COMPARATIVE GC-MS ANALYSIS OF *PHYLLANTHUS EMBLICA* AND *TERMINALIA BELLIRICA* FRUITS EXTRACT TO IDENTIFY ACTIVE CHEMICAL PHYTO CONSTITUENTS

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Abstract

Background: *Phyllanthus emblica* L. is a native of the family *Phyllanthaceae*, generally famous by Indian gooseberry or amla. It is used as a traditional medicine for the treatment of different diseases. *Terminalia bellirica* (Gaertn.) Roxb is commonly known as Baheda and widely beneficial in the traditional Indian medicinal system for centuries as a remedial source in various diseases.

Methods: In the present study, Phytochemical analysis of aqueous methanol fraction of *Phyllanthus emblica* L. (PEAM) and *Terminalia bellirica* (Gaertn.) Roxb (TBAM) fruits was done. Antibacterial activity was tested against *S. aureus* (MTCC 6908), *E. coli* (MTCC 1698), *P. aeruginosa* (MTCC 4306) and *K. pneumoniae* (MTCC 9544). To analyse chemical composition of PEAM and TBAM, GC-MS analysis has been performed.

Results: Overall 27 chemical components in PEAM and 38 components in fruits of TBAM were identified. The major components identified in the PEAM fruit extracts were 5-Hydroxymethylfurfural (30.61%), 1,2,3-Benzenetriol (24.78%), 9,12-Octadecadienoic acid (Z,Z) (9.52%) whereas other constituents were present in relatively small amounts. In TBAM fruit extracts the chief chemical components were 1,2,3-Benzenetriol (52.59), Oxacycloheptadec-8-en-2-one (20.66%), 5-Hydroxymethylfurfural (7.85%), respectively.

Conclusion: The phytochemical analysis of PEAM and TBAM showed presence of diverse range of phytochemicals and antibacterial assessment of these extracts showed efficacy against different pathogenic bacterial strains. The results of GC-MS analysis illustrated the existence of numerous chemical constituents in fruits of PEAM and TBAM and are recommended as potential drug candidates of pharmaceutical significance.

Keywords: Phytochemicals, GC-MS, Pharmaceutical, antibacterial, pathogenic

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Background

Phyllanthus emblica L. (*Emblica officinalis*), is a deciduous tree, belongs to Euphorbiaceae family generally known as 'Aonla' or 'Amla' or 'Indian gooseberry'. According to the age-old Indian mythology 'Amla' is the very first tree is said to be originated on earth. The Amla fruit considered as pool of diverse nutraceuticals such as calcium, methionine, minerals, tryptophane, nicotinic acid, riboflavin, vitamin- C, lysine, phosphorus. Additionally, *P. emblica* is believed to have immunity enhancing capabilities beside various diseases, as well broadly useful in ayurvedic medicine, an Indian traditional medicine system (Bhagat, 2014). The unripe fruit of *P. emblica* is believed to have beneficial effects on health. It has various applications in the pharmaceutical, cosmetic division and food processing. *P. emblica* tree is very well adapted to develop in harsh (saline, wasteland soil) environment, as well, fruits persist in season for approximately a period of ten months. At the present time, *P. emblica* is considered as one of the ideal species for small industries in numerous countries, due to various nutraceutical factors in it. In addition to this, versatility of *P. emblica* in a variety of therapeutic products makes it a potent therapeutic candidate drug (Pathak *et al*., 2003). India is the native place for *P. emblica*, as well grown in numerous tropical and sub-tropical countries like Malaysia, China, Bangladesh, Myanmar, Mascarene Islands, Sri Lanka, Uzbekistan and Pakistan. Generally, *P. emblica* can found in India at different altitude levels such as tropical, sub-tropical, some coastal regions and hilly areas (upto 4500ft) (Rai *et al*., 2012; Thilaga *et al*., 2013). *P. emblica* extracts and preparations possess therapeutic potential against various diseases in a beneficial way as compared to the normal medicines. That is due to its ethnobotanical, therapeutic importance. In addition to this, whole tree parts which include fruit, bark, root, seed, flower are extensively used in the Indian traditional medicine system of Ayurveda (Khan 2009; Kumar *et al*. 2012b). *Terminalia bellerica* (TB) Roxb belongs to Combretaceae family, is a huge deciduous tree and is generally known as beleric mycobalane. It is a traditional worthy herbal plant in ancient and Ayurvedic medicine structure for cure of large array of diseases having numerous therapeutic actions like anticancer, anti-inflammatory, immunomodulatory, hepatoprotective and antimicrobial activities (Saraphanchotiwitthaya and Ingkaninan, 2014). *T. bellirica* is an essential ingredient of traditional laxative formulation, one of the well known Triphala formulation, used since ancient era for numerous ailments in Ayurvedic medicines (Rashed *et al*., 2014). Fruits of TB are anthelmintic, analgesic, purgative and antipyretic as well beneficial in dyspepsia, asthma, bronchitis, diarrhea, piles and cough. *T. bellirica* leaf extracts exhibited promising free radical scavenging activity. It augments the immunity against several diseases and is used as potent herbal medicine.

Methods

Plant collection and identification

Plants were collected from Dehradun, Uttarakhand, India and crude extracts of fruits of PEAM and TBAM were prepared. Further, voucher specimens (BSI/NRC-114632) and (BSI/NRC-115221) has been preserved in the herbarium of Botanical Survey of India, Northern Regional Centre, Dehradun Uttarakhand, India.

Preparation of Plant material

Fruit samples of both plants were thoroughly rinsed with running tap water, then shade dried and grinded to form fine powder. Powdered sample (500 g) was taken and extracted with methanol and water (80%) by using a Soxhlet apparatus. Further, obtained extracts were sieved and concentrated with a rotavapour (Strike-12, Steroglass, Italy) and finally formed aqueous methanolic extracts was used for future experiments (Phytochemical, antibacterial and GC-MS analysis).

Preliminary phytochemical screening

Phytochemical profiling of aqueous methanolic fraction of PEAM and TBAM was done for qualitative analyses of major phytoconstituents likewise phenolics, Saponins, flavonoids, steroids, alkaloids, proteins, tannins, quinones, carbohydrates, coumarins and glycosides. Qualitative analyses of phytochemical of PEAM and TBAM were done according to Badoni *et al*., 2016.

Antibacterial activity

Antibacterial activity of PEAM and TBAM was assessed by agar well diffusion assay (Poonkothai *et al*., 2014). The bacterial strains taken for experiment were *S. aureus* (MTCC-6908), *K. pneumoniae* (MTCC-9544), *E. coli* (MTCC-1698) and *P. aeruginosa* (MTCC-4306). An appropriate amount of bacterial suspension i.e.100 µl was placed on Luria Bertani agar by using sterilized cotton swabs. Further, the plant extracts (20 µl) was added into wells (5 mm) and the petri plates were kept to permit the dispersion of the extract. In the current study, ampicillin was served as positive control and DMSO was used as negative control.

The width of zone of inhibition, was calculated to assess antibacterial potential by calculating mean of two replicates ± SEM.

GC-MS analysis

GC-MS analysis for both PEAM and TBAM was carried out at University Science Instrumentation Centre, Jawaharlal Nehru University (JNU), Delhi (India). The PEAM and TBAM extracts were analysed on a GC-MS (GCMS-QP2010 Plus, Shimadzu, Japan). An auto injector, a head space sampler, a mass selective detector, an ion source (220 °C), and an interface (260 °C) were all well-equipped for the GCMS. For GC-MS analyses, a Restek Company, Bellefonte, USA, Rtx-5 MS capillary column with dimensions of 30 m (length), 0.25 mm (diameter), and 0.25 µm (film thickness) was utilised. With a threshold of 1000 ev, the mass range for analysis was employed in series between 40 and 650 m/z. The setup of injector was placed in the split injection mode which has temperature of 250 °C. The initial temperature was regulated to 80 °C (3 min), that subsequently augmented to 280 °C with a ramp rate of 10 °C/min. Helium was employed as a carrier gas of linear velocity (> 99.99%) with 40.5 cm/s. According to the established techniques, the system programme was set up with a total flow rate of 16.3 ml/min and a column flow rate of 1.21 ml/min. Gas chromatography was used to identify the ingredients of the sample fruit extracts (PEAM and TBAM) based on retention time (RT), and the mass spectrum data was analysed by comparing the results.

Results and discussion

Phytochemical Analysis

The preliminary phytochemical analyses determined that PEAM possess tannins, phenol, saponins, carbohydrates, Alkaloids, flavonoids and TBAM possess tannins, saponins, Quinones, phenols, carbohydrates, Alkaloids, flavonoids and Carbohydrates.

Table 1: Phytochemical constituents in PEAM and TBAM

Phytochemicals	PEAM	TBAM
Alkaloids	+	+
Tannins	+	+
Proteins	-	-
Flavonoids	+	+
Phenols	+	+
Saponins	+	+
Quinones	-	+
Coumarins	-	+
Sterols	-	-
Glycosides	-	-
Carbohydrates	+	+

PEAM- *P. emblica* aqueous methanolic extract, TBAM- *T. bellirica* aqueous methanolic extract (+) Present; (-) Absent.

Table 2: Antibacterial activity of PEAM and TBAM against Test bacteria

Plant Extracts / Bacterial Strains	PEAM (1mg/ml) (ZOI in mm)	TBAM (1mg/ml) (ZOI in mm)	Positive Control (Ampicillin (1 mg/ml) (ZOI in mm)	Negative Control (DMSO)
S. aureus	11.5±0.5	9.5±0.5	24±0	0
K. pneumoniae	12.5±0.5	12±1	23±0	0
E. coli	10.5 ±1	9±1	25±0	0
P. aeruginosa	12±2	10.5±0.5	22±0	0

Antibacterial activity of aqueous methanolic extracts of *P. emblica* and *T. bellirica* fruits. Each value is expressed as the mean ± standard error. There is a statistically significant difference (p<0.001). ZOI- Zone of inhibition. PEAM- *P. emblica* aqueous methanolic extract, TBAM- *T. bellirica* aqueous methanolic extract

GC-MS analysis

The result of GC-MS analysis showed the presence of abundant chemical constituents in fruits of PEAM and TBAM.

Table 3: GC-MS analysis of PEAM

S. No.	Name of Compound	R. Time	Area %
1	2-Furancarboxaldehyde, 5-methyl-	3.088	0.14
2	2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	3.22	0.37
3	2H-PYRAN-2,6(3H)-DIONE	3.45	6.12
4	1,3-Dioxane-4-methanol, 4,5-dimethyl	3.978	0.56
5	3-FURANCARBOXYLIC ACID, ETHYL ESTER	4.433	4.82
6	5-OXO-TETRAHYDRO-FURAN-2-CARBOXYLIC ACID	4.723	0.2
7	2-METHYL-2H-PYRAN-3,4,5(6H)-TRIONE	5.901	0.7
8	5-Hydroxymethylfurfural	6.684	30.61
9	3,4-Anhydro-d-galactosan	7	1.1
10	2-HEPTANOL, ACETATE	8.11	1.21

11	1,2,3-BENZENETRIOL	8.982	24.78
12	trans-Cinnamic acid	9.365	0.92
13	D-Allose	10.762	7.83
14	1,5-Anhydro-d-mannitol	11.929	1.05
15	Hexadecanoic acid, methyl ester	14.626	0.07
16	PENTADECANOIC ACID	15.076	2.79
17	Methyl 10-trans,12-cis-octadecadienoate	16.302	0.08
18	Octadecanoic acid	16.97	0.71
19	10,12-HEXADECADIEN-1-OL	17.538	0.14
20	9,12-Octadecadienoic acid (Z,Z)-, 2,3-dihydroxypropyl ester	23.757	0.12
21	STIGMAST-5-EN-3-OL, OLEAT	30.681	0.09

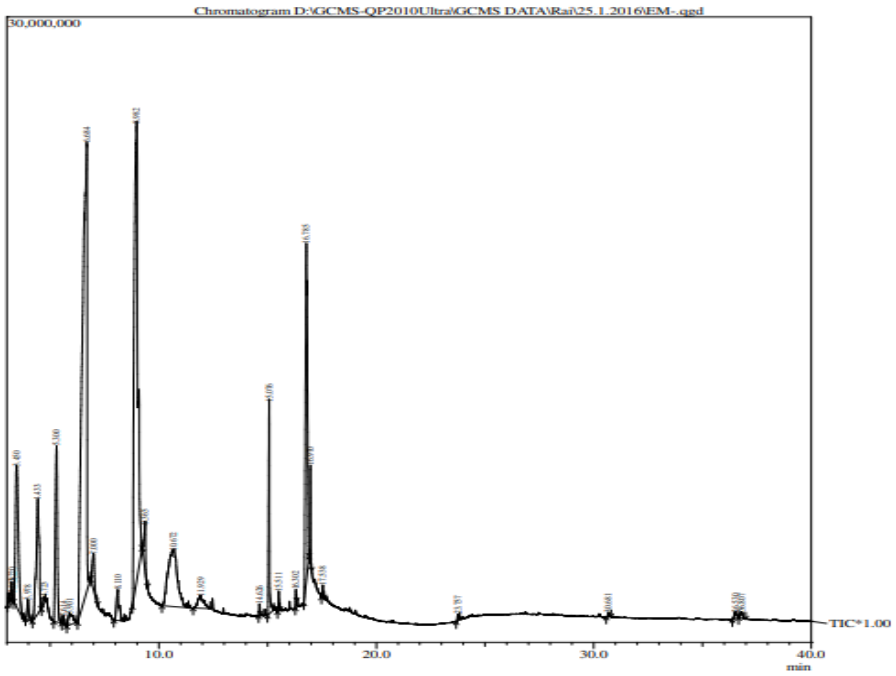

Figure 1: Chromatogram of GC-MS analysis

Table 4: GC-MS analysis of TBAM

S. No.	Name of Compound	R. Time	Area %
1	2,4-Dihydroxy-2,5-dimethyl-3(2H)-furan-3-one	3.204	0.89
2	1,3,5-TRIAZINE-2,4,6-TRIAMINE	4.339	0.47
3	Methyl 2-furoate	4.423	0.23
4	1,2,3-PROPANETRIOL	4.707	0.20
5	2-METHYL-2H-PYRAN-3,4,5(6H)-TRIONE	5.808	0.30
6	5-Hydroxymethylfurfural	6.444	7.85
7	3-Hydroxy-3-methylvaleric acid	6.626	0.19
8	5-Hydroxymethylfurfural	6.857	0.40
9	Methyl 3,4-ethylidene-alpha.-D-galactopyranoside	7.465	0.05
10	CIS-DIMETHYL MORPHOLINE	7.612	0.17
11	2-HEPTANOL, ACETATE	7.992	0.12
12	CIS-DIMETHYL MORPHOLINE	8.116	0.11
13	1,2,3-BENZENETRIOL	8.948	52.59
14	D-Allose	10.345	0.73
15	Tetradecanoic acid	12.961	0.06
16	Hexadecanoic acid, methyl ester	14.627	0.11
17	cis-9-Hexadecenoic acid	14.876	0.08
18	PENTADECANOIC ACID	15.087	5.98
19	cis-Vaccenic acid	15.911	0.07
20	HEPTADECANOIC ACID	16.011	0.05
21	9-Octadecenoic acid (Z)-, methyl ester	16.352	0.09
22	Oxacycloheptadec-8-en-2-one, (8Z)	16.814	20.66
23	10,12-HEXADECADIEN-1-OL	17.553	0.27
24	9,12,15-OCTADECATRIEN-1-OL	18.248	0.10
25	Eicosanoic acid	19.04	0.15
26	STIGMAST-5-EN-3-OL, OLEAT	30.702	0.13
27	Vitamin E	31.434	0.11
28	Lup-20(29)-en-3-one	38.377	0.23

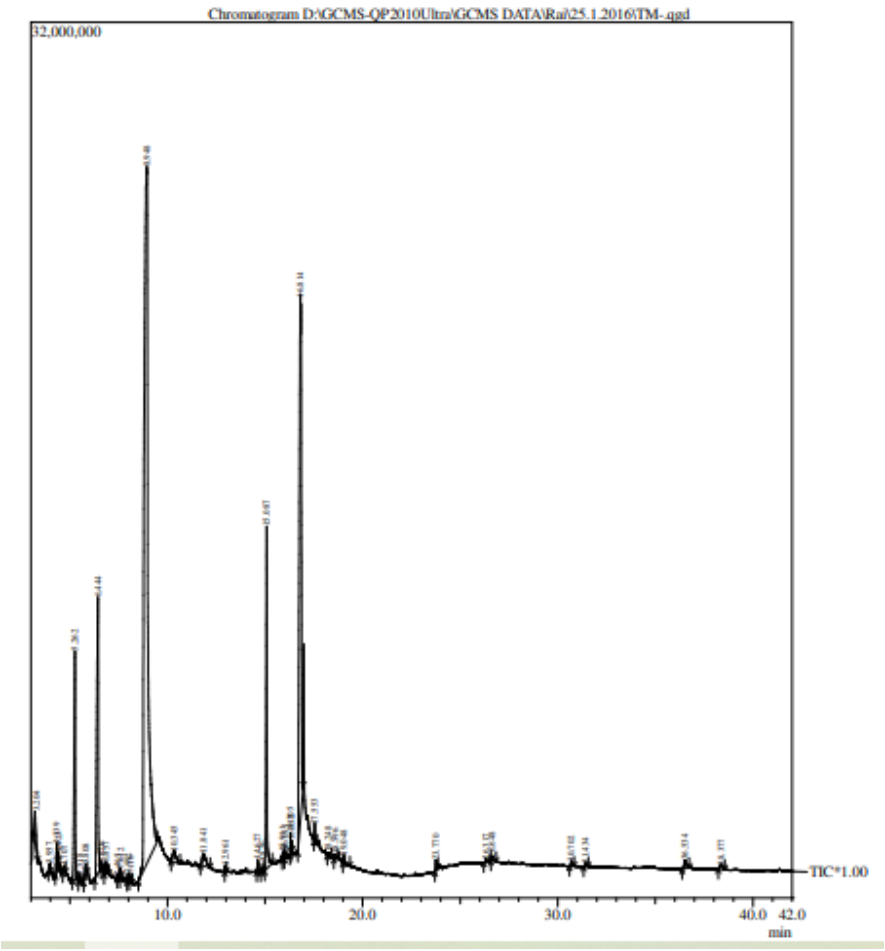

Figure 2: Chromatogram of GC-MS analysis

The current study was centered on the phytochemical analysis, antibacterial screening and chemical composition of EOAM and TBAM extracts. An array of volatile chemical constituents has been recognized by GC-MS in PEAM and TBAM. The present study depicts the percentages as well the retention time (RT) of the phytocomponents enlisted in Tables 3 and 4. There are total 21 compounds found in PEAM and the major compounds were 5-Hydroxymethylfurfural (30.61) having antioxidant, antiproliferative activity (Zhao *et al*., 2013), 1,2,3-BENZENETRIOL (24.78) is a pyrogallol, polphenolic compound exhibits, antibacterial, Anti-inflammatory, Antioxidant, Analgesic, Insecticide, Anticancer, Cytotoxic properties (Beulah *et al*., 2018), D-Allose (7.83) possess antioxidant, anticancer, anti- metabolic activioties (Shintani *et al*., 2020). There are total 28 compounds identified in TBAM and the major compounds reported were 1,2,3-BENZENETRIOL (52.59) pyrogallol, polphenolic having antibacterial, Anti-inflammatory, Antioxidant, Analgesic, Insecticide, Anticancer, Cytotoxic properties (Beulah *et al*., 2018), Oxacycloheptadec-8-en-2-one (8Z) (20.66) possess anticancer, antibacterial activity, Poma *et al*., 2019), 5-Hydroxymethylfurfural (7.85) exhibits antioxidant, antiproliferative activities (Zhao *et al*., 2013).

Quantitative and qualtitative differences in phytochemical constituents of every plant extract are vastly affected by various environmental and genetic factors, likewise the seasonal and geographical origin, genetic variation, as well plant portion used for the study. In addition to this, several agronomic conditions such as time of collection, developmental stage, solvent system and extraction method (Tejerina *et al*., 2011). It was previously reported that methanolic and aqueous extracts of *E. officinalis* and *T. bellirica* possess excellent antibacterial activity against *K. pneumoniae*, *P. aeruginosa S. aureus* and *E.coli*, and (Badoni *et al*., 2016). In the present study antibacterial activity of PEAM and TBAM were determined against four bacterial strains by agar well diffusion assay. The results gained of antibacterial activity of PEAM and TBAM are expressed as the width of Zone of inhibition (millimeter) PEAM and TBAM demonstrated zone of inhibition (ZOI) starting from a series of 10.5±1 to 12.5 ± 0.5 mm and 9±1 to 12 ± 1 mm,

respectively. PEAM and TBAM showed the highest and lowest zone of inhibition (ZOI) against bacterial strains of *K. pneuomoniae* and *E. coli*, respectively. Positive control ampicillin represents ZOI within a range of 22±0 to 25±0 mm for all mentioned bacterial strains, and negative control DMSO showed no zone of inhibition (Table 2). In the present study both PEAM and TBAM illustrated good antibacterial activity as compared to previous reports.

Conclusion

The phytochemical analysis of PEAM and TBAM fruits demonstrate the diversity of bioactive components present in the extracts. Also, PEAM and TBAM showed antibacterial efficacy against various pathogenic microbes. GC-MS analysis of aqueous methanol fraction of PEAM and TBAM fruits illustrated the presence of diverse range of medicinally important bioactive components. In the present study, PEAM and TBAM possesses various secondary metabolites which contributes for many pharmacological properties. The GC-MS analysis revealed the presence of 21 phytochemical constituents in PEAM and 28 phytochemical constituents in TBAM. These phytochemicals support several biological processes, including antioxidant, anticancer, hypercholesterolemic, antimicrobial, anti-inflammatory, and other processes. Therefore, the therapeutic benefits of phytochemicals are due to their existence. In order to produce innovative medications using some of the bioactive chemicals discovered in PEAM and TBAM, more research is necessary. Hence, the present study concludes that PEAM and TBAM fruits possess diverse range of bioactive constituents and having therapeutic importance.

Abbreviations

EOAM: Aqueous methanol fraction of *Phyllanthus emblica* L.fruits
PEAM: Aqueous methanol fraction of *Terminalia bellirica* (Gaertn.) Roxb fruits
Ampi: Ampicillin
DMSO: Dimethyl sulfoxide
GC-MS: Gas Chromatography- Mass spectrometry
E. coli: *Escherichia coli*
P. aeruginosa: *Pseudomonas aeruginosa*
K. pneumonia: *Klebsiella pneumoniae*
S. aureus: *Staphylococcus aureus*
RT: Retention time
ZOI: Zone of inhibition

References

1. Saraphanchotiwitthaya A, Ingkaninan K. 2014. Immunomodulatory activity of an acetone extract of Terminalia bellerica Roxb fruit on the mouse immune response in vitro. Int J Pharm Pharm Sci. 6:274-8.2.
2. Bhagat M. Indian gooseberry (Emblica officinalis): Pharmacognosy review. In: Gupta A, Kaul VK. 2014. Utilisation and management of medicinal plants. New Delhi: Daya Publishing House. pp. 471–487.Pathak RK, Pandey D, Singh G, Mishra D. 2003. Approaches and strategies for precision farming in aonla. In: Singh HP, Singh G, Singh JC, Samuel, Pathak RK (Eds) Proceedings of National seminar-cum-workshop on hi-tech horticulture and precision farming, CISH, Lucknow, India, pp 176–190.Thilaga S, Largia MJV, Parameswari A, Nair RR, Ganesh D. 2013. High frequency somatic embryogenesis from leaf tissue of '*Emblica officinalis*' Gaertn.—a high valued tree for non-timber forest products. *Aus J Crop Sci.*7:1480.
3. Rai N, Tiwari L, Sharma RK, Verma AK. Pharmaco-botanical profile on *Emblica officinalis* Gaertn.—a pharmacopoeial herbal drug. *STM J.* 2012; 1:29–41.
4. Khan KH. 2009. Roles of *Emblica officinalis* in medicine—a review. *Bot Res Int.* 2:218–228.Kumar A, Singh A, Dora J. 2012. Essential perspectives for *Emblica offcinalis*. *Int J Pharma Chem Sci.*1:11–18.
5. Rashed K, Potocnjak I , Giacometti J. 2014. Terminalia bellerica aerial parts ethyl acetate extract exhibits antioxidant, anti-inflammatory and anti-fibrotic activity in carbon tetrachloride in toxicated mice. J Funct Foods. 8:319-30.3.
6. Ghate NB, Hazra B, Sarkar R, Chaudhuri D, Mandal N. 2014. Alteration of bax/bcl-2 ratio contributes to Terminalia bellerica induced apoptosis in human lung and breast carcinoma. In Vitro Cell Dev Biol: Animal. 50:527-37.4.
7. Gupta R, Gupta A, Singh RL. 2015. Hepatoprotective activities of Triphala and its constituents. Int J Pharm Sci Rev Res. 4:34-55.5.
8. Shah CP, Santani DD. 2011. In vitro susceptibilities of human bacterial pathogens associated with dacryocystitis to Terminalia bellerica. Int J Curr Pharm Res. 3:32-3.6.
9. Das MS, Devi G. 2015. In vitro cytotoxicity and glucose uptake activityof fruits of Terminalia bellerica in vero, L-6 and 3T3 cell lines. J Appl Pharm Sci. 5:92-5.7.
10. Ali MS, Faruq KO, Islam A. 2013. Thrombolytic and cytotoxic activities of

Terminalia bellerica Roxb. Bangladesh Pharm J.16:131-5.8.
11. Gupta R, Singh RL, Singh P. 2015. Quantification of phytochemicals andevaluation of the antioxidant potential of ethanolic leaf extract ofTerminalia bellerica, Terminalia chebula and Emblica officinalisvis-à-vis Triphala. Int J Pharm Sci Rev Res. 32:14-22.9.
12. Zhao L, Chen J, Su J, Li L, Hu S, Li B, Zhang X, Xu Z, and Chen T . 2013. In Vitro Antioxidant and Antiproliferative Activities of 5-Hydroxymethylfurfural. Journal of Agricultural and Food Chemistry. 61 (44), 10604-10611.
13. Gnana Priyanka Beulah G, Tresina Soris P, Mohan V R. 2018. GC-MS Determination of Bioactive Compounds of Dendrophthoe falcata (L.F) Ettingsh: An Epiphytic Plant. International Journal of Health Sciences and Research. ISSN: 2249-9571. Vol.8; Issue: 11.
14. Shintani H, Shintani T, Sato M. 2020. D-Allose, a Trace Component in Human Serum, and Its Pharmaceutical Applicability. International Journal of Applied Biology and Pharmaceutical Technology 11: 200-213.
15. Poma P, Labbozzetta M, Zito P, Alduina R, Ramarosandratana AV, Bruno M, Rosselli S, Sajeva M, Notarbartolo M.2019. Essential Oil Composition of *Alluaudia procera* and in Vitro Biological Activity on Two Drug-Resistant Models. Molecules. 24(16):2871.
16. Badoni H, Sharma P, Waheed SM, Singh S. 2016. Phytochemical analyses and evaluation of antioxidant, antibacterial and toxic properties of *Emblica officinalis* and *Terminalia bellirica* fruit extracts. Asian j pharm clin res, vol 9, issue 6, 96-102.
17. Tejerina D, Garc'a-Torres S, Cabeza de Vaca M, Va 'zquez FM, Cava R. 2011. Acorns (*Quercus rotundifolia* lam.) and grass as natural sources of antioxidants and fatty acids in the montanera feeding of Iberian pig: intra- and inter-annual variations. Food Chem. 124:997 –1004.
18. Semwal P, Painuli S, Badoni H. et al. 2018. Screening of phytoconstituents and antibacterial activity of leaves and bark of Quercus leucotrichophora A. Camus from Uttarakhand Himalaya. Clin Phytosci 4, 30.
19. Devi PN, Kaleeswari S, Poonkothai M. 2014. Antimicrobial activity and phytochemical analysis of fruit extracts of Terminalia Bellerica. Int J Pharm Pharm Sci. 6(5):639-42.
20. Badoni H, Painuli S, Semwal P. 2015. In silico screening of phytoactive components against Junin, Hanta, Dengue, Marburg and Ebola Viruses. J Chem Pharm Res. 7:209-24.
21. Deb A, Sikha B, Biswajit D. 2016. Pharmacological activities of baheda (Terminalia bellerica): a review. In Vitro Antioxidant Activity and GC-MS Analysis of The Ethanolic Extracts Of Terminalia Bellerica Roxb (Baheda). J Pharmacogn Phytochem.5:194-7.