bodies of *Rhizopogon roseolus* like ethyl acetate which inhibit *Bacillus cereus*, *Micrococcus lutans*. In comparison of both mushroom *C. alexandri* are most effective in inhibition than *R. roseolus* [43]. *Cantharellus cibarius* cultivated mostly in Europe is an edible mushroom having fruiting and apricot like aroma with great texture [44]. Antimicrobial activity of *Cantharellus cibarius* define by their methanol extract against mostly on Gram positive bacteria that is *Staphylococcus aureus*, *Enterococcus faecalis*, *Bacillus cereus* and *Listeria monocytogenes*. Less effective against gram negative bacteria like *Escherichia coli*, *Salmonella enteritidis*, *Shigella sonnei* and *Yersinia enterocolitica*. This mushroom extract show higher activity in comparison to synthetic antibiotics like tetracycline and gentamicin [45]. Edible woodland mushroom *Lepista nuda* mostly cultivated in Asia, Africa, America, Australia and Europe, their texture is like lilac colour, consist aroma, delicate flavours with pharmacological properties [46]. Determination of antimicrobial activity of *Lepista nuda* by ethanol extract this compound inhibit the activity of *Micrococcus luteus*, *Micrococcus flavus*, *Staphylococcus aureus*, *Bacillus cereus*, *Salmonella enteritidis* mean this is effective in some infectious disease [47]. A mushroom name *Armillaria mellea* mushroom have many compounds like Sesquiterpene aryl esters, 4-o methylmelleolide and judeol, three melleolides K, L, M show antibacterial activity against gram positive bacteria [48]. *Clitocybe geotropa* and *Clitocybe nebularis* mushroom consist acetone extract having antimicrobial activity. *C. geotropa* show strong antibacterial activity than *C. nebularis*. *Bacillus cereus* species is most susceptible towards both species of mushroom. Gram positive bacteria species shows promising result toward these extract in compare to Gram negative bacterial species [49]. *Laetiporus sulphureus* appeared as colour of sulphur yellow having bright pores and locally known as "chicken of the woods". This consist large bracket having high nutritional value [50]. Antimicrobial property of *Laetiporus sulphureus* extract ethyl alcohol was effective against gram positive bacteria including *Bacillus subtilis*, *B. cereus*, *M. luteus* and *M. flavus* [51].

A.4 Mechanism of mushroom extract against bacteria:

There is study of effect and action of organic compounds that can be obtained from methanol and ethanol extract of mushroom *Coriolus versicolor* which act against different gram positive and gram-negative bacteria. Phenol and phenolic acid having hydroxyl group determine the toxicity to microorganism. Quinones are other bioactive compound performs irreversible reaction with nucleophilic amino acid in proteins which forward the reaction towards inactivation and loss of functional protein [26]. The other compounds like *p-coumaric acid* work against some gram-negative bacteria like *Salmonella typhimurium* and *Shigella dysenteriae* and *E. coli*. These acids switch permeability of cell membranes and change binding capacity of DNA and slow down or hinder the cell function [52]. Mechanisms of natural extract antimicrobials are disturbing pH of cytoplasm content and have potential to disrupt membrane of microorganism. These chemical compounds like ethyl ester, ethyl alcohol, and terpenes can target multiple sites against bacterial cells [53].



II. CONCLUSION

We conclude that multidrug resistance organism or antimicrobial resistance create a great havoc in healthcare field due to which there is difficulty in to treat infectious diseases. In these global threat situation natural antimicrobials agents like plants and fungi appear as a boon. Hence the present study reveals that mushroom have a great potent of antimicrobial activity. We reviewed three type of mushroom mainly edible mushroom (*Agaricus bisporus*) wild mushroom and medicinal mushroom (*Ganoderma* species) which consist different extract like methanol, ethanol, acetone, flavonoids, n-hexane, diethyl ether, water, chloroform, phenol, ascorbic acid etc. having numerous bioactive compound show antimicrobial activity against pathogen like *Staphylococcus* species, *Streptococcus*, *Micrococcus* species, *E.coli*, *Bacillus* species, *Listeria monocytogenes*, *P. aeruginosa*, *Prevotella intermedia* etc. In bacterial species these extracts either show strong activity or in some weak inhibition zone. There is also one point to be noted that gram positive bacteria are more susceptible to these natural antimicrobial mushroom extract in compare to gram negative bacteria. These extract activities show promising changes in bacteria mechanism of resistance in two ways first slow down the function and second is there resistance mechanism is completely breakdown. These novel antimicrobial agents are economically important mean they are readily available, cheap and almost do not any kind of side effect. According to study these natural antimicrobials are most effective than synthetic antibiotics. There is a need of further study or research regarding mushroom and their bioactive compounds as antimicrobials agents.

III. FUTURE PERSPECTIVE

In future the exploration and practices of mushroom extract as natural antimicrobial will arise rapidly for the welfare of society. If we further research on mushroom bioactive compounds then we will find out interesting role, properties and mechanism of these extract against various harmful microorganism. This will lead toward in treating various infectious or degenerative diseases. we relate both medicinal and antimicrobial activity of mushroom extract which will be a cause of revolutionary change in medical field. Further it is economically profitable especially in developing countries.'

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