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Comparative phytochemical analysis and antimicrobial activity of selected trees: *Tamarindus indica* L. (Caesalpiniaceae) & *Quassia indica* (Gaertn.) Noot. (Simaroubaceae)

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Abstract

The present study on comparative phytochemical analysis and antimicrobial activity of selected trees such as *Tamarindus indica* L. and *Quassia indica* (Gaertn.) Noot. reveals that, the leaves of both plants possess Carbohydrates, Proteins, Phenols, Amino acids and Alkaloids. When compared to *Q. indica* (Gaertn.) Noot. *T. indica* L. leaves possess highest amount of Phenols and Alkaloids. The amount of Carbohydrate, Proteins and Amino acids is higher in *Q. indica* than that of *T. indica*. Both the plants have many health benefits and improves the defence mechanism in living system. It is very necessary to introduce new and biologically safe and active drugs eco-friendly in nature and effective as an antimicrobial agent. Due to the presence of significant amount of Phenols and Alkaloids, both the plants possess medicinal and antimicrobial properties. The study also revealed that, the leaves of both plants contain a considerable quantity of Phenolic and Alkaloid compounds that we found to be major contribution to their antibacterial activity. Plants are rich source of secondary metabolites with interesting biological activities. Analyzing phytochemicals with antimicrobial activity in such selected plants will provides an insight into how effective these plants in terms of its medicinal value and also to understand how and why they are effective, which can lead to development of new medicines with lesser side effects.

Keywords: Phytochemical analysis, antimicrobial activity, *T. indica*, *Q. indica*

Introduction

Majority of the people living in the developing world are struggling to increase the standard of living and to improve the health care delivery in the face of increasing poverty and growing population. According to WHO survey, 80% of populations living in the developing countries depends exclusively on traditional medicine for their primary health care needs of which most involve the use of plant extracts ^[1]. India has a great diversity of medicinal plants. There are thousands of plants which are used in traditional medicinal system to cure many diseases since thousands of years. The knowledge of medicinal plants has been accumulated in the course of many centuries based on different medicinal systems such as Ayurveda, Unani and Siddha ^[2]. A large portion of the world population, especially in developing countries depends on the traditional system of medicine for a variety of disease ^[3]. Herbs and spices have been used since antiquity for their flavoring qualities and also for their preservatives and medicinal properties. Their extracts have been used to cure various disorders, spasmodic gastric-intestinal complains, cough, bronchitis, laryngitis, tonsillitis and acting as carminative and diuretic agents. Therefore, the demands for these plants are increasing in both, industrialized and non - industrialized countries which leads to increase in their prices ^[4].

Phytochemicals play a vital role against number of diseases such as asthma, arthritis, cancer etc. unlike pharmaceutical chemicals these phytochemicals do not have any side effects. Since the phytochemicals cure diseases without causing any harm to human beings these can also be considered as "man- friendly medicines ^[5]." In the last few years, the search continues for safe and effective antimicrobial agents with which can be treated a wide variety of bacterial infections. This need has been heightened recently by the emergence of many antimicrobial-resistant organisms ^[6]. This worldwide interest in medicinal plants reflects recognition of the validity of many traditional claims regarding the value of natural products in health care ^[7]. Several components having antimicrobial properties were also isolated and identified from plants, which have great significance in treatment of various microbial infections ^[8]. There is therefore the need to look inwards to search for herbal medicinal plants with the aim of validating the ethno-medicinal use and subsequently the isolation and characterization of compounds which will be added to the potential list of drugs ^[9].

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About the selected plants



Fig 1: *Tamarindus indica* L. (Caesalpinaceae)

Tamarindus indica L. (Caesalpinaceae)

Trees, to 20 m high, bark brown to brownish-black, rough with vertical fissures; branchlets warty, tomentose. Leaves paripinnate, alternate; stipules lateral, minute, caudaceous; rachis 8-13 cm long, slender, glabrous, pulvinate; leaflets 20-34, opposite, sessile, estipellate; lamina 1.5-4 x 0.4-1.3 cm, oblong, base unequal, apex obtuse, margin entire, glabrous, chartaceous; lateral nerves 10-15 pairs, pinnate, slender, obscure, looped at the margin forming intramarginal nerve; intercostae reticulate, obscure. Flowers bisexual, 1 cm across, yellow with reddish-pink dots, in lax terminal racemes; bracts and bracteoles ovate-oblong, coloured, caudaceous; pedicels upto 5 mm; calyx tube narrowly turbinate, lined by disc; lobes 4, subequal, oblong, imbricate; petals 3, outer one, 1 x 0.3 cm, rolled up, pink dotted, lateral 2, 1-1.5 x 0.7-1 cm, clawed, subequal, oblong-lanceolate, lower pair scaly; stamens 9 monadelphous, only 3 fertile, others reduced to bristle, base pubescent; anthers versatile; ovary half inferior, stipitate, adnate to the disc, ovules many; style attenuate, tomentose; stigma globose. Fruit a pod 10-15 x 1-2 cm, oblong, fruit wall crustaceous, mesocarp pulpy, endocarp septate, leathery, indehiscent; seeds 3-8 or more, obovoid-orbicular, compressed, brown (Fig.1).

Local Name: *Valampuli*

Habit: Tree

Habitat: Cultivated

Fl. & Fr.: September-April

Distribution: Native of Tropical Africa; introduced and widely grown in India ^[10].



Fig 2: *Quassia indica* (Gaertn.)Noot. (Simaroubaceae)

Quassia indica (Gaertn.)Noot. (Simaroubaceae)

Evergreen tree or shrub to 10 m high. Leaves elliptic-oblong, subacute-rounded at base, acute to acuminate at apex, coriaceous, glabrous, shining, reticulate nerved. Petioles 1-2

cm long, stout. Flowers 20 or more in umbelliform glabrous or querulous inflorescences. Peduncles 7-30 cm long, stout, flat, thick-above; Pedicels 1-1.5 cm long, to 3 cm in fruit, jointed at base; bracts minute. Calyx 2-3 cm long, 4-lobed; lobes semi orbicular, thick, puberulous outside. Petals 4, free, oblong-oblongate, obtuse, 1-2 x ca 0.5 cm, dorsally pubescent, white, pale yellow or purplish. Stamens 8, pubescent. Anthers oblong-lanceolate, 2-3 mm long; filaments puberulous. Ovary ca 2 mm across, puberulous; styles to 2 cm long, glabrous. Drupes 1-4 together, flat, smooth, glandular and reticulate (Fig.2).

Local Name: *Karinjotta*

Habit: Tree

Habitat: Along backwaters and moist deciduous forests

Fl. & Fr: Throughout the year

Distribution: India, Myanmar and Sri Lanka ^[10].

Materials and Methods

The leaves of two plants were collected and washed in tap water to remove any foreign material and dried under shade. After optimum drying the leaves were powdered separately using grinders. The leaf powder of each plant were stored in well-closed containers. Extraction of two samples in ethanol, methanol and acetone were done using plant tissue homogenization method. Dried powder of leaves were grinded in a blender to fine particles, put in certain quantity of solvent and shaken vigorously for 5-10 min or left for 24h after which the extract is filtered. The filtrate then may be dried under reduced pressure and re-dissolved in the solvent to determine the concentration. Water extract of two samples are prepared separately by dissolving 1g of leaf powders in 25ml of water in a conical flask and keep the conical flasks in a boiling water bath till the solutions become decoctions. Phytochemical experiments were carried out using these samples.

Qualitative analysis

Test for Carbohydrates

Benedict's test

Extracts were treated with Benedict's reagent and heated gently and result was observed.

Test for reducing sugar

Fehling's test

Mix 1 ml Fehling's A and 1 ml Fehling's B solutions, boil for one minute. Add equal volume of test solution. Heat in boiling water bath for 5-10min, brick red color precipitate is obtained.

Test for Non-reducing polysaccharides

Iodine test

Mix the test solution and few drops of dilute iodine solution. The coloration is observed.

Test for Proteins

Xanthoproteic test

Extracts were treated with few drops of concentrated HNO₃.

Test for Amino acids

Xanthoproteic test

Extracts were treated with few drops of concentrated HNO₃.

Test for Steroids

Salkowski test

The plant extracts add few drops of chloroform and 2 ml conc. H₂SO₄ shake well.

Test for Glycosides

Plant extract were treated with 10 ml of 50% HCl. The color formation was observed.

Test for Alkaloids

Wagner's test

1ml of test solution is mixed with Wagner's reagent. A brown precipitate indicates the presence of alkaloids. Wagner's reagents were prepared by dissolving 1.27 g of iodine and 2 g of potassium iodide in 5ml of water and make up the volume to 100ml with distilled water.

Test for Tannins

FeCl₃ test

It is done using ferric chloride test, the test solution was added to 2ml of FeCl₃. The result was observed.

Test for Flavonoids

Alkaline reagent test

1ml of aqueous Na OH was added to 1ml of test solution. Formation of yellow color indicates the presence of flavonoids.

Test for Terpenoids

Salkowski test

The plant extracts add few drops of chloroform and 2 ml conc. H₂SO₄ shake well.

Test for Saponins

Foam test

The extract was dissolved in distilled water and shaken well. A froth formation that last for at least five minutes indicated the presence of Saponins.

Test for Quinones

A small amount of extract was treated with concentrated HCl and observed for the formation of yellow precipitate.

Test for Phenol

FeCl₃ test

To 2ml of extract, add 2ml of ferric chloride solution and formation of bluish green color indicate presence of phenol.

Quantitative analysis

1) Estimation of Protein

Lowry's method was followed for the estimation of protein.

Procedure

One gram leaf sample was weighted using electric balance and ground with the help of a mortar and pestle in 20 ml of 0.1 M phosphate buffer (pH-7). The extracts were centrifuged for 20 minutes. To 1 ml of the sample 5 ml of the alkaline copper solution was added, mixed well and allowed to stand for 10 minutes. Then 0.5 ml of the Folin-ciocalteu reagent was added, mixed well and incubated at room temperature in the dark for 30 minutes. After the development of blue color, the absorbency was read using spectrophotometer at 660nm.

2) Estimation of total Carbohydrate

Anthrone method was followed for the estimation of total carbohydrate.

Procedure

One gram leaf sample was weighted using electronic balance and put it into a boiling tube. The sample was then hydrolysed

by keeping in a boiling water bath for three hours with 10ml of 2.5N HCl. The solution was cooled to room temperature and neutralized with solid sodium carbonate until the effervescence ceases. The solution was then made up to 100ml with double distilled water and centrifuged for 20 minutes. To 1 ml of this sample, 4 ml Anthrone reagent was added. Then it was kept in a boiling water bath for 8 minutes and allowed to cool. The Absorbency of the light green solution was measured at 630nm^[11].

3) Estimation of Phenol

The method proposed by Malik and singh (1980) was adopted for the estimation of phenol.

Procedure

One gram of leaf tissue was weighted and grind with a mortar and pistil in 10 ml of 80% of ethanol. The extract was centrifuged for 20 minutes and the supernatant was collected. The residue was re extracted with 10ml 80% ethanol, centrifuged and collected the supernatant. The supernatant was then evaporated to dryness and the residue was dissolved in 10ml water. 1ml of this sample was made up to 3ml with double distilled water and 0.5ml of Folin- ciocalteu reagent was added. After 3 minutes 2ml of 20% Na₂CO₃ solution was added and mixed well. The solution was then placed in a boiling water bath for exactly one minute, cooled and the absorbency was measured at 650nm against blank.

4) Estimation of free Amino acid

The amino acids are color less ionic compounds that form basic building block of proteins. Apart from being bound as Protein, amino acids also exist in the free form in many tissues and are known as amino acids. They are mostly water soluble in nature. Very thin often in plants during disease conditions, the free amino acid composition exhibit a change and hence, the measurement of total free amino acids give the physiological and health status of plants.

Procedure

Extraction of Amino acid

Weigh 500mg and grind it in a mortar with a small quantity of acid washed sand. To this homogenate add 5-10ml of 80% ethanol filter or centrifuge, save the filtrate or supernatant repeat the extraction twice with the residue and cool all the supernatant. Reduce the volume if needed, by evaporation and use the extract for quantitative estimation of total free amino acid.

Estimation

1. To 0.1ml of extract add 1ml of Ninhydrin solution.
2. Make up the volume to 2ml with distilled water.
3. Heat the tubes in a boiling water bath for 20 minutes.
4. Add 5ml diluent and mix the contents.
5. After 15 minutes read the intensity of purple colour against a reagent blank in a colorimeter at 570nm.
6. The colour is stable for 1 hour.

Prepare the reagent blank as above by taking 0.1ml 80% ethanol instead of extract.

5) Estimation of Alkaloid

Procedure

One gram of leaf tissue was weighted and macerated with 20% H₂SO₄ and 10ml of ethanol for 10 minutes. The tube was allowed to stand for an hour with intermitted shaking and

centrifuge for 5 minutes. 0.5 ml supernatant was transferred into test tube. 2.5 ml 60% H₂SO₄ was added and two were mixed, 2.5 ml of 0.5% formaldehyde was subsequently added and test tubes were allowed to stand for 3 hours and read the absorbency at 565 nm.^[12]

6) Estimation of chlorophyll

Procedure

1. Weigh 1g of finely cut well mixed representative sample tissues into a clean mortar.
2. Grind the tissues to a fine pulp with the addition of 20 ml of 80% acetone.
3. Centrifuge (5000 rpm for 5 minutes) and transfer the supernatant to 100 ml volumetric flask.
4. Grind the residue with 20 ml of 80% acetone, centrifuge and transfer the supernatant to the same volumetric flask.
5. Repeat this procedure until the residue is colorless. Wash the mortar and pestle thoroughly with 80% acetone and collect the clear washings in the volumetric flask.
6. Make up the volume to 100 ml with water.
7. Read the absorbance of the solution at 645 nm and 663 nm against the solvent blank (80% acetone).

Antibacterial activity

Sample preparation

The fresh plant materials (leaves of *Tamarindus indica* L. and *Quassia indica* (Gaertn.) Noot. Were collected, dried in the shade and powdered. About 1g of powder was used for extraction. Extraction of two samples in ethanol, methanol and acetone were done using plant tissue homogenization method. Water extract of two samples are prepared separately by dissolving 1g of leaf powders in 25 ml of water in a conical flask and keep the conical flasks in a boiling water bath till the solutions become decoctions. These extracts were subjected for antimicrobial screening.

Microbial strains

Gram negative bacterial strains used were *E. coli*, *Salmonella typhi* and *Klebsiella pneumoniae* while gram positive strain used was *Corynebacterium diphtheriae*. The above bacterial strains isolated from Modern Diagnostic Centre Kottayam. Their cultural characters and morphological features were confirmed before experimentation. The test organisms were maintained in nutrient agar slants.

Preparation of inoculum

The nutrient agar broth for culturing of microbes was sub-cultured to test tubes. Culture collection grown at 37 °C

approximately 12-16 hours was used as inoculum. 5g of peptone, 3g beef extract, 5g NaCl in 1000 ml distilled water, boiled to dissolve the medium, completely. P^H of the medium was adjusted to 7 and sterilized by autoclaving at 15 lb/inch (121 °C) for 20 minutes. Just before setting the medium it was poured into the test tubes to make broth. Muller Hinton agar (Hi Medium) was prepared for the study.

Antibacterial assay

Agar well diffusion method was followed to determine the antimicrobial activity. Wells were made in each of Muller Hinton agar plates using sterile cork borer. Stock solutions of each plant extract were added into the wells. The plates were incubated at 37 °C for 24 hours. After 24 hours the plates were observed for antibacterial activity and the zone of inhibition was measured in centimeter.^[13]

Results and Discussion

Preliminary phytochemical investigation

The preliminary phytochemical investigation of different extracts of leaves of *Tamarindus indica* L. and *Quassia indica* (Gaertn.) Noot. Showed the following observations. Preliminary phytochemical investigation of the aqueous leaf extracts of *Tamarindus indica* L. showed the presence of Carbohydrates, Reducing sugars, Proteins, Amino acids, Steroids, Terpenoids, Alkaloids, Tannins, Flavonoids, Saponins and Phenols. Certain compounds like Non-reducing sugars, Glycosides and Quinones were not detected in this aqueous extract. The methanol extract of *T. indica* leaves showed the presence of compounds like Carbohydrates, Reducing sugars, Proteins, Amino acids, Steroids, Terpenoids, Alkaloids, Tannins, Quinones, Phenols. Compounds like Non-reducing sugars, Glycosides, Saponins and Flavonoids were not detected in the methanol extract of tamarind leaves. Preliminary phytochemical examination of tamarind leaves showed positive results for the presence of compounds like Reducing sugars, Proteins, Amino acids, Steroids, Terpenoids, Alkaloids, Tannins, Flavonoids and Phenols, and it showed negative results for compounds like Carbohydrates, Reducing sugars, Glycosides and Quinones. Positive results were observed for compounds like Reducing sugars, Proteins, Amino acids, Steroids, Terpenoids, Alkaloids, Tannins, Flavonoids, Saponins, and Phenols during the preliminary examination of ethanolic leaf extract of *Tamarindus indica* L. compounds such as Carbohydrates, Non-reducing sugars, Glycosides and Quinones were not detected in the ethanolic extract (Table 1).

Table 1: Qualitative analysis of metabolites in different extracts in leaves of *Tamarindus indica* L.

S. No	Metabolites	Test	<i>Tamarindus indica</i> L.			
1.	Carbohydrate	Benedict's test	+	+	-	-
2.	Reducing sugar	Fehling's test	+	+	+	+
3.	Non-reducing sugar	Iodine test	-	-	-	-
4.	Proteins	Xanthoproteic test	+	+	+	+
5.	Amino acids	Xanthoproteic test	+	+	+	+
6.	Steroids	Salkowski test	+	+	+	+
7.	Terpenoids	Salkowski test	+	+	+	+
8.	Glycosides	Modified Borntrager's test	-	-	-	-
9.	Alkaloids	Wagner's test	+	+	+	+
10.	Tannins	FeCl ₃ test	+	+	+	+
11.	Flavonoids	Alkali reagent test	+	-	+	+
12.	Saponins	Foam test	+	-	+	+
13.	Quinones	Test for quinones	-	+	-	-
14.	Phenols	FeCl ₃ test	+	+	+	+

Preliminary phytochemical investigation of aqueous leaf extract of *Quassia indica* (Gaertn.) Noot. Showed positive results for compounds such as Carbohydrates, Reducing sugars, Proteins, Amino acids, Steroids, Terpenoids, Alkaloids, Tannins, Flavonoids, Saponins and Phenols. It showed negative results for compounds such as Non-reducing sugars, Quinones and Glycosides. The presence of compounds like Carbohydrates, Reducing sugars, Proteins, Amino acids, Steroids, Terpenoids, Alkaloids, Tannins, Quinones and Phenols were detected in methanolic extracts of *Q. Indica* leaves, and certain compounds like Non reducing sugars, Flavonoids, Glycosides and Saponins were not detected in this methanolic extract of *Quassia*. The acetone

extract on preliminary phytochemical test showed the presence of compounds like Reducing sugars, Proteins, Amino acids, Phenols, Steroids, Terpenoids, Flavonoids, Tannins, Quinones, Saponins and Alkaloids. Certain compounds like Carbohydrates, Glycosides and Non-reducing sugars showed negative results in preliminary phytochemical tests of acetone leaf extract of *Quassia*. The ethanol extract of *Q. indica* leaves showed the presence of Reducing sugars, Proteins, Amino acids, Steroids, Terpenoids, Alkaloids, Tannins, Saponins and Phenols. Compounds like Carbohydrates, Non-reducing sugars, Glycosides and Quinones were not detected in ethanol extract of *Quassia* (Table 2).

Table 2: Qualitative analysis of metabolites in different extracts of leaves of *Quassia indica* (Gaertn.) Noot.

S. No.	Metabolites	Test	<i>Quassia indica</i> (Gaertn.) Noot.			
			Aqueous extract	Methanol Extract	Acetone extract	Ethanol Extract
1.	Carbohydrate	Benedict's test				-
2.	Reducing sugar	Fehling's test	+	+	+	+
3.	Non-reducing sugar	Iodine test	-	-	-	-
4.	Proteins	Xanthoproteic test	+	+	+	+
5.	Amino acids	Xanthoproteic test	+	+	+	+
6.	Steroids	Salkowski test	+	+	+	+
7.	Terpenoids	Salkowski test	+	+	+	+
8.	Glycosides	Modified Borntrager's test	-	-	-	-
9.	Alkaloids	Wagner's test	+	+	+	+
10.	Tannins	FeCl ₃ test	+	+	+	+
11.	Flavonoids	Alkali reagent test	+	-	+	+
12.	Saponins	Foam test	+	-	+	+
13.	Quinones	Test for quinones	-	+	+	-
14.	Phenols	FeCl ₃ test	+	+	+	+

Quantitative estimation of phytoconstituents

From this observation it is clear that the leaves of *T. indica* L. possess more amount of Chlorophyll a, Chlorophyll b and

total Chlorophyll content than that of *Q. indica* (Gaertn.) Noot. (Table 3).

Table 3: Quantification of pigments in leaves of *Tamarindus indica* L. and *Quassia indica* (Gaertn.) Noot.

Sl No.	Name of pigments	Amount of chlorophyll (mg/g tissue)	
		<i>Tamarindus indica</i> L.	<i>Quassia indica</i> (Gaertn.) Noot.
1.	Chlorophyll a	0.57	0.23
2.	Chlorophyll b	1.08	0.30
3.	Total chlorophyll	1.66	0.53

Various chemical compounds like Carbohydrates, Proteins, Phenols, Alkaloids and Amino acids are present in leaves of both plants. When comparing the quantity of phytochemical constituents in *T. indica* L. and *Q. indica* (Gaertn.) Noot. The

leaves of *T. indica* L. Have higher amount of Phenols and Alkaloids than that of *Q. indica* (Gaertn.) Noot. But the leaves of *Q. indica* (Gaertn.)Noot. Possess high amount of Carbohydrates, Proteins and free Amino acids (Table 4).

Table 4: Quantitative analysis of phytochemical compounds of leaves of *Tamarindus indica* L. and *Quassia indica* (Gaertn.) Noot.

Sl No.	Name of the phytochemical compounds	Amount of phytochemical compounds (mg/g tissue)	
		<i>Tamarindus indica</i> L.	<i>Quassia indica</i> (Gaertn.) Noot.
1.	Phenol	455	285
2.	protein	55	430
3.	Free amino acid	150	400
4.	Alkaloids	550	425
5.	Carbohydrates	100	330

The phytochemical screening of leaves, stem and roots of *Oldenlandia cormbosa*, *Ricinus communis*, *Lpomea aquatica*, *Xanthium strumarium* and *Mentha piperita* also showed the presence of active components like Saponins, Tannins, Flavonoids, Terpenoids, Reducing sugars etc. from aqueous and ethanolic extracts.^[14] It was found that the leaf extracts of *Plantago lanceolata* contain metabolites like Steroids, Alkaloids, Flavonoids, Tannins, Saponins, Phenols and

Terpenoids. The presence of the important phytochemicals in the plants is a scientific justification of the plant use in the medicinal treatment against various diseases affecting humans.^[15]

When comparing the quantity of phytochemical constituents in *Tamarindus indica* L. and *Q. indica* (Gaertn.) Noot. the leaves of *T. indica* L. have higher amounts of Phenols and Alkaloids than that of *Q. indica* (Gaertn.) Noot. But the leaves of *Q. indica* (Gaertn.) Noot. Possess higher amounts of

Carbohydrates, Proteins and free Amino acids. The leaves of *T. indica* L. possess more amounts of Chlorophyll a, b and total chlorophyll contents than that of *Q. indica* (Gaertn.) Noot.

Antimicrobial activity

The four different extracts of *T. indica* L. and *Q. indica* (Gaertn.) Noot. were tested for their antibacterial activity against four different strains of bacteria like *Corynebacterium diphtheriae*, *E. coli*, *Salmonella typhi* and *Klebsiella pneumonia* (Fig.3&4). After 24 hours of incubation, the

acetone extract of *T. indica* L. leaves shows more resistance to *Salmonella typhi* (0.3cm). The methanol extract of *Tamarindus* leaves shows equal resistance to all four strains of bacteria (0.1cm). The aqueous extract of *T. indica* L. shows equal resistance to *Corynebacterium diphtheriae*, *Salmonella typhi* and *E. coli* (0.2cm). The acetone extract of *Tamarindus* leaves resulted on formation of equal zone of inhibition to *C. diphtheria* and *Klebsiella pneumoniae* (0.2cm). The ethanol extract of leaves of *T. indica* L. didn't shows resistance to *E. coli* (0cm), and it shows equal resistance to other three bacterial strains (0.1cm) (Table 5).

Table 5: Antimicrobial activity of different extracts of leaves of *Tamarindus indica* L. on 4 different strains of bacteria.

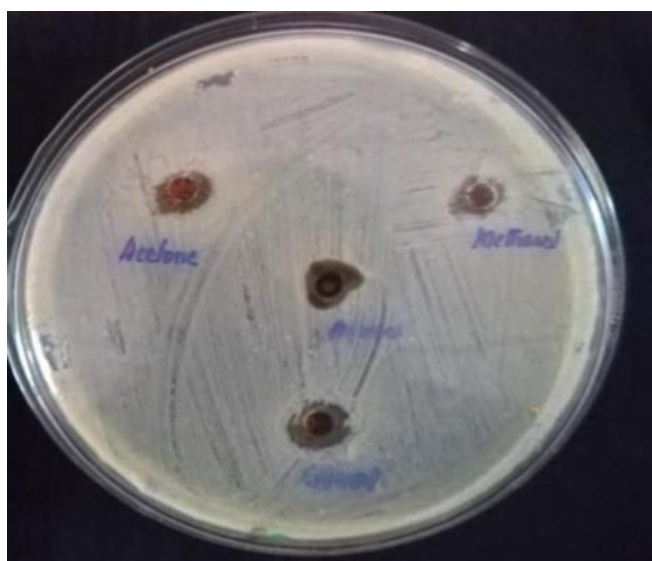
S. No	Name of organism	<i>Tamarindus indica</i> L.			
		Zone of Inhibition (cm)			
		Aqueous extract	Methanol Extract	Acetone extract	Ethanol Extract
1.	<i>Salmonella typhi</i>	0.2	0.1	0.3	0.1
2.	<i>Corynebacterium diphtheriae</i>	0.2	0.1	0.2	0.1
3.	<i>E. coli</i>	0.2	0.1	0.1	0
4.	<i>Klebsiella pneumoniae</i>	0.1	0.1	0.2	0.1

The ethanol extract of *Tamarindus indica* L. shows maximum resistance to *Salmonella typhi*. After 24 hours of incubation, the aqueous extract of *Quassia indica* (Gaertn.) Noot. Shows maximum resistance to *Salmonella typhi* (0.4cm), and it shows less resistance to *C. diphtheria* (0.3cm). And shows very less resistance to *E. coli*. The antibacterial activity of methanolic extract of *Q. indica* (Gaertn.) Noot. Shows maximum resistance to *Salmonella typhi* (0.5cm), it shows less resistance to *E. coli* (0.3cm) than *Salmonella typhi*. The methanolic extract of *Q. indica* shows equal resistance to *K. pneumoniae* and *C. diphtheria* (0.2cm). The acetone extract of leaves of *Q. indica* (Gaertn.) Noot. Shows equal resistance to *C. diphtheriae*, *E. coli* and *Salmonella typhi* (0.4cm). The ethanol extracts of leaves of *Quassia* plant shows maximum

zone of inhibition against *E. coli* and *S. typhi* (0.5cm), and this extract produced less zone of inhibition against *K. pneumoniae* (0.3cm) and *C. diphtheria* (0.4cm). The aqueous extract and acetone extract of leaves of *Q. indica* (Gaertn.) Noot. Didn't show resistance against *Klebsiella pneumoniae* (Table 6). The methanolic and acetone extract of *Q. indica* (Gaertn.) Noot. Shows maximum resistance to *Salmonella typhi*, and the acetone extract shows resistance to *E. coli* also. Hence the present study explores the scope of developing better, cost effective and indigenous alternatives which can substitute conventional antibiotics or antimicrobial agents. Similar studies like the extracts of leaves and fruits of *Tribulus terrestris* was showed antibacterial activity with diameters of zone of inhibition ranging from 8- 23mm. ^[16]

Table 6: Antimicrobial activity of different extracts of *Quassia indica* (Gaertn.) Noot. on 4 different strains of bacteria.

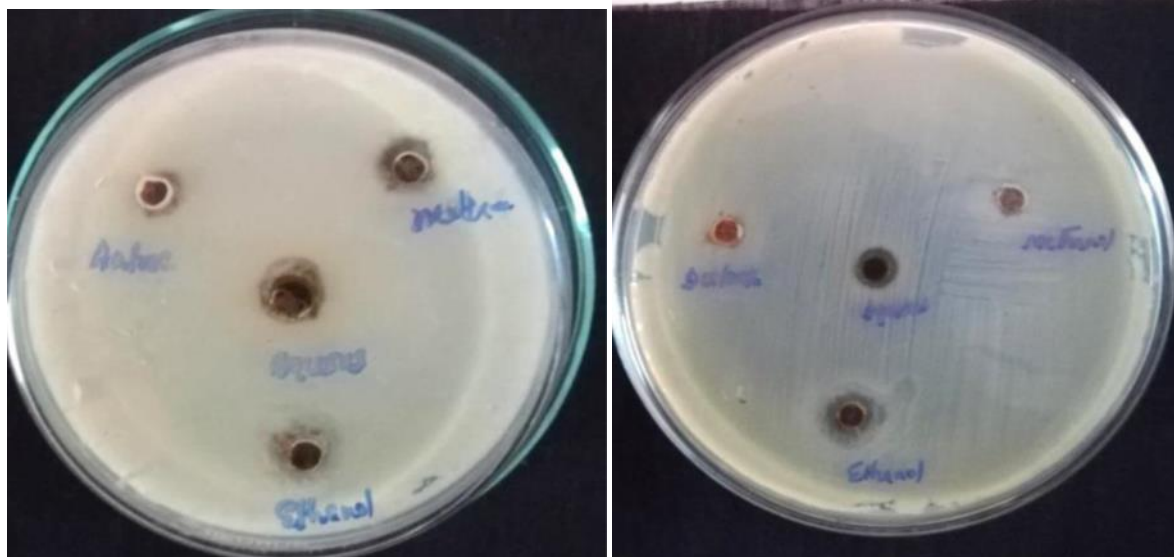
S. No.	Name of organism	<i>Quassia indica</i> (Gaertn.) Noot.			
		Zone Of Inhibition (cm)			
		Aqueous extract	Methanol Extract	Acetone extract	Ethanol Extract
1.	<i>Salmonella typhi</i>	0.4	0.5	0.4	0.5
2.	<i>Corynebacterium diphtheriae</i>	0.3	0.2	0.4	0.4
3.	<i>E. coli</i>	0.1	0.3	0.4	0.5
4.	<i>Klebsiella pneumoniae</i>	0	0.2	0	0.3



Salmonella typhi



Corynebacterium diphtheria



E. coli

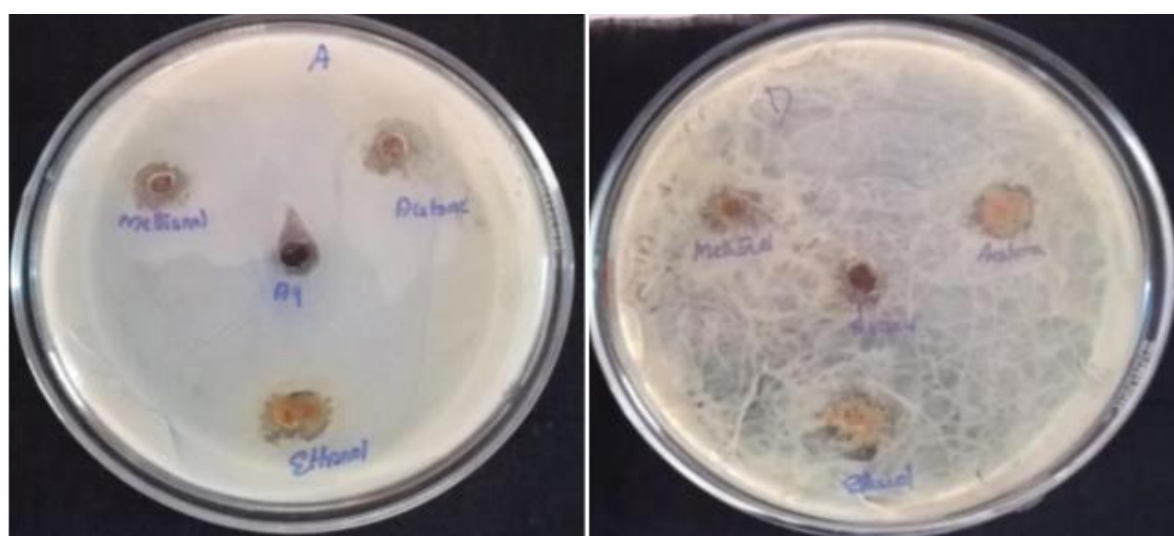
Klebsiella pneumonia

Fig 3: Antibacterial effect of different extracts of *Tamarindus indica* L. leaves on 4 different of bacteria.



Salmonella typhi

Corynebacterium diphtheria



E. coli

Klebsiella pneumoniae

Fig 4: Antibacterial effect of different extracts of *Quassia indica* (Gaertn.) Noot leaves. On 4 different strains of bacteria.

Conclusion

The selected species of the present study are *Tamarindus indica* L. and *Quassia indica* (Gaertn.) Noot. The phytochemical constituents and the bioactive compounds possess the medicinal properties which are present in respective plants make them as potential medicinal plants. The obtained results showed the leaves of both plants possess Carbohydrates, Proteins, Phenols, Amino acids and Alkaloids. When compared to *Q. indica* (Gaertn.) Noot. *T. indica* L. leaves possess highest amount of Phenols and Alkaloids. The amount of Carbohydrate, Proteins and Amino acids is higher in *Q. indica* than that of *T. indica*. Both the plants have many health benefits and improves the defence mechanism in living system. It is very necessary to introduce new and biologically safe and active drugs eco-friendly in nature and effective as an antimicrobial agent. Due to the presence of significant amount of Phenols and Alkaloids, both the plants possess medicinal and antimicrobial properties. The study also revealed that, the leaves of both plants contain a considerable quantity of Phenolic and Alkaloid compounds that we found to be major contribution to their antibacterial activity. Plants are rich source of secondary metabolites with interesting biological activities. These secondary metabolites are an important source with a variety of structural arrangements and properties. Natural products from microbial sources have been primary source of antibiotics. But with increasing recognition of herbal medicine as an alternative for health care, the screening of medicinal plants for active compounds has become very significant in now a days.

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