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Anti-microbial Activity and GC-MS Analysis of Leaves Extracts of *Butea Monosperma* (Lam.) Taub

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ABSTRACT

Butea monosperma (Lam.) Taub is a well-known medicinal plant belonging to the family Fabaceae. More than hundreds of plants have been reported in the Ethno-botanical literature of India for their anti-microbial activity as well as for treatment of many diseases and *Butea monosperma* (Lam.) Taub is one of them. The present investigation is focused on the anti-microbial activity of *Butea monosperma* leaves against both gram-positive (*Bacillus subtilis*, *Enterococcus faecalis*, *Lactobacillus acidophilus, Staphylococcus aureus* and *Streptococcus mutans*) and gram-negative bacteria (*Escherichia coli* and *Pseudomonas aeruginosa*) as well as fungi (*Candida albicans* and *Trichophyton rubrum*). Both excerpts (ethanol and methanol) show positive responses against all the selected microorganisms. GC-MS analysis is done to find out important compound which is anti-microbial. A total of 38 compounds are identified in GC-MS analysis. Out of 38 compounds, 8 compounds are identified as antimicrobial in nature such as Dodecane, 2-HEXADECEN-1-OL, 3,7,11,15-TETRAMETHYL-, [R-[, Hexadecanoic acid, methyl ester, Phytol, Palmidrol, Squalene, Tetracosane, Vitamin E and Lup-20(29)-en-3-one which justify, this plant possess significant anti-microbial property. GC-MS analysis reveals that majorly, this plant leaves also possess[10] antioxidant compounds (Neophytadiene, 2-HEXADECEN-1-OL, 3,7,11,15-TETRAMETHYL-, [R-[, n-Hexadecanoic acid, Phytol, squalene, .alpha.-Tocospiro B, Tetracosane, .gamma.-Tocopherol, Ergost-5-en-3-ol, (3.beta.)- and STIGMASTA-5,22-DIEN-3-OL, (3.BETA.,22E)-,), 9 anti-cancerous compounds (Hexadecanoic acid, methyl ester, 9,12,15-OCTADECATRIENOIC ACID, METHYL ESTER, squalene, .gamma.-Tocopherol, Vitamin E, Ergost-5-en-3-ol, (3.beta.)-, STIGMASTA-5,22-DIEN-3-OL, (3.BETA.,22E)-, .gamma.-Sitosterol and Lupeol),8 anti-inflammatory compounds (Neophytadiene, 2-HEXADECEN-1-OL, 3,7,11,15-TETRAMETHYL-, [R-[, Hexadecanoic acid, methyl ester, n-Hexadecanoic acid, 9,12,15-OCTADECATRIENOIC ACID, METHYL ESTER, Phytol, Palmidrol, .alpha.-Tocospiro B and Lupeol), 3 cardioprotective compounds (Neophytadiene, .alpha.-Tocospiro B and .gamma.-Tocopherol A) and 5 antidiabetic compounds (.alpha.-Tocospiro B, Vitamin E, STIGMASTA-5,22-DIEN-3-OL, (3.BETA.,22E)-, .gamma.-Sitosterol and Lup-20(29)-en-3-one).This investigation suggests that this plant leaf has not only anti-microbial potential but also possesses other important compounds to fight against many deadly diseases. Thus, this plant has immense potential to make an individual place in pharmacological industries, especially as antibiotics.

Keywords: *Butea monosperma* (Lam.) Taub; Anti-microbial; GC-MS analysis

1. INTRODUCTION

In developing countries like India, 80% of people are depends on herbal medicine for their principal health care needs reported by WHO.[1] Different plant parts of Kingdom Plantae rich in the organic compound which is used as ethnic medicine from ancient times has mentioned in Ayurvedic, Chinese, and Unani medicine.[1,2]

Ayurveda acts as a connecting link between plant and human health rights from human civilization. This plant is reported in Upanishads, Vedas, Susruta Samhita, Caraka Samhita, and in Astanga Hardaya and Astanga Sangraha.[3] This tree also mention in 'Satpath Brahman', 'Matsya-purana', and 'Vau-Purana'. During Vedic times this tree is commonly known as 'Brahma-vriksha'. The Palash tree also specify in Mahabharata and Ramayana.[4]

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Butea monosperma (Lam.) Taub is a reservoir of important chemical compounds which show significant physiological activities in the human body, so this plant can treat bacterial, fungal, and viral infections. Currently, Phyto-drugs are more popular than synthetic drugs because of their maximum benefits and fewer or no side effects.[5]

More than hundreds of plants have been reported in the Ethno-botanical literature of India for their anti-microbial activity as well as for treatment of many diseases and *Butea monosperma*(Lam.) Taub is one of them.[6]

Butea monosperma(Lam.) Taub is frequently branded as Palash (pal means leaf and sha means sacred, thus this plant represents; the leaf is pure and sacred), Dhak, and Muthuga which belong to the family Fabaceae.[7] This medicinal plant is native to India, Pakistan, Sri

Lanka, Bangladesh, Vietnam, Thailand, Indonesia, Laos, Thailand, and Cambodia.

The genus name *Butea* was given by Koenig in 1972 which represents a beautiful flower whereas the species name *monosperma* given by O. Kuntze in 1891 which is characteristic, each fruit contains only one seed in the apical end. During the spring season, the leaves are shed and trees are seen in full bloom with bright orange-coloured flowers (Fig. 1(a)) making it easily recognizable even to untrained eyes which gives the appearance of fire in the forest so this plant is also called the 'forest's flame'.

To authenticate the beauty of the Dhak plant flowers, government of Jharkhand make a State flower of Jharkhand. In India Palash positions second to *Schleichera oleosa* (Kusum) as the host of a lac insect.[8] Palash tree grows up to 12-15 m high with irregular branches and crooked trunks (Fig. 1(b)). Leaves (Fig. 1(c)) are stipulate, trifoliate, alternate, petiolate and 10-15 cm long. Each leaflet is coriaceous, asymmetric, obtuse, glabrous, stipulate, reticulate, and petiolate. Leaf surface are pubescent and glutinous.The leaf margin is smooth and entire.

Flowers produced in racemes, terminal or axillary, bisexual with bract and bracteoles, pedicellate, and deciduous. Each flower (Fig. 1(d)) contains five petals, the outermost layer is called vexillum or standard. Two petals are united to form a cavity that is boat-shaped known as carina or keel, and two wings that look like the beak of a parrot. So, this plant is also called Kimsuka. The longest petal of flowers is the keel. This tree represents the God, Agnidev.[9] The calyx is velvety, five-ridged, fleshy, gamosepalous, campanulate, and green. Corolla is scarlet, inside glossy and outside silvery tomentose. Stamens are diadelphous. The anther is bilobed, uniform, and basifixed. The ovary is linear, elongated, falcate, and sessile containing four-six ovules. Stigma is terminal, small and presents near to keel. Fruit (Fig. 1(e)) a pod, flat base, wing-like, oblong, the tip splitting around the apical seed, compressed, ovate seed[4,10,11] (Fig. 1(f)). This plant well grows in both irrigated and dry land.

Almost all parts of the plant have medicinal importance as the roots show anti-parasitic activity[12], anti-fertility activity[13]; leaves show anti-microbial[14], anti-filarial[15], flower; free radical scavenging activity[16], anti-microbial activity[17], anti-diabetic activity[18], hepatoprotective activity[19], anti-cancer activity[20], bark; hepatoprotective[21], anti- diarrheal[22], anti-ulcer[23], fruit; anti-diabetic[24], seed; protease inhibitor activity[25], anti-fertility activity.[26]

2. PHYTOCONSTITUENTS OF LEAVES

Leaves of Dhak plant show an abundance of glucoside, linoleic acid; antimicrobial[27], oleic acid; antimicrobial[27], lignoceric acid, and palmitic acid[28].

3. METHODOLOGY

3.1 Collection

Fresh leaves of Palash were collected from Namkum area (Ranchi district at lat 23°14'42''N, long 85°18'43''E) during March.

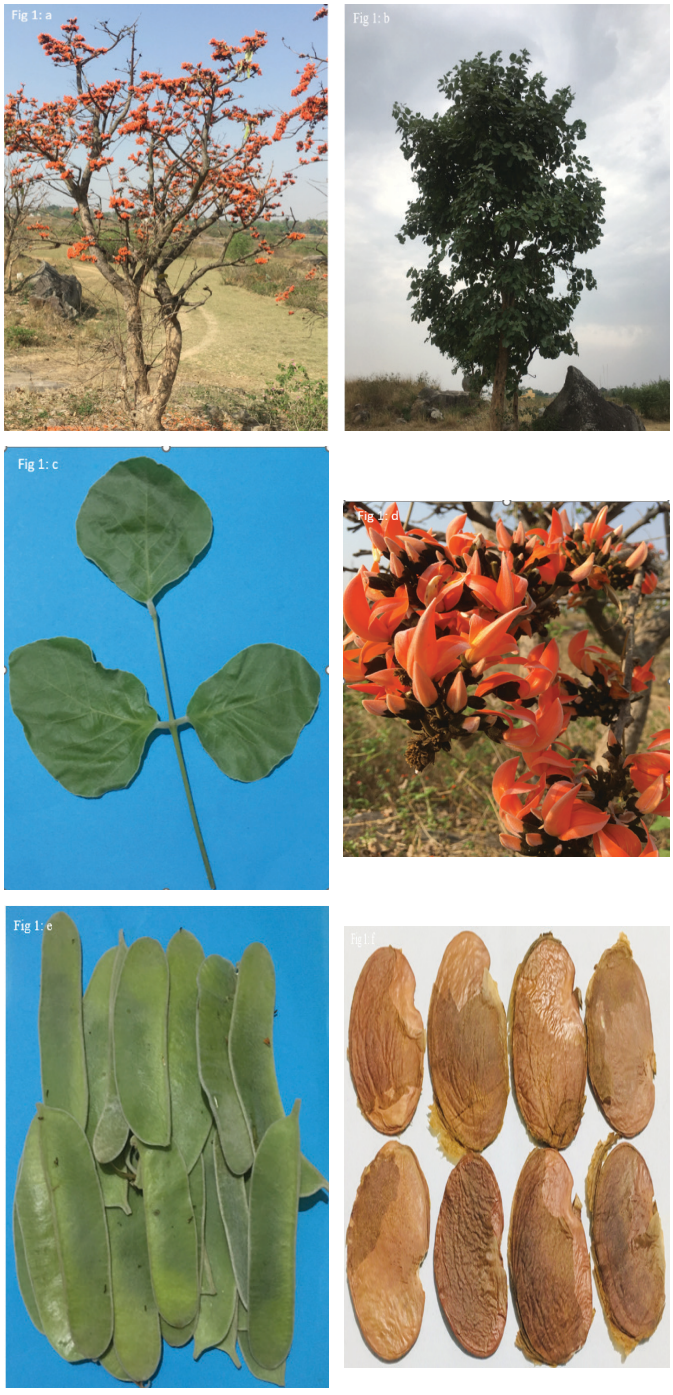


Figure 1. Flowering plant (a),Non-flowering plant (b), Single leaf (c), Flowers (d), Fruits (e) and Seeds (f)

3.2 Identification

Fieldwork was carried out in the city of Ranchi for the identification of Palash plant leaf. The collected plant samples were tentatively identified with the help of keys and descriptions given in various floras[29] and monographs[4] and later confirmed by matching with type

specimens present in the herbarium at the University Department of Botany, Ranchi University, Ranchi. The final authentication of this plant was done by the National Institute of Science Communication and Policy Research (authentication no.- NIScPR/RHMD/Consult/2022/4258-59-1), New Delhi.

3.3 Plant Extract Preparation

Collected leaves were washed properly with tap water and then wipe with a soft dry cloth to remove excess water and dust. These collected leaves were kept under shade dry conditions for about one month. Dry leaves were ground into fine powder. The cold extraction method was used for extract preparation.[30] Powder leaves are mixed into methanol at a 1:10 (w/v) ratio and then placed into a shaker-incubator for about 28°C, 80rpm for 72 hours for mixing. After that, mixture is filtered by using Whatman filter paper-1. Keep the filtrate under an incubator at 37°C, subjected to evaporation of methanol. A dry extract was prepared, called stock. Take 7mg of extract from this stock and mixed it with 1000µl of ethanol and methanol solvents. Both extracts were mixed properly by using a thermomixer at a temperature of 30°C, 1000rpm for 10 minutes and then centrifuged at 30°C, 1400rpm for 5 min. Removed the palate and the supernatant was transferred to a new centrifuge tube. This extract was used to test the antibiotic potential against selected microorganisms.

3.4 Anti-microbial Assay

Disc-diffusion method[31] is used to test the anti-microbial commotion of the ethanol and methanol leaf excerpt of *Butea monosperma*. Bacteria are inoculated in nutrient agar media and fungus in SDS media on sterilized Petri plates. Sterilization was done by autoclave at a temperature of 120°C, 15 lbs pressure for 30-40 minutes. 100µl of microbial inoculum is uniformly spread in media by using a spreader (glass rod) and left to settle for about 1-2 minutes. After that 6mm of the disc is placed into the media and then different volumes (5 µl, 10 µl, and 15 µl) of concentration i.e., 7mg/1000µl of ethanol and methanol extract, were loaded into the disc. Petri plates were kept under two different sterilized (wiped by 70% ethanol) incubators, 37°C for bacteria and 28°C for fungus for 16-18 hours for maximum growth of microorganisms. The precinct of inhibition was calculated and compared with the standard. Tetracycline is used as the positive control for ethanolic extract and erythromycin for methanolic extract. Ethanol and methanol were used as a negative control.

3.5 Microorganism Used

Nine different microorganisms are accustomed to test the antimicrobial activity of leaf excerpts such as gram-positive bacteria; *Bacillus subtilis* (MCC 2511), *Enterococcus faecalis* (MCC 3040), *Lactobacillus acidophilus* (MCC LA), *Streptococcus mutans* (MCC SM), *Staphylococcus aureus (MCC 2408),* gram-negative bacteria; *Pseudomonas aeruginosa* (MCC 3973), *Escherichia coli* (MCC 3099) and fungi; *Candida albicans* (MCC 1152) and *Trichophyton rubrum* (MCC 1850).

3.6 Calculations

A Triplicate is made of each experiment to calculate the mean value (mm) for standard calculation. The standard deviation is presented in ±form and the area of the inhibited zone is calculated in mm^2.

$$Zone\ of\ inhibition\ (mm^2) = Area\ of\ inhibited\ zone\ (\pi r_1^2) - Area\ of\ disc\ (\pi r_2^2)$$

The percentage of inhibition of Dhak plant leaves is calculated by using the formula:

$$\%\ \text{inhibition} = \frac{Zone\ of\ sample}{Zone\ of\ standard} * 100$$

3.7 GC-MS Analysis

From stock, take 10mg of extract and mixed it with 1000µl of ethanol. Then this mixture is mixed by using a thermomixer and then a centrifuge. The palate was removed and the supernatant was transferred to the new centrifuge tube. Test samples were prepared was sent to Advanced Instrumentation Research Facility at Jawaharlal Nehru University, New Delhi. Shimadzu QP-2010 Plus with Thermal Desorption System TD 20 was used for this analysis. He (Helium) was used as carrier gas (flow rate of 16.3 mL/min and column flow rate of 1.21 mL/min) and temperature of column oven was set at 100^0C. The total time for the GC-MS analysis test was 35 minutes. For calculating the phytoconstituents the acquired retention time (RT) and mass weight were compared with the spectra of the GC-MS database of NIST (National Institute of Standard and Technology) and Wiley library (online). An online literature survey was done by using the most popular sites such as Google Scholar, Pub-chem, and Pub-med to investigate the bioactivity of phytoconstituents.

4. RESULTS

Day by day microorganisms modify themselves to reverse the activity of antibiotics, in such condition development of new antibiotics is essential, which have fewer or no side effects and maximum benefits to fight against such microorganisms. Nine different microorganisms were used in this experiment, which shows resistance such as *Bacillus subtilis* shows resistance against streptomycin[32], *Enterococcus faecalis*; clindamycin, quinupristin-dalfopristin[33], *Lactobacillus acidophilus;* cephalosporins, vancomycin[34], *Streptococcus mutants;* fluoride resistance[35], *Staphylococcus aureus*; methicillin resistance[36], *Pseudomonas aeruginosa*; fosfomysin[37], *Escherichia coli*; beta lactum[38], *Candida albicans*; Flucnazole[39] and *Trichophyton rubrum*; azoles, amorolfine, terbinafine resistance[40].

This investigation shows, both the leaf excerpts of *Butea monosperma* inhibit the growth of all nine microorganisms which were selected for this experiment such as a- *Bacillus subtilis* (MCC 2511), b- *Enterococcus faecalis* (MCC 3040), c- *Lactobacillus acidophilus* (MCC LA), d- S*treptococcus mutans* (MCC SM), e- *Staphylococcus aureus* (MCC 2408), f- *Pseudomonas aeruginosa* (MCC 3973), g- *Escherichia coli* (MCC 3099) h- *Candida albicans* (MCC 1152) and i-*Trichophyton rubrum* (MCC 1850), clearly shown in Fig. 2(a-i) and by ethanol excerpts and Fig. 3(a-i) by methanol excerpts of leaves. In ethanol excerpts maximum precinct of inhibition is conveyed against *Streptococcus mutans* i.e.,18.33±0.33 (235.49)and the minimum against *Escherichia coli* i.e.,11.33±0.33(72.50) shown in Table 1. In methanol excerpts, the maximum precinct of inhibition is reported against *Candida albicans* i.e.,15±0.57(148.36) and the minimum against *Escherichia coli* i.e., 7.66±0.33(17.80) shown in Table 2.

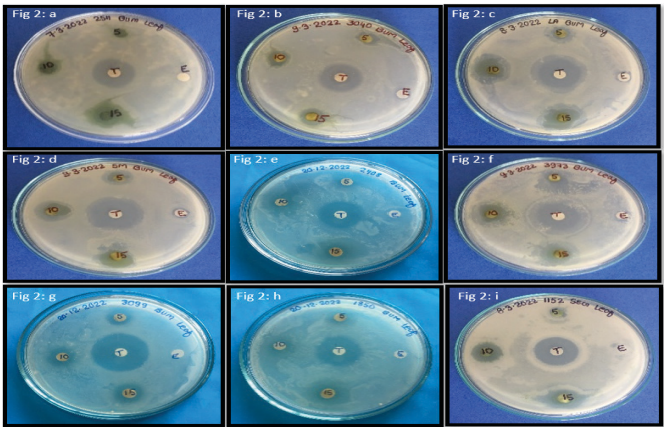


Figure 2. Anti-biotic potential of Dhak plant leaves excerpts (ethanol) against (a) *Bacillus subtilis* (MCC 2511), (b) *Enterococcus faecalis* (MCC 3040), *(c) Lactobacillus acidophilus* (MCC LA) (d) *Streptococcus mutans* (MCC SM), (e) *Staphylococcus aureus* (MCC 2408), (f) *Pseudomonas aeruginosa* (MCC 3973), (g) *Escherichia coli* (MCC 3099), (h) *Trichophyton rubrum* (MCC 1850) *and* (i) *Candida albicans* (MCC 1152).

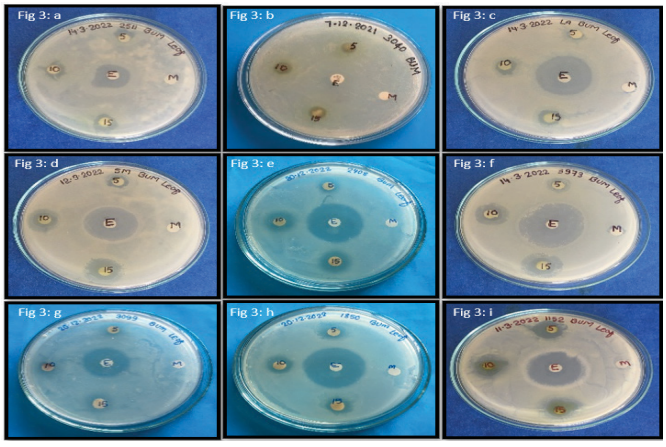


Figure 3. Anti-biotic potential of Dhak plant leaves excerpts (methanol) against (a) *Bacillus subtilis* (MCC 2511), (b) *Enterococcus faecalis* (MCC 3040), *(c) Lactobacillus acidophilus* (MCC LA) (d) *Streptococcus mutans* (MCC SM), (e) *Staphylococcus aureus* (MCC 2408), (f) *Pseudomonas aeruginosa* (MCC 3973), (g) *Escherichia coli* (MCC 3099),(h) *Trichophyton rubrum* (MCC 1850) *and* (i)*Candida albicans* (MCC 1152).

Table 1. Anti-microbial activity of ethanolic leaf excerpt of *Butea monosperma*

Microbial Strains	Zone of inhibition									
	5µl		10 µl		15 µl		T		E	
	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2
Bacillus subtilis	11.6 ± 0.33	77.36	13.66 ±0.88	118.21	17.33 ±0.88	207.49	21.33 ±0.66	328.49	7 ± 0.33	10.20
Enterococcus faecalis	9.66 ± 0.33	44.99	11.66±0.33	78.46	14.33±0.33	132.93	20± 0.57	285.74	7.66±0.33	17.80
Lactobacillus acidophilus	11 ± 0.57	66.72	14.66±0.33	140.44	16± 0.57	172.7	25.33±0.33	475.40	8.66±0.66	30.61
Streptococcus mutans	13.66 ± 0.33	118.21	15.66±0.33	164.24	18.33±0.33	235.49	24.66±0.88	449.11	8.33±0.33	26.21
Staphylococcus aureus	7 ± 0.57	10.20	10.66±0.66	60.94	15.33±0.33	156.22	19± 0.57	255.12	6.33±0.33	3.19
Pseudomonas aeruginosa	13.66 ± 0.66	118.21	15 ± 0.57	148.365	17.66±0.33	216.56	24.66±0.88	449.11	7.66±0.33	17.80
Escherichia coli	9.33 ± 0.57	40.12	10.33 ±0.57	55.56	12±0.33	84.78	21.66±0.88	340.02	-	-
Trichophyton rubrum	9.66 ± 0.33	44.99	12 ± 0.57	84.78	13.33±0.66	111.22	19± 0.57	255.12	6.33±0.33	3.19
Candida albicans	9.66 ± 0.66	44.99	14.66± 0.33	140.44	17± 0.57	198.60	25.66±0.33	488.611	7± 0.57	10.205

Table 2. Anti-microbial activity of methanolic leaf excerpt of *Butea monosperma*

Microbial Strains	Zone of inhibition									
	5µl		10 µl		15 µl		Er		M	
	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2	Mean and SD (±)	mm^2
Bacillus subtilis	7± 0.57	10.20	8.66± 0.33	30.61	10.33±0.33	55.02	19± 0.57	255.12	6.33± 0.33	3.19
Enterococcus faecalis	6.66± 0.33	6.55	7.66± 0.33	17.80	8.33± 0.33	26.21	8.44± 0.33	27.65	7±0.33	10.26
Lactobacillus acidophilus	6.33± 0.33	3.19	7.66± 0.33	17.80	8.66± 0.33	30.61	21± 0.57	317.92	6.33± 0.33	3.19
Streptococcus mutans	7.66± 0.33	17.80	11± 0.57	66.72	13± 0.57	104.40	20.33±0.33	296.18	6.33± 0.33	3.19
Staphylococcus aureus	8.33± 0.33	26.21	10.33±0.88	55.50	11.66±0.88	77.36	23.33±0.33	399.00	6.33± 0.33	3.19
Pseudomonas aeruginosa	7.66± 0.33	17.80	11.33±0.33	72.50	14± 0.57	125.6	24± 0.57	423.9	-	-
Escherichia coli	-	-	6.66± 0.33	6.55	7.66± 0.33	17.80	18.33±0.33	235.49	-	-
Trichophyton rubrum	8.33± 0.33	26.25	9.66±0.57	45.09	10.83±0.66	63.86	19± 0.57	296.18	6.33± 0.33	3.19
Candida albicans	11.33±0.33	71.91	14± 0.57	125.6	15± 0.57	148.36	21± 0.57	317.92	6.33± 0.33	10.20

Anti-microbial study shows this plant leaf has immense potential to produce herbal antibiotics. The present study shows ethanol excerpts of leaves are more effective as compared to methanol excerpts. In ethanol excerpts, the maximum zone of inhibition is calculated against Streptococcus mutans and by methanol excerpts calculated against *Candida albicans*. Both the excerpts show minimum inhibitory effects against *Escherichia coli* (at higher volume, i.e., 15µl) seen in Fig. 4. The amount of drug loaded on the disc for both the excerpts are the same such as for the volume of 5µl were 35µg, 10 µl; 70 µg and 15 µl; 105 µg. The zone of inhibition by both excerpts was increased in a dose-dependent manner visualized in Figs 5 and 6.

The percentage of inhibition of ethanol and methanol excerpts of Dhak plant leaves is calculated. In ethanol excerpts of Dhak leaves, a maximum percentage of inhibition, at a volume of 5µl was calculated against *Streptococcus mutans* and *Pseudomonas aeruginosa* i.e., 26.32%, at a volume of 10 µl was reported against *Streptococcus mutans i.e.,* 36.57% and at a volume of 15µl is reported against *Bacillus subtilis* i.e., 63.16% respectively and minimum percentage of inhibition, at a volumeof 5µl is reported against *Staphylococcus aureus*i.e., 3.99% and at volume 10µl and 15µl is reported against *Escherichia coli* i.e., 16.34% and 24.93% respectively, visualized in Fig. 7. In methanol excerpts,the maximum percentage of inhibition at a volume of 5µl, 10µl, and 15µl is reported against *Enterococcus faecalis* i.e., 23.68%, 64.37%, and 94.79% and minimum percentage of inhibition at a volume of 5µl,10µl, and 15µl is reported against *Escherichia coli i.e.,* 0%, 2.78% and 7.55%. visualized in Fig. 8.

GC-MS analysis is one of the important corridors

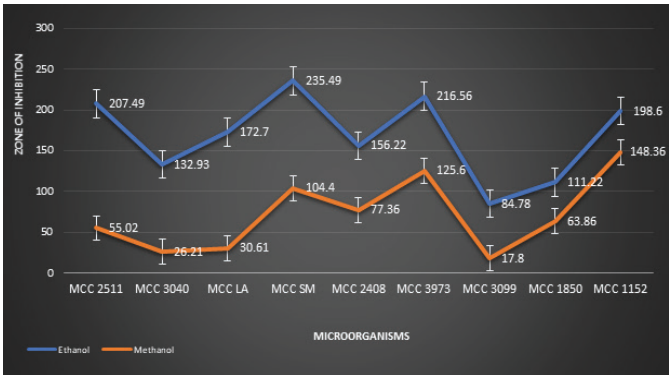


Figure 4. Comparison of the inhibitory zone of ethanolic and methanolic leaf excerpts of *Butea monosperma*

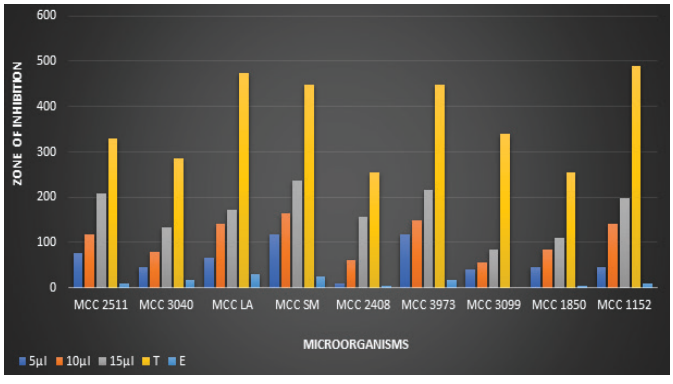


Figure 5. Dose-dependent activity of Ethanol excerpts against microbial pathogens

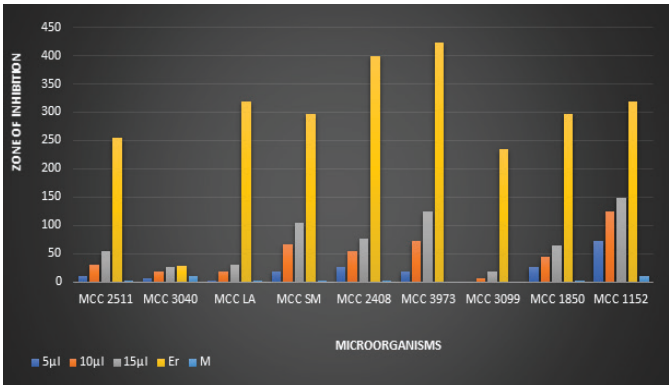
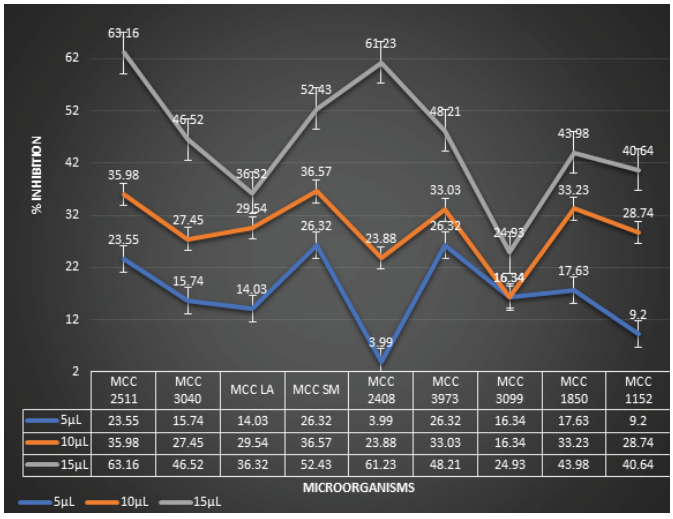
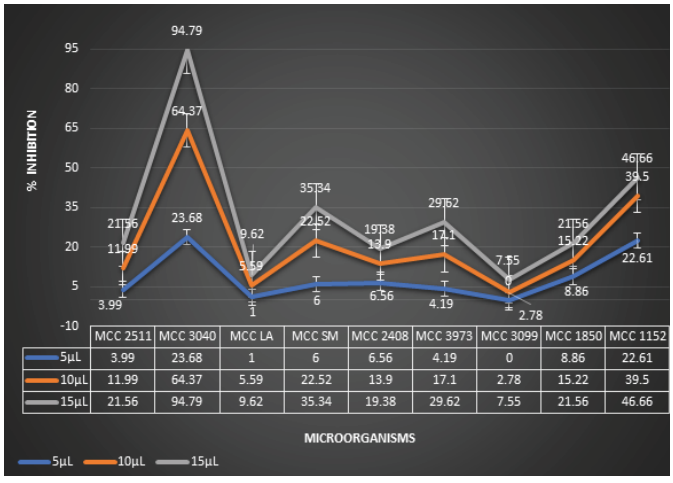


Figure 6. Dose-dependent activity of methanol excerpts against microbial pathogens



	MCC 2511	MCC 3040	MCC LA	MCC SM	MCC 2408	MCC 3973	MCC 3099	MCC 1850	MCC 1152
5µL	23.55	15.74	14.03	26.32	3.99	26.32	16.34	17.63	9.2
10µL	35.98	27.45	29.54	36.57	23.88	33.03	16.34	33.23	28.74
15µL	63.16	46.52	36.32	52.43	61.23	48.21	24.93	43.98	40.64

Figure 7. % inhibition by ethanol excerpts of Dhak plant leaves against microbial pathogen



	MCC 2511	MCC 3040	MCC LA	MCC SM	MCC 2408	MCC 3973	MCC 3099	MCC 1850	MCC 1152
5µL	3.99	23.68	1	6	6.56	4.19	0	8.86	22.61
10µL	11.99	64.37	5.59	22.52	13.9	17.1	2.78	15.22	39.5
15µL	21.56	94.79	9.62	35.34	19.38	29.62	7.55	21.56	46.66

Figure 8. %inhibition by methanol excerpts of Dhak plant leaves against microbial pathogen

for the identification of the important volatile compound from the test sample. By this instrumental technique (GC-MS) analysis, 38 compounds are pointed out by different peaks of chromatograms. Out of these 38 compounds, mome inositol shows the uppermost peak area% of 53.00% at a retaining time of 12.294 minutes, and the minimum showed by dodecane with a peak area% of 0.11 at 10.115 minutes, retention time. Retention time, percentage of peak area, chemical compound, molecular weight, nature, and molecular formula are mentioned in Table 3. The bioactivity of 20 chemical compounds is identified, mentioned in Table 4, which are effective against many diseases.

5. CONCLUSION

The present investigation provides scientific validation thus these plant leaves are a potent source of antibiotics against all selected microorganisms. The maximum percentage of inhibition is found against *Enterococcus faecalis* (methanol). Ethanol excerpts of Dhak plant

Table 3. Retention time, percentage of peak area, chemical compound, molecular weight, nature, the structure of chromatograms, molecular formula

S. No.	R.T.	Peak area %	Chemical compounds	Molecular Weight (g/mol)	Nature	Mf
1	10.115	0.11	Dodecane	170.33	Clear colourless liquid.	$C_{12}H_{26}$
2	10.617	0.14	MEGASTIGMATRIENONE 4	190.28	Nor – isoprenoids (βcarotene)	$C_{13}H_{18}O$
3	10.974	0.29	4,4,5,8-Tetramethylchroman-2-ol	206.28	Alkaloid	$C_{13}H_{18}O_2$
4	12.294	53.00	MOME INOSITOL			
5	12.757	7.69	Neophytadiene	278.5	Diterpene	$C_{20}H_{38}$
6	13.208	2.73	2-HEXADECEN-1-OL, 3,7,11,15-TETRAMETHYL-, [R-[		Phytol	
7	13.575	0.22	Dibutyl phthalate	278.34	Phthalate ester	$C_{16}H_{22}O_4$
8	13.685	0.31	Hexadecanoic acid, methyl ester	270.5	Fatty acid methyl ester	$C_{17}H_{34}O_2$
9	14.140	0.32	n-Hexadecanoic acid	256.42	Saturated long-chain fatty acid	$C_{16}H_{32}O_2$

10	15.316	0.06	Carbonic acid, ethyl undec-10-enyl ester	242.35		$C_{14}H_{26}O_3$
11	15.376	0.28	9,12,15-OCTADECATRIENOIC ACID, METHYL ESTER	292.5	Linoleic acid, methyl este	$C_{19}H_{32}O_2$
12	14.479	4.70	Phytol	296.5	Acyclic diterpene alcohol and a constituent of chlorophyll.	$C_{20}H_{40}O$
13	16.211	0.09	Bicyclo[3.1.1]heptan-3-one, 2,6,6-trimethyl-, (1.alpha.,2.alp			
14	17.130	0.10	14-.BETA.-H-PREGNA			
15	17.303	0.17	Palmidrol	299.5	ethanolamide of palmitic (hexadecanoic) acid	$C_{18}H_{37}NO_2$
16	17.371	0.31	2-Pyrrolidinone, 1-[2-(4-piperidinyl)ethyl]-	196.29		$C_{11}H_{20}N_{2O}$
17	18.767	0.49	HEXATRIACONTANE	507	Alkane	$C_{36}H_{74}$
18	18.987	0.08	4-Methoxy-2-methyl-1-butanol, TMS derivative	190.35		$C_9H_{22}O_2Si$
19	19.069	1.96	1,2-BENZENE DICARBOXYLIC ACID	166.13	Benzene dicarboxylic acid	$C_8H_6O_4$
20	19.555	1.10	3,7,11-trimethyldodeca-2,6,10-trien-1-yl palmitate	460.8		$C_{31}H_{56}O_2$
21	20.289	0.63	1,54-DIBROMOTETRAPENTACONTANE	917.2		$C_{54}H_{108}Br_2$
22	20.421	0.49	2,6,10,14-HEXADECATETRAEN, 1-ACETOXY-3,7,11,15			
23	20.986	0.48	3,7,11-trimethyldodeca-2,6,10-trien-1-yl palmitate	460.8		$C_{31}H_{56}O_2$
24	21.120	1.17	Squalene	410.7	Triterpene	$C_{30}H_{50}$
25	21.384	0.17	.alpha.-Tocospiro B			
26	21.544	0.34	.alpha.-Tocospiro B			
27	21.758	0.19	Tetracosane	338.7	Straight-chain alkane	$C_{24}H_{50}$
28	21.949	0.16	3,7,11,15-TETRAMETHYL-2,6,10,14-HEXADECATETR			
29	23.238	0.25	.gamma.-Tocopherol	416.7	Tocopherol	$C_{28}H_{48}O_2$
30	23.769	0.46	(3S,8S,9S,10R,13R,14S,17R)-17 -((2R,5R)-5-Ethyl-6-methyl	38.062	Phytosterols	$C_{29}H_{50}O$
31	24.078	3.27	Vitamin E	430.7	Fat-soluble	$C_{29}H_{50}O_2$
32	25.498	0.86	Ergost-5-en-3-ol, (3.beta.)-	400.7	Steroid derivative	$C_{28}H_{48}O$
33	25.845	3.03	STIGMASTA-5,22-DIEN-3-OL, (3.BETA.,22E)-	412.7	Steroid derivative	$C_{29}H_{48}O$
34	26.791	5.13	.gamma.-Sitosterol	414.7	Phytosterols	$C_{29}H_{50}O$
35	27.528	1.22	.beta.-Amyrin	426.7	Triterpenes	$C_{30}H_{50}O$
36	27.813	1.15	Lup-20(29)-en-3-one	424.7	Triterpenoid	$C_{30}H_{48}O$
37	28.180	0.36	4,4-Dinorlupan-4-one-28-carboxylic acid, 3.beta.-methyl-, m			
38	28.360	6.52	Lupeol	426.7	Pentacyclic triterpenoid	$C_{30}H_{50}O$

Table 4. Bioactivity of a chemical compound

S.No.	Chemical compound	Biological activity
1	Dodecane	Anti-bacterial[41]
4	MOME INOSITOL	Anti-cirrhotic, lipotropic, anti-alopecic, anti-neuropathic cholesterolytic, and have sweetening properties[42,43]
5	Neophytadiene	Important for treatment of headaches, anti-rheumatism, cardioprotective, anti-oxidant, anti-inflammatory and used for cure skin disease[44]
8	Hexadecanoic acid, methyl ester	Anti-inflammatory, antiarthritic, anti-coronary, hypocholesterolemic, anti-cancer, antiacne, hepatoprotective, antihistaminic, antieczemic, alpha-reductase inhibitor, antiandrogenic, nematicide[45]
9	n-Hexadecanoic acid	Anti-inflammatory, anti-androgenic, anti-oxidant[46]
11	9,12,15-OCTADECATRIENOIC ACID, METHYL ESTER	Anti-plasmodial, urine acidifier, and urinary acidulant, arachidonic acid inhibitor also inhibits the production of uric acid, anti-inflammatory, anti-cancerous[47]
12	Phytol	Anti-microbial, anti-tuberculosis, anti-convulsant, antinociceptive, anti-inflammatory, antioxidant[48]
15	Palmidrol	Non-Steroidal, analgesics, anti-Inflammatory, antihypertensive, neuroprotective, antiviral,anticonvulsant, anti-oxidative[49]
24	Squalene	Anti-cancerous, anti-bacterial, anti-oxidant, immunostimulant UV ray protection[50]
25	.alpha.-Tocospiro B	Anti-oxidant, anti-diabetic, anti-inflammatory, cardioprotective, hypochlolesterolemic[51]
26	.alpha.-Tocospiro B	Anti-oxidant, anti-diabetic, anti-inflammatory, cardioprotective, hypochlolesterolemic[51]
27	Tetracosane	Ant-microbial, anti-oxidant[52]
29	.gamma.-Tocopherol	Anti-cancerous, anti-tumour, anti-oxidant, cardioprotective, hypocholesterolemic[53,54]
31	Vitamin E	Major known anti-ageing and anti-dermatic compounds. It also possesses anti-diabetic, anti-tumour, anti-cancerous, hypocholesterolemia, anti-bronchitis, and anti-coronary[55.56]
32	Ergost-5-en-3-ol, (3.beta.)-	Anti-cancerous, Liver disease, Atherosclerosis, Jaundice, Antioxidant[57]
33	STIGMASTA-5,22-DIEN-3-OL, (3.BETA.,22E)-	Hypolipidemic agent, anti-cancerous, antioxidant, anti-diabetic, exhibit antihepatotoxic and is the major source of synthetic progesterone, hypocholesterolemic[57]
34	.gamma.-Sitosterol	Anti-cancer, anti-diabetic[58]
35	.beta.-Amyrin	Antitumor[59]
36	Lup-20(29)-en-3-one	Have melanogenesis activity, anti-diabetic[60], anti-bacterial,anti-HIV[61]
38	Lupeol	Anti-Inflammatory, Anti-cancerous, anti-arthritis, anti-diabetes[62]

leaves show more than 50% of inhibition against *Bacillus subtilis*, *Streptococcus mutans* and *Staphylococcus aureus* at a volume of 15µl. In methanolic excerpts, more than 50% of inhibition is found against *Enterococcus faecal* is at a volume of 10µl and 15µl. Out of 38 compounds which are identified in GC-MS analysis, 8 compounds are identified as anti-microbial in nature such as Dodecane, 2-HEXADECEN-1-OL, 3,7,11,15-TETRAMETHYL-, [R-[, Hexadecanoic acid, methyl ester, Phytol, Palmidrol, Squalene, Tetracosane, Vitamin E and Lup-20(29)-en-

3-one which justify, this plant have significant anti-microbial property. This plant leaves also possesses 9 anti-cancerous compounds such as Hexadecanoic acid, methyl ester, 9,12,15-OCTADECATRIENOIC ACID, METHYL ESTER, squalene, .gamma.-Tocopherol, Vitamin E, Ergost-5-en-3-ol, (3.beta.)-, STIGMASTA-5,22-DIEN-3-OL, (3.BETA.,22E)-, .gamma.-Sitosterol and Lupeol show this plant is very effective against deadly cancer disease which ranks second for worldwide death.[63] Leaves of dhak are also rich in the anti-oxidant compound where 10 compounds are antioxidants such as Neophytadiene, 2-HEXADECEN-1-OL, 3,7,11,15-TETRAMETHYL-, [R-[, n-Hexadecanoic acid, Phytol, squalene, .alpha.-Tocospiro B, Tetracosane, .gamma.-Tocopherol, Ergost-5-en-3-ol, (3.beta.)- and STIGMASTA-5,22-DIEN-3-OL, (3.BETA.,22E)-,. 8 compounds are anti-inflammatory in nature such as Neophytadiene, 2-HEXADECEN-1-OL, 3,7,11,15-TETRAMETHYL-, [R-[, Hexadecanoic acid, methyl ester, n-Hexadecanoic acid, 9,12,15-OCTADECATRIENOIC ACID, METHYL ESTER, Phytol, Palmidrol, .alpha.-Tocospiro B and Lupeol. Leaves are also rich in 3 cardioprotective compounds such as Neophytadiene, .alpha.-Tocospiro B and .gamma.-Tocopherol. 5 antidiabetic compounds such as alpha. -Tocospiro B, Vitamin E, STIGMASTA-5,22-DIEN-3-OL, (3. BETA.,22E) -,. gamma. -Sitosterol and Lup-20(29)-en-3-one are also justifying that these plant leaves have the potential for the production of herbal medicines.This investigation suggests that this plant leaf has not only anti-microbial potential but also possesses other important compounds to fight against many deadly diseases. Thus, this plant has immense potential to make an individual place in pharmacological industries.

6. DISCUSSION

Hot leaf excerpts of the Dhak plant show antibiotic potential against *P. aeruginosa*, *S. aureus*, *K. pneumoniae*, *E. coli*, and *C. freundii*.[14] Methanol excerpts of Dhak plant leaves are effective against *S. typhi*, *B. megaterium*, *P. Vulgaris*, *E. coli*, *S. typhi* A and B and *B.cerus* as well as Fungi, *Rhizopus stolonifera*, and *A. niger*.[64] Water and ethanol of Dhak plant bark are significant against *B. cereus*, *P. aeruginosa*, and *E. coli*. Maximum inhibition is reported against *B. cereus* (water) and *E. coli* (ethanol) i.e., 26 mm. Gentamicin is used as a standard drug.[65] Dhak plant shows significant anti-microbial activity against *S. aureus, B. subtilis* and *E. coli*.[66] GC-MS analysis of Dhak plant leaves is not previously reported.These plant leaves are rich in important phytochemicals such as flavonoids, phenol, tannin, saponin and alkaloids.[67,68]Alkaloids,[69] tannins[70] and flavanoids[71]possess antimicrobial properties. Phenols are effective against *Pseudomonas aeruginosa* and *Staphylococcus epidermidis*.[72] Saponins are effective against E. coli.[73]*Butea monosperma* is one of the known ethnomedicinal plant which help to fight against many diseases.74If the present investigation has collaborated with previous work, the effectiveness of Dhak plant leaves reported previously against *E. coli* and *B. subtilis*, *Pseudomonas aeruginosa* and *Staphylococcus* species justify this plant as a potent *source* of antibiotics.

REFERENCES

1. Ambastha, S.; Kumari, A.; Oraon, V.; Patnaik, A. & Sharan, L. Pharmacological review on *Sesbania grandiflora* (Linn). *International Journal of Botany Studies*., 2022, **7**(2), 259-268.
2. Kumari, S.; Kumari, A.; Ambastha, S.; Perween, Z.; Patnaik, A. & Sharan, L. Pharmacological attributes of Bombax ceiba L. *Paripex-Indian Journal of Research.,* 2022, **11**(3), 69-71.
3. Neelam, Dwivedi, K.N.; Ram, B. & Soni, G. A study on Palash (*Butea Monosperma* Lam, Kuntz.) with special reference to its role in Mashumeha (Diabetes Mellitus Type 2). *Journal of Medicinal Plants Studies*., 2017, **5**(2), 204-206.
4. Lohot, V.D.; Thamilarasi, K.; Ghosh, J.; Mohansundaram, A. & and Sharma K.K. Monograph on Palas, *Butea monosperma* (Lam.) Taubert. ICAR-Indian Institute of Natural Resins and Gums, Ranchi (Jharkhand), India, 2018.
5. Sindhi, V.R. & Bairwa, R. Plant Review: *Butea Monosperma*. *International Journal of Pharmaceutical and Clinical Research*., 2010, **2**(2), 90-94.
6. Kirtikar, K.R. & Basu, B.D. Indian medicinal plants, 2nd edition, Allahabad: Allahabad press; 1935, 785-788.
7. Sahu, C.M. & Padhy, R.N. In Vitro potency of *Butea monosperma* Lam. Against 12 clinically isolated multidrug resistance bacteria.*Asian Pacific Journal of Tropical Disease*., 2013, **3**(3), 217-226. doi: 10.1016/S2222-1808(13)60044-4
8. Dave, K.; Darji, P. & Gandhi, F. Antimicrobial activity and phytochemical study of plant parts of *Butea monosperma*. *Journal of Drug Delivery and Therapeutics*., 2019, **9**(4), 334-348. doi: 10.22270/jddt. v9i4-A.3435
9. Somayaji, A. & Hegde, K. A review on pharmacological profile of *Butea monosperma*.*International Journal of Phytopharmacology.*, 2016, **7**(4), 237-249.
10. Overview of *Butea monosperma*, Accessed on March 02, 2022, From https://indiabiodiversity.org/species/show/31135, 1-27
11. Burili, D.A. & Khade, A.B. A Comprehensive Review on *Butea Monosperma* (Lam.) Kuntze.*Pharmacognosy Reviews.*, 2007, **2**(1), 376-384.
12. Agarwal, A.K.; Singh, M.; Gupta, N.; Saxena, R.; Puri, A.; Verma, A.K.; Saxena, R.P.; Dubey, C.B. & Saxena, K.C. Management of giardiasis by an immunomodulatory herbal drugs Pippalirasayana. *Journal of Ethnopharmacol.*, 1994, **44**(3), 143-146. doi: 10.1016/0378-8741(94)01181-8
13. Vasudeva, N.; Rai, G. & Sharma, S.K. Anti-spermatogenic Activity of *Butea monosperma* (Lam.) Kuntze Root. *Asian Journal of Biological Sciences*., 2011, **4(8)**, 591-600. doi: 10.3923/ajbs.2011.591.600
14. Sahu, M.C.; Pandey, R.N. In vitro antibacterial potency of *Butea monosperma* Lam. against 12 clinically isolated multidrug resistance bacteria.*Asian Pacific Journal of Tropical Disease.*, 2013, **3**(3), 217-226. doi: 10.1016/S2222-1808(13)60044-4
15. Sahare, K.N; Anantharaman, V.;Meshram, V.G.;Meshram,

S.U.; Singh, V.; Reddy, M.V.R. & Goswami K. Antifilarial Potential of *Butea monosperma* L. against microfilaria in vitro. *International Journal of PharmTech Research.* 2012., **4**(3), 1181-1184.

16. Hasan, S.M.R., Hossain, M.M.;Akter, R.; Jamila, M.; Mazumder, M.E.H. & Rahman, S. DPPH free radical scavenging activity of some Bangladeshi medicinal plants. *Journal of Medicinal Plants Research*., 2009, **3**(11), 875-879.
doi: 10.5897/JMPR.9000460
17. Tambekar, D.H. & Khante, B.S. Antibacterial Properties of Traditionally Used Medicinal Plants for Enteric Infections by Adivasi (Bhumka) In Melghat Forest (Amravati District). *International Journal of Pharmaceutical Sciences and Research*., 2010, **1**(9), 120-128.
doi: 10.13040/IJPSR.0975-8232.1(9-S).120-28
18. Parween, K. & Siddiqui, W.A. Protective effect of *Butea monosperma* on high-fat diet and streptozotocin-induced non-genetic rat model of type 2 diabetes: biochemical and histological evidences.*International Journal of Pharmacy and Pharmaceutical Sciences.*, 2011, **3**(3), 74-81.
19. Sharma, N. & Shukla, S. Hepatoprotective potential of aqueous extract of *Butea monosperma* against CCl4 induced damage in rats. *Experimental and toxicologic pathology*., 2011, **63(7-8)**, 671-676.
doi: 10.1016/j.etp.2010.05.009
20. Choedon, T.; Shukla, S.K. & Kumar V. Chemopreventive and anti-cancer properties of the aqueous excerpt of flowers of *Butea monosperma*. *Journal of Ethnopharmacology*., 2010, **129**, 208-213
doi: 10.1016/j.jep.2010.03.011
21. Tiwari, P.; Kumar, K.;Panik, R.; Pandey, A.; Pandey, A. & Sahu, P.K. Hepatoprotective potential of *Butea monosperma* stem bark excerpt against carbon tetrachloride-induced hepatotoxicity in albino rats. *International Journal of Medicine and Medical Sciences*., 2011, **3**(8), 252-255
doi: 10.5897/IJMMS.9000122
22. Gunakkunru, A.;Padmanaban, K.; Thirumal, P.;Pritila, J.;Parimala, G.;vengatesan, N.;Gnanasekar, N.;Perianayagam, J.B.; Sharma, S.K. & Pillai, K.K. Anti-diarrheal activity of *Butea monosperma* in experimental animals.*Journal of Ethnopharmacology.*, 2005, **98**(3), 241-244.
doi: 10.1016/j.jep.2004.12.021
23. Patil, P.; Prakash, T.;Shivakumar, H. & Pal S. Anti-Ulcer and Anti-Secretary Properties of the *Butea monosperma* (Lam) Bark Excerpt with Relation to Antioxidant Studies. *Iranian Journal of Pharmacology & Therapeutics*., 2009, **8**(1), 1-6.
24. Akhtar, M.S.; Naeem, F.; Muhammad, F. & and Bhatty, N. Effect of *Butea monosperma* (Lamk.) Taub. (Palas Papra) fruit on blood glucose and lipid profiles of normal and diabetic human volunteers. *African Journal of Pharmacy and Pharmacology*., 2010, **4**(8), 539-543.
doi: 10.5897/AJPP.9000107
25. Pandey, P.K.; Singh, D.; Singh, S.; Khan, M.Y. & Jamal, F. A Nonhost Peptidase Inhibitor of ~14 kDa from *Butea monosperma* (Lam.) Taub. Seeds Affects Negatively the Growth and Development Physiology of *Helicoverpaarmigera*. *Biochemistry Research International*., 2014, 1-10.
doi: 10.1155/2014/361821
26. Bhargava, S.K. Estrogenic and postcoital anticonceptive activity in rats of butin isolated from *Butea monosperma* seed. *Journal of Ethnopharmacology.*, 1986, **18**(1), 95-101.
doi: 10.1016/0378-8741(86)90046-2
27. Dilika, F.;Bremner, PD. & Meyer, M. Antimicrobial activity of linoleic and oleic acids isolated from Helichrysum pedunculatum: a plant used during circumcision rites. *Fitoterapia.*, 1999, **71**(4), 450-452.
doi: 10.1016/S0367-326X (00)00150-7
28. Casillas-Vargas, G.; Ocasio-Malave, C.; Medina, S.; Morales-Guzman, C.; Valle, R.G.D.;Carballeira, N.M.& Sanabria-Rios, D.J. Antibacterial fatty acids: An update of possible mechanism of action and implication in the development of the next-generation of antibacterial agents. Progress in Lipid Research., 2007, **82**, 1-10
doi: 10.1016/j.plipres.2021.101093
29. Singh, B.; Singh, M.P. & Henry,H.H. "Papilionaceae," in The Botany of Bihar and Orissa. London: *Adlard.*, 1922, 279-280.
30. Kumari, A.; Patnaik, A. & Sharan, L. Phytochemical Screening and Antimicrobial activity of Annona reticulata L. and Bauhinia Variegata L. Biodiversity Exploration, *Exploitation and conservation.*, 2022, 21-27.
31. Bauer, A.W.; Kirby, W.M.; Sherris, J.C. &Turck, M. Antibiotic susceptibility testing by a standardized single disk method.*American Journal of Clinical Pathology.*, 1966, **45**(4), 493-496.
32. Adimpong, D.B.; Sorensen, K.L.; Thorsen, L.;Stuer-Lauridsen, B.;Abdelgadir, W.S.; Nielsen, D.S.;Derkx, P.M.F. & Jespersen, L. Antimicrobial Susceptibility of *Bacillus* Strains Isolated from Primary Starters for African Traditional Bread Production and Characterization of the Bacitracin Operon and Bacitracin Biosynthesis. *Applied and Environmental Microbiology*., 2012, **78**(22), 7903-7914.
doi: 10.1128/AEM.00730-12
33. Kristich, C.J; Rice, L.B. & Arias, C.A.Enrerococcal Infection-Treatment and Antibiotic Resistance. Boston: Massachusetts Eye and Ear Infirmary., 2014. Bookshelf ID: NBK190420.
34. Gueimonde, M.; Sanchez, B.; Reyes-Gavilan, C.G.D.L. & Margolles, A.Antibiotic resistance in probiotic bacteria. *Frontiers in Microbiology.*, 2013, **4**, 1-6.
doi: 10.3389/fmicb.2013.00202
35. Liao, Y.; Brandt, B.W.; Li, J.;Crielaard, W.;Loveren. C.V. & Deng, D.M.Floride resistance in Streptococcus mutans: a mini-review.*Journal of Oral Microbiology.*, 2017, **9**(1), 1-9.
doi: 10.1080/20002297.2017.1344509
36. Stapleton, P.D. & Taylor, P.W. Methicillin resistance in Staphylococcus aureus: mechanism and modulation.

Science Progress., 2002, **85**(1), 57-72.
doi:10.3184/003685002783238870

37. Yayan. J.;Ghebremedhin, B. &Rasche, K. Antibiotic Resistance of *Pseudomonas aeruginosa* in Pneumonia at a Single University Hospital in Germany over a 10-Year Period.*PLOS.*, 2015, **10**(10), 1-20
doi: 10.1371/journal.pone.0139836
38. Wu, D.; Ding, Y.; Yao, K.; Gao, W. & Wang Y. Antimicrobial Resistance Analysis of Clinical Escherichia coli Isolates in Neonatal Ward.*Frontiers.*, 2021.
doi: 10.3389/fped.2021.670470
39. Perea, S. & Patterson, T.F. Antifungal Resistance in Pathogenic Fungi.*Antimicrobial Resistance.*, 2002, **35**(9), 1073-1080.
doi: 10.1086/344058
40. Jiang, Y.; Luo, W.; Verweij, P.E.; Song, Y.; Zhang, B.; Zhang, Z.; Al-Hatmi, A.M.S.; Ahmed, S.A.; Wan, Z.; Li, R. & Hoog, G.S.D. Regional Differences in Antifungal Susceptibility of the Prevalent Dermatophyte *Trichophyton rubrum*, 2021, 53-70.
doi: 10.1007/s11046-020-00515-z
41. Naoko, T.; Akiko, S.; Miki, N.; Keisuke, M.;Kazutoyo, E.; Hajime, H. & Yoshihiro, I. Antibacterial activity of long-chain fatty alcohols against Staphylococcus aureus.*Molecule.,* 2007, **12**, 139–148.
doi:10.3390/12020139
42. Kumar, N.R.; Reddy, J.S.;Gopikrishna, G. & Solomon, K.A. GC-MS determination of bioactive constituents of Cycas beddomei cones. *International Journal Pharm Bio Sci.*, 2012, **3**(3), 344–350.
43. Das, S.; Vasudev, N.& Sharma, S. Chemical composition of ethanol extract of Macrotyloma uniflorum (Lam.) Verdc. using GC-MS spectroscopy. *Org Med Chem Lett.*, 2012, **4**, 1-4.
doi: 10.1186/s13588-014-0013-y
44. Bhardwaj, M.; Sali, V.K. & Vasanthi, H.R. Neophytadiene from Turbinariaornata Suppresses LPS-Induced Inflammatory Response in RAW 264.7 Macrophages and Sprague Dawley Rats.*Inflammation.*,2020, **43**, 937-950.
doi: 10.1007/s10753-020-01179-z
45. Chandrasenkaran, M. &Senthilkumar, V. V.Antibacterial and antifungal efficacy of fatty acid methyl esters from the leaves of Sesuviumportulacastrum L. *Eur. Rev. med. Pharmacol Sci.*, 2011, **15**(7), 775-780.
46. Aparana, V.; Dileep, K.V.; Mandal, P.K.;Karth, P.;Sadasivan, C. & Haridas, M.Anti-Inflammatory Property of *n*-Hexadecanoic Acid: Structural Evidence and Kinetic Assessment. *Chemical biology & drug design.,* 2012, **80**(3), 434-439.
doi: 10.1111/j.1747-0285.2012. 01418.x
47. Starlin, T.; Prabha, P.S.;Thayakumar, B.K.A. & Gopalakrishan, V.K. Screening and GC-MS profiling of ethanolic extract of *Tylophora pauciflora*. *Bioinformation.,*2019, **15**(6), 425-429.
doi: 10.6026/97320630015425
48. Olofsson, P.;Hultqvist, M.;Hellgren, L.I.&Holmdhal R. Recent Advances in Redox Active Plant and Microbial Products. Springer, *Dordrecht.*, 2014, pp. 345-359.
49. Yusuf, S.I.;*Riskayanti, R.;Amaliah, N.;Latief, M.;Sjafruddin, R. & Attahmid, N.F.U.*GC-MS and Antioxidant Capacity Analysis in Propanol Extract of Carthamus Tinctorious L.*Intek: Journal Penelitian.*, 2021, **8**(1), 67.
doi: 10.31963/intek. v8i1.2801
50. Kumar, P.P.;Kumaravel, S. & Lalitha, C. Screening of antioxidant activity, total phenolics and GC-MS study of Vitex negundo.*African Journal of Biochemistry Research*., 2010, **4**(7), 191-195.
51. Mohammed, H.A.;Abdelwahab, M.F.; El-Ghaly, E.M. & Ragab, E.A. Phytochemical Characterization, In Vitro Anti-Inflammatory, Anti-Diabetic, and Cytotoxic Activities of the Edible Aromatic Plant; *Pulicariajaubertii. Molecules.*, 2021, **26**(1), 203.
doi: 10.3390/molecules26010203
52. Ponnamma, S.U. & Manjunath, K. GC-MS analysis of phytocomponents in the methanolic extract of *Justicia wynaadensis* (Nees) T. Anders. *International Journal of Pharma and Bio Sciences.*, 2012, **3**(3), 570-576.
53. Boussaada, O.; Ammar, S.;Saidana, D.;Chriaa, J.;Chraif, I.;Daami, M.;Helal, A.N. & Mighri, Z. Chemical composition and antimicrobial activity of volatile components from capitula and aerial parts of Rhaponticumacaule DC growing wild in Tunisia. *Microbiol Res.*, 2007, **163**, 87–95.
doi:10.1080/10412905.2009.9700142
54. Gysin, R.;Azzi, A. & Visarius, T. Gamma-Tocopherol inhibits human cancer cell cycle progression and cell proliferation by down-regulation of cyclins.*The FASEB Journal express.*, 2002.
55. Mitchel, R.E. & McCann, R.A. Skin tumor promotion by Vitamin E in mice: amplification by ionizing radiation and Vitamin C.*Cancer Detection and Prevention.*, 2003, **27**(2), 102-108.
doi: 10.1016/s0361-090x (03)00028-x
56. Srinivasan, K.; Sivasubramanian. S. & Kumaravel, S. Phytochemical profiling and GC-MS study of Adhatodavasica leaves. *International Journal of Pharma and Bio Sciences*., 2014, **5**(1)**,** 714-720.
57. Bradford, P. & Awad, A.B. Phytosterols as anticancer compounds. *Molecular nutrition & food research.*, 2007, **51**(2), 161-170.
doi: 10.1002/mnfr.200600164
58. Cerqueira, F.;Watanadilok, R.;Sonchaeng, P.;Kijjoa, A., Pinto, M.;Ufford, H.Q.V.;Kroes, B.;Beukelman, C. & Nascimento, M.S.J. Clionasterol: A Potent Inhibitor of Complement Component C1.*Planta Med.*, 2003, **69**(2), 174-176.
doi: 10.1055/s-2003-37719
59. Wen, S.; Gu, D. & Zeng H. Antitumor effects of beta-amyrin in Hep-G2 liver carcinoma cells are mediated via apoptosis induction, cell cycle disruption and activation of JNK and P38 signalling pathways. JBUON2., 018, **23**(4), 965-970.
60. Villareal, M.O.;Han, J.; Matsuyama, K.; Sekii, Y.;Smaoui, A.;Shingemori, H. & Isoda, H. Lupenone from *Erica multiflora* Leaf Extract Stimulates Melanogenesis in B16 Murine Melanoma Cells through the Inhibition of ERK1/2 Activation, *Planta Med*, 2013; **79(3-4),** 236-243.

doi: 10.1055/s-0032-1328189
61. Callies, O.; Bedoya, L.M.; Beltrán, M.; Muñoz, A.; Calderón, P.O.; Osorio, A.A.; Jiménez, A.I.;Alcamí. J. & Bazzocchi, I.L. Isolation, Structural Modification, and HIV Inhibition of Pentacyclic Lupane-Type Triterpenoids from Cassinexylocarpa and Maytenuscuzcoina. *Journal of Natural Products.*, 2015, **78**(5), 1045-1055. doi: 10.1021/np501025r
62. Saleem, M. Lupeol, A Novel Anti-inflammatory and Anti-cancer Dietary Triterpene. *Cancer Lett.*, 2009, **285**(2), 109–115. doi: 10.1016/j.canlet.2009.04.033
63. Overview, Health topics on cancer by WHO, Assessed on March 25, 2022, From https://www.who.int/health-topics/cancer#tab=tab_1.
64. Bandara, B.M.R.; Kumar, N.S.; Swarna, K.M.; An antifungal constituent from the stem bark of *Butea monosperma*.*Journal of Ethnopharmacology.*, 1989, **25**, 73-75.
65. Lohitha, P.; Kiran, V.R.; Babu, K.R.M.; Natraj, K.; Rani, P.A.; Mahadevi, N.; Chaitanya, M.; Divya, N.; Phytochemical Screening and in vitro antimicrobial activity of *Butea monosperma* (L) bark ethanolic and aqueous extract.*International Journal of Pharmaceutical Sciences and Research.*, 2010, **1**(10), 150-155 doi: 10.13040/IJPSR.0975-8232.1(10).150-55.
66. Dale, D.A.; Chamke, D.R.; Panchal, V.H.; Evaluation of phytochemical constituents and antimicrobial activity of *Butea monosperma* (Fabaceae).*J Phytol.*, 2010, **2**(12), 17-21.
67. Vaidya, A. & Pandita, N. Comparative Pharmacognostic and Phytochemical Studies of Flower, leaf and Stem Extracts of *Butea monosperma*. *Asian Journal of Biomedical and Pharmaceutical Sciences*., 2017, **7**(63), 10-18.
68. Gupta, P., Naresh, C. & Meeta,B. Anatomical and Phytochemical study of plant parts of *Butea monosperma* (Lamk.). *International Journal of life Sciences*., 2016, **4**(2), 227-234.
69. Othman L., Sleiman A., Abdel-Massih R.M. Antimicrobial Activity of Polyphenols and Alkaloids in Middle Eastern Plants.*Frontiers*, 10:911. doi: https://doi.org/10.3389/fmicb.2019.00911
70. Biologique, C.D.L. Antimicrobial properties of **tannins.** Phytochemistry., 2001, **30**(12), 3875-3883.
71. Maleki, S.J.; Crespo, J.F.&Cabanillas, B. Anti-inflammatory effects of flavonoids.*Food Chem*., 2019,299. doi: https://doi.org/10.1016/j.foodchem.2019.125124
72. Mandal, M.S.; Dias, R.O.& Franco, O.L. Phenolic Compound in Antimicrobial Therapy.*J Med Food*., 2017,**20**(10), 1031-1038. doi- https://doi.org/10.1089/jmf.2017.0017.
73. Arabski, M.;Wegierek-Ciuk, A.;Czewonka, G.;Lankoff, A. & Kaca, W. Effects of Saponin against Clinical E. coli strains and Eukaryotic Cell Line**.***Journal of Biomedicine and Biotechnology*., 2012, **1-7.** Doi: https://doi.org/10.1155/2012/286216
74. Ambastha, S.; & Sharan, L. Review on medicinal importance of *Butea monosperma* Lam. (Taub). *Defense Life Science Journal*., 2023, **8**(1), 83-92. Doi: https://doi.org/10.14429/dlsj.8.18536

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