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Research Article

ANTIMICROBIAL ACTIVITIES OF *Pleurotus* SPECIES AGAINST HUMAN PATHOGENIC BACTERIA

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Abstract- The fruiting bodies and mycelium of mushrooms exhibit health promoting values including antibacterial activities. Among different cultivated mushrooms, *Pleurotus* species are easy to cultivate and also exhibit many medicinal properties. Many of the *Pleurotus* species have also been reported to exhibit antimicrobial action against different pathogens associated with human beings. Keeping this in view, antimicrobial activities of three species of *Pleurotus viz*., *P. florida, P. ostreatus* and *P. sajor-caju* were screened by paper disc method against human pathogenic bacteria *viz., Escherichia coli, Pseudomonas* sp., *Proteus* sp., *Bacillus* sp. and *Streptococcus* sp. by preparing the aqueous, hot water, ethanolic and methanolic extracts of mycelia, pileus and stipe. Among aqueous extracts, stipe extracts of all the three species were effective in inhibiting the growth of human pathogenic bacteria (9.33 mm), *P. sajor-caju* being the most effective in terms of inhibiting all the five test bacteria. However, hot water, ethanolic and methanolic extracts of pileus of three *Pleurotus* spp. were found to be most effective in terms of exhibiting maximum zone of inhibition (8.16, 6.64 and 7.23 mm, respectively). Among the three species, hot water extract of *P. ostreatus* (3.20 mm) and ethanolic as well as methanolic extracts of *P. sajor-caju* (2.09 and 4.02 mm, respectively) were most effective against the test bacteria.

Keywords- *Antibacterial property, Bacillus sp. E. coli, Pleurotus florida, Pleurotus ostreatus, Pleurotus sajor-caju, , Proteus sp., Pseudomonas sp., Streptococcus sp*

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Introduction

Mushroom species release various bioactive compounds such as terpenoids, flavonoids, tannins, alkaloids, and polysaccharides [1]. These bioactive compounds are found in various cellular components and secondary metabolites, which have been isolated and identified from the fruiting bodies [2,3]. The genus *Pleurotus* comprising of about 40 species grow widely in tropical and subtropical areas and are easily cultivated artificially. This genus includes, *P. ostreatus, P. sajor-caju, P. florida, P. sapidus, P. highbing* and others some of which are of a special consideration due to their high nutritional value and medicinal importance [4,5]. Most of the mineral salts required by human body such as K, Na, P, Fe and Ca are present in oyster mushroom. The niacin content in *Pleurotus* spp. is about 10 time higher than most of the vegetables. A polycyclic aromatic compound pleurotin has been isolated from *Pleurotus* spp. which has shown to possess antitumor, immunomodulatory, antioxidant, anti-inflammatory and hypocholesterolaemic activities [6]. The folic acid present in oyster mushrooms helps to cure anemia. Alkaline ash and high fiber content make them suitable for consumption for those having hyperacidity and constipation & cholesterol inhibitors mushrooms [7]. Many of the *Pleurotus* species have also been reported to exhibit antimicrobial action against different pathogens associated with human beings [8-10]. So, the objective of the present investigations was to screen the antimicrobial activities of three species of *Pleurotus viz*., *P florida, P. sajor-caju* and *P ostreatus* against different human pathogenic bacteria.

Materials and Methods

Antimicrobial activities of three species of *Pleurotus viz*., *P florida, P. sajor-caju* and *P. ostreatus* were evaluated against five human pathogenic bacteria *viz., Escherichia coli, Pseudomonas* sp., *Proteus* sp., *Bacillus* sp. *and Streptococcus* sp.

Procurement and maintenance of pure culture

The pure cultures of human pathogenic bacteria [Fig-1] were procured from Shoolini University of Biotechnology and Management Sciences and were maintained on nutrient agar medium (NAM) and sub cultured periodically at an interval of 2 weeks for further studies.

Collection of fruit bodies of oyster mushroom

The fruit bodies of different species of *Pleurotus viz*., *P. ostreatus, P. sajor-caju* and *P. florida* were collected from the Mushroom unit, College of Horticulture and Forestry, Neri, Hamirpur. The mycelium and fruit body (pileus and stipe) of different species of *Pleurotus* were dried in shade and ground into powdered form for further use in experimentation.

Extract preparation

Preparation of aqueous extract

The powdered material of mycelium, pileus and stipe was soaked in sterilized distilled water in the ratio of 1:10 and left for 24 hours. Thereafter, the extract was filtered through Whatman No.1 filter paper and stored in an airtight container at 4°C until use.

Preparation of hot water extract

The powdered material of mycelium, pileus and stipe was soaked in sterilized distilled water in the ratio of 1:30 and boiled until the volume of solution reduced to 1/3rd of the original so as to get the final concentration of 1:10. The extract was then filtered through Whatman No.1 filter paper and stored in an airtight container at 4°C until use

Fig-1 Pure cultures of human pathogenic bacteria

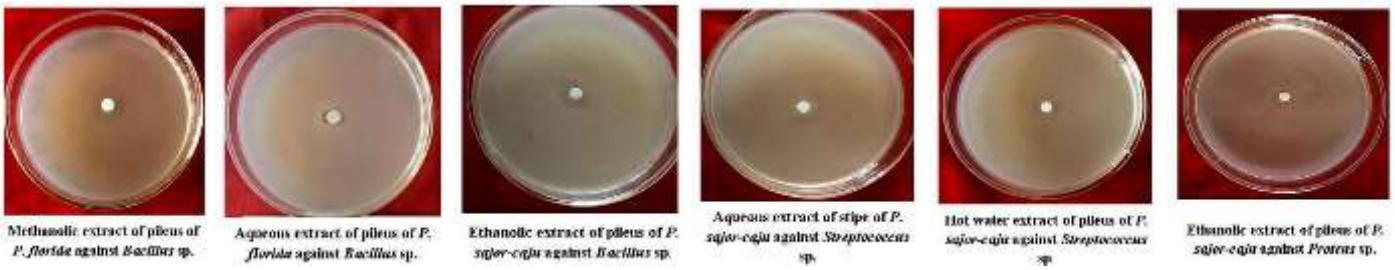

Fig-2 Zone of Inhibition of different spp. of *Pleurotus* against different human pathogenic bacteria

Preparation of ethanolic extract

The powdered material of mycelium, pileus and stipe was soaked in ethanol in the ratio of 1:10 and left for 24 hours. Thereafter, extract was filtered through Whatman No.1 filter paper and stored in an airtight container at 4°C until use

Preparation of methanolic extract

The powdered material of mycelium, pileus and stipe was soaked in methanol in the ratio of 1:10 and left for 24 hours. Thereafter, extract was filtered through Whatman No.1 filter paper and stored in an airtight container at 4°C until use

Antimicrobial Activity of different species of *Pleurotus*

The antimicrobial activity of different species of *Pleurotus* was proved by using the paper disc method. Different parts of the test fungus (mycelium, pileus and stipe) were evaluated for their antimicrobial activity against five human pathogenic bacteria. 24 h old bacterial suspension was poured plated with the nutrient agar medium in the Petri plates. After the solidification of the media, each paper disc of 5 mm diameter presoaked in the different extracts (aqueous, hot water, ethanolic and methanolic extracts) of the parts of the test fungi (mycelium, pileus and stipe) for 2 to 3 hours were placed in the center of the Petri plates. A standard +ve control and –ve control was maintained in each experiment with a common antibiotic ampicillin and water in which the paper discs soaked in ampicillin solution and water were used. Each treatment was replicated thrice and the data were recorded in terms of zone of inhibition (mm) after 24, 48, 72 and 96 h of incubation.

Results

The data presented in [Table-1] clearly indicate that irrespective of different human pathogenic bacteria and *Pleurotus* species under study, mean maximum zone of inhibition (9.33 mm) was recorded in aqueous extract of stipe followed by aqueous extract of pileus (9.19 mm) of different species of *Pleurotus* under study while, minimum zone of inhibition (6.83) was recorded in case of mycelia extracts of three species. Among the three species compared with positive and negative control, significantly maximum mean zone of inhibition (26.69 mm) was recorded in positive control (Ampicillin) and minimum zone of inhibition (4.69 mm) was recorded in aqueous extract of *P. ostreatus* followed by *P. florida* (5.36 mm) which was statistically at par with *P. sajor-caju* (5.51 mm), whereas, no zone of inhibition was recorded in negative control, irrespective of the extract and bacterial species under study. Irrespective of type of extract and different species of *Pleurotus* under study, significantly maximum zone of inhibition (10.58 mm) was recorded against *Pseudomonas* species followed by *Bacillus* species (7.84 mm) which was statistically at par with *Streptococcus* species (8.44 mm). However, significantly minimum average zone of inhibition was recorded against *Proteus* species (7.27 mm) followed by *E. coli* (8.11 mm).

[Table-1] reveals that maximum zone of inhibition (34.33 mm) was recorded against *Pseudomonas* species in positive control (Ampicillin) with pileus extract. However, keeping aside the positive control, maximum zone of inhibition (10.33 mm) was recorded in pileus extract of P. *sajor-caju* against *Proteus* sp. and *Streptococcus* sp. while, minimum zone of inhibition (5.67 mm) was recorded in aqueous extract of mycelium of *P. florida* against *Pseudomonas* species and aqueous extract of stipe of *P. sajor-caju* against *Proteus* species. An intermediate range of zone of inhibition was recorded against the test bacteria by using different type of extracts of three *Pleurotus* species under study. In general, pileus and stipe extracts of all the three *Pleurotus* species were found to exhibit antimicrobial activity against all the five test bacteria as compared to mycelia extracts [Fig-2].

Antimicrobial activities of hot water extracts of three *Pleurotus* species under study against different human pathogenic bacteria have been presented in [Table-2]. A perusal of the data presented in table clearly indicate that irrespective of different species of *Pleurotus* against different human pathogenic bacteria, significantly maximum mean zone of inhibition (8.16 mm) was recorded in hot water extract of pileus followed hot water extract of stipe (6.36 mm) which was statistically at par with mycelia extract (6.12 mm) of different species of *Pleurotus*. Irrespective of different human pathogenic bacteria and extract of different parts of *Pleurotus* species under study, significantly maximum mean zone of inhibition (26.47 mm) was recorded in positive control (Ampicillin) while, minimum zone of inhibition (2.18 mm) was recorded in hot water extract of *P. florida* followed by *P. sajor-caju* (2.56 mm) and *P. ostreatus* (3.20 mm), whereas, no zone of inhibition was recorded in negative control. Irrespective of hot water extract of mycelium and different part of fruit body *viz*., pileus and stipe of different *Pleurotus* species, maximum zone of inhibition (7.18 mm) was recorded against *Bacillus* species followed by *E. coli* (7.29 mm). However, minimum zone of inhibition (5.44 mm) was recorded in *Proteus* species followed by *Pseudomonas* species (7.69 mm) and *Streptococcus* species (6.80 mm).

[Table-2] reveals that maximum zone of inhibition (35.00 mm) was recorded against *Pseudomonas* species in positive control (Ampicillin) of hot water extract of stipe. Among the three *Pleurotus* species, maximum zone of inhibition was recorded in pileus extract of *P sajor-caju* against *Bacillus* sp. while, minimum zone of inhibition (5.33mm) was recorded in hot water extract of stipe of *P. ostreatus* against *E. coli* which was statistically at par with *P. sajor-caju* against *Proteus* species (5.67 mm) and mycelium extract of *P. ostreatus* against *Bacillus* species (6.00 mm). Antimicrobial activities of ethanolic extracts of different species of *Pleurotus* against different human pathogenic bacteria have been presented in [Table-3]. The data presented in table indicate that irrespective of different human pathogenic bacteria and *Pleurotus* species under study, significantly maximum mean zone of inhibition (6.64 mm) was recorded in ethanolic extract of pileus which was followed by stipe (6.19 mm) and mycelium extracts (5.57 mm).

Table-1 *Effect of aqueous extract of different species of Pleurotus against different human pathogenic bacteria*

Extracts	Bacteria Species	Zone of inhibition (mm)					Overall mean (species)	Overall mean (extract)
		E. coli	*Proteus* sp.	*Bacillus* sp.	*Streptococcus* sp.	*Pseudomonas* sp.		
Mycelium	*P. f*	7.00(2.82)	0.00(1.00)	0.00(1.00)	0.00(1.00)	5.67(2.58)	5.36 (2.33)	
	P. sc	0.00(1.00)	0.00(1.00)	6.67(2.77)	0.00(1.00)	6.33(2.70)	5.51(2.35)	
	P.o	6.33(2.71)	0.00(1.00)	0.00(1.00)	0.00(1.00)	6.00(2.64)	4.69(2.22)	6.83(2.25)
	+ve control (Ampicillin)	26.67(5.26)	26.00(5.19)	21.00(4.69)	25.00(5.10)	34.00(5.92)	26.69(5.25)	
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	
Pileus	*P. f*	9.33(3.21)	0.00(1.00)	9.00(3.16)	7.67(2.93)	9.33(3.21)		
	P.sc	0.00(1.00)	10.33(3.31)	9.00(3.14)	10.33(3.36)	0.00(1.00)		
	P.o	8.00(3.00)	0.00(1.00)	7.67(2.94)	6.33(2.71)	8.00(3.00)		9.19(2.77)
	+ve control (Ampicillin)	27.67(5.35)	26.67(5.26)	20.33(4.62)	25.67(5.16)	34.33(5.94)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Stipe	*P. f*	0.00(1.00)	7.67(2.93)	7.67(2.94)	9.67(3.26)	7.33(2.88)		
	P.sc	9.67(3.25)	5.67(2.58)	7.67(2.94)	9.67(3.26)	7.33(2.89)		
	P.o	0.00(1.00)	6.67(2.77)	8.00(3.00)	7.00(2.82)	6.33(2.71)		9.33(2.86)
	+ve control (Ampicillin)	27.00(5.29)	26.00(5.19)	20.67(4.65)	25.33(5.13)	34.00(5.92)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Overall mean		8.11(2.53)	7.27(2.35)	7.84(2.66)	8.44(2.65)	10.58(2.96)		
		$C.D_{0.05}$		S.E(m)				
Extract		0.04		0.02				
Species		0.06		0.02				
Bacteria		0.06		0.02				
Interaction		0.22		0.08				

Table-2 *Effect of hot water extracts of different species of Pleurotus against human pathogenic bacteria*

Extracts	Bacteria Species	Zone of inhibition (mm)					Overall mean (species)	*Overall mean (Extract)*
		E. coli	*Proteus* sp.	*Bacillus* sp.	*Streptococcus* sp.	*Pseudomonas* sp.		
Mycelium	*P. f*	6.67(2.77)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	2.18(1.54)	
	P. sc	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	6.67(2.77)	2.56(1.64)	
	P.o	0.00(1.00)	0.00(1.00)	6.00(2.65)	0.00(1.00)	0.00(1.00)	3.20(1.84)	*6.12(2.06)*
	+ve control (Ampicillin)	26.67(5.26)	25.33(5.13)	22.00(4.80)	26.00(5.20)	33.67(5.89)	26.47(5.22)	
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	
Pileus	*P. f*	9.00(3.16)	0.00(1.00)	7.33(2.89)	9.67(3.26)	0.00(1.00)		
	P.sc	0.00(1.00)	0.00(1.00)	10.00(3.31)	8.67(3.10)	0.00(1.00)		
	P.o	9.00(3.16)	0.00(1.00)	7.33(2.89)	7.33(2.86)	6.33(2.70)		*8.16(2.57)*
	+ve control (Ampicillin)	26.00(5.20)	25.00(5.10)	20.00(4.58)	24.67(5.07)	33.67(5.89)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Stipe	*P. f*	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
	P.sc	0.00(1.00)	5.67(2.58)	7.33(2.89)	0.00(1.00)	0.00(1.00)		
	P.o	5.33(2.51)	0.00(1.00)	6.67(2.77)	0.00(1.00)	0.00(1.00)		*6.36(2.12)*
	+ve control (Ampicillin)	26.67(5.26)	25.67(5.16)	21.00(4.69)	25.67(5.16)	35.00(6.00)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Overall mean		7.29(2.35)	5.44(1.93)	7.18(2.50)	6.80(2.24)	7.69(2.22)		
		$C.D_{0.05}$		S.E(m)				
Extract		0.03		0.01				
Species		0.04		0.01				
Bacteria		0.04		0.01				
Interaction		0.16		0.05				

Table-3 *Effect of ethanolic extract of different species of Pleurotus against different human pathogenic bacteria*

Extracts	Bacteria Species	Zone of inhibition (mm)					Overall mean (species)	Overall mean (Extract)
		E. coli	*Proteus* sp.	*Bacillus* sp.	*Streptococcus* sp.	*Pseudomonas* sp.		
Mycelium	*P. f*	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.93(1.24)	
	P. sc	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	6.00(2.64)	2.09(1.52)	
	P.o	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	1.20(1.33)	5.57(1.91)
	+ve control (Ampicillin)	27.33(5.32)	26.00(5.20)	20.33(4.62)	25.33(5.13)	34.33(5.94)	26.44(5.22)	
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	
Pileus	*P. f*	6.33(2.71)	0.00(1.00)	7.67(2.93)	0.00(1.00)	0.00(1.00)		
	P.sc	0.00(1.00)	0.00(1.00)	0.00(1.00)	9.67(3.26)	0.00(1.00)		
	P.o	6.00(2.64)	0.00(1.00)	6.00(2.64)	0.00(1.00)	0.00(1.00)		6.64(2.20)
	+ve control (Ampicillin)	27.33(5.32)	25.33(5.13)	20.33(4.62)	24.67(5.07)	32.67(5.80)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Stipe	*P. f*	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
	P.sc	7.00(2.82)	0.00(1.00)	8.67(3.19)	0.00(1.00)	0.00(1.00)		
	P.o	6.00(2.64)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		6.19(2.07)
	+ve control (Ampicillin)	27.00(5.29)	25.33(5.13)	21.00(4.69)	25.33(5.13)	34.33(5.94)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Overall mean	7.13(2.32)		5.11(1.83)	5.60(2.11)	5.70(1.97)	7.16(2.01)		
	C.D			S.E(m)				
Extract	0.03			0.01				
Species	0.04			0.01				
Bacteria	0.04			0.01				
Interaction	0.15			0.05				

Table-4 *Effect of methanolic extract of different species of Pleurotus against different human pathogenic bacteria*

Extracts	Bacteria	Zone of inhibition (mm)					Overall mean	Overall mean
	Species	*E. coli*	*Proteus* sp.	*Bacillus* sp.	*Streptococcus* sp.	*Pseudomonas* sp.	(species)	(Extract)
Mycelium	*P. f*	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	1.60(1.39)	
	P. sc	0.00(1.00)	6.00(2.64)	6.00(2.64)	0.00(1.00)	5.67(2.58)	4.02(2.01)	
	P.o	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.84(1.23)	6.01(2.04)
	+ve control (Ampicillin)	27.00(5.29)	25.33(5.13)	20.67(4.64)	26.00(5.20)	33.67(5.88)	26.58(5.23)	
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	
Pileus	*P. f*	0.00(1.00)	0.00(1.00)	11.00(3.42)	0.00(1.00)	0.00(1.00)		
	P.sc	0.00(1.00)	8.33(3.05)	11.33(3.49)	10.00(3.31)	0.00(1.00)		
	P.o	0.00(1.00)	0.00(1.00)	7.00(2.82)	0.00(1.00)	0.00(1.00)		7.23(2.29)
	+ve control (Ampicillin)	27.67(5.35)	26.00(5.20)	20.67(4.65)	25.67(5.16)	33.00(5.83)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Stipe	*P. f*	0.00(1.00)	0.00(1.00)	0.00(1.00)	5.67(2.58)	7.33(2.89)		
	P.sc	0.00(1.00)	0.00(1.00)	5.33(2.51)	7.67(2.89)	0.00(1.00)		
	P.o	0.00(1.00)	0.00(1.00)	0.00(1.00)	5.67(2.58)	0.00(1.00)		6.59(2.19)
	+ve control (Ampicillin)	27.00(5.29)	26.00(5.19)	20.33(4.61)	25.00(5.10)	34.67(5.97)		
	-ve control	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)	0.00(1.00)		
Overall mean		5.44(1.86)	6.11(2.08)	6.82(2.39)	7.04(2.32)	7.62(2.21)		
		C.D		S.E(m)				
Extract		0.04		0.01				
Species		0.05		0.01				
Bacteria		0.05		0.01				
Interaction		0.20		0.07				

Figures in parentheses are Square root transformed values, P. f = Pleurotus florida, P. sc= P. sajor-caju, P. o= P. ostreatus

However, irrespective of type of extracts and human pathogenic bacteria under study, significantly maximum mean zone of inhibition (26.44mm) was recorded in positive control (Ampicillin) while, minimum zone of inhibition (0.93 mm) was recorded in ethanolic extract of *P. florida* followed by *P. ostreatus* (1.20 mm) and *P. sajor-caju* (2.09 mm), whereas, no zone of inhibition was recorded in negative control. Irrespective of extracts and different species of *Pleurotus*, maximum zone of inhibition (7.13 mm) was recorded against *E. coli* followed by *Bacillus* species (5.60 mm) and minimum zone of inhibition was recorded against *Proteus* species (5.11 mm) significantly followed by *Streptococcus* species (5.70 mm) which was statistically at par with *Pseudomonas* species (7.16 mm).

[Table-3] reveals that maximum zone of inhibition (34.33 mm) was recorded against *Pseudomonas* species in positive control (Ampicillin) of mycelium as well as stipe. However, minimum zone of inhibition (6.00 mm) was recorded in ethanolic extract of mycelium of *P. sajor-caju* against *Pseudomonas* species and ethanolic extract of pileus and stipe of *P. ostreatus* against *E. coli* (6.00 mm) and pileus extract of *P. ostreatus* against *Bacillus* species (6.00 mm).

Effect of methanolic extracts of different species of *Pleurotus* against different human pathogenic bacteria has been recorded in terms of zone of inhibition and presented in [Table-4]. A perusal of the data clearly depicts that irrespective of different species of *Pleurotus* and human pathogenic bacteria, maximum mean zone of inhibition (7.23 mm) was recorded in methanolic extract of pileus followed by methanolic extract of stipe (6.59 mm) and mycelium (6.01 mm) of different species of *Pleurotus*. Irrespective of extract and different human pathogenic bacteria under study, significantly maximum average zone of inhibition (26.58 mm) was recorded in positive control (Ampicillin) and significantly minimum zone of inhibition (0.84 mm) was recorded in methanolic extract of *P. ostreatus* followed by *P. florida* (1.60 mm) and *P. sajor-caju* (4.02 mm). However, no zone of inhibition was recorded in negative control. Irrespective of different *Pleurotus* species and type of extracts, maximum zone of inhibition (6.82 mm) was recorded against *Bacillus* species followed by *Streptococcus* species (7.04 mm) and *Pseudomonas* species (7.62 mm). However, minimum zone of inhibition (5.44 mm) was recorded in *E. coli* significantly followed by *Proteus* species (6.11 mm).

[Table-4] reveals that maximum zone of inhibition (34.67mm) was recorded against *Pseudomonas* species in positive control (Ampicillin) of stipe, while, minimum zone of inhibition (5.33mm) was recorded in methanolic extract of stipe of *P. sajor-caju* against *Bacillus* species which was statistically at par with stipe extract of *P. florida* and *P. ostreatus* against *Streptococcus* species (5.67 mm) and mycelia extract of *P. sajor-caju* against *Pseudomonas* species (5.67 mm).

Discussion

During present studies, hot water, ethanolic and methanolic extracts of pileus of three *Pleurotus* spp. were found to be most effective in terms of exhibiting maximum zone of inhibition (8.16, 6.64 and 7.23 mm, respectively). Among the three species, hot water extract of *P. ostreatus* (3.20 mm) and ethanolic as well as methanolic extracts of *P. sajor-caju* (2.09 and 4.02 mm, respectively) were most effective against the test bacteria. Antibacterial effect of mushroom extracts largely depends on the mushroom species, their strains and vegetative form, cultivation condition, methods of extract preparation and methods of evaluation [11-13]. The difference of antibacterial properties of difference species of oyster mushroom may be due to genetic characteristics of that particular species which leads to alterations in chemical composition [14]. The present finding is more or less close to the findings of Ahmed *et al*. (2015) [9], who reported that ethanol and methanol extracts were significantly effective against *Staphylococcus aureus* (25mm) followed by *E. coli* (23.00 mm).

On contrary Owaid *et al*. (2015) [10] reported that filtrate of pink strain *Pleurotus salmoneostraminus* has higher antimicrobial activity while, none of the filtrate of *P. ostreatus* showed any activity against pathogenic bacteria and yeast. Nithya and Ragunathan (2009) [15] reported that silver nano particle produced by *P. sajor-caju* have good antimicrobial action against gram –ve bacteria, *Pseudomonas aeruginosa* and *E. coli* as compared to +ve bacteria, *Staphylococcus aureus*. Pandiarajan *et al*. (2012) [8] reported that *B. subtilis* and *E. coli* were more susceptible in ethanol extract of *P. sajor-caju*. However, Thillaimaharani *et al*. (2012) [16] reported that maximum antibacterial activity of *P. florida* in ethanol extract against *Streptococcus*. In addition to this, Sathyan *et al*. (2017) [17] reported that dimethyl ether-based extract of *P. ostreatus* showed the maximum activity against *E. coli* while, minimum against *Klebsiella pneumoniae* and no activity against *P. aeruginosa*.

Conclusion

Among aqueous extracts, stipe extracts of all the three species of *Pleurotus* were effective in inhibiting the growth of five human pathogenic bacteria (*viz*., *Escherichia coli*, *Pseudomonas* sp., *Proteus* sp., *Bacillus* sp. and *Streptococcus* sp.), *P. sajor-caju* being the most effective in terms of inhibiting all the five test bacteria. However, hot water, ethanolic and methanolic extracts of pileus of three *Pleurotus* spp. were found to be most effective in terms of exhibiting maximum zone of inhibition. Among the three species, hot water extract of *P. ostreatus* and ethanolic as well as methanolic extracts of *P. sajor-caju* were most effective against the test bacteria. From these findings, it was concluded that all the three species of *Pleurotus* under study contain antibacterial compounds effective against the test human pathogenic bacteria in one of the other parts of fruit body which can be extracted in different solvents. These findings can be applied in further pharmaceutical research in future.

Application of research: The findings of these studies will be helpful for the pharmacological research on the compounds present in these mushroom species which can further prove beneficial to fight against the concerned human pathogenic bacteria.

Research Category: Antimicrobial activity of mushrooms

Abbreviations: °C-degree Celsius, h-hour(s), mm-millimeter

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