IJP (2018), Vol. 5, Issue 8 **(Research Article)**

Received on 05 May, 2018; received in revised form, 07 June, 2018; accepted, 13 June, 2018; published 01 August, 2018

COMPARATIVE PHARMACOGNOSY AND PHYTOCHEMICAL ANALYSIS OF MEDICINAL PLANTS WITH ANTIDIABETIC ACTIVITY (*PTEROCARPUS MARSUPIUM* ROXB., *AZADIRACHTA INDICA* A. JUSS., *TRICHOSANTHES DIOICA* ROXB., *SYZYGIUM CUMINI* LINN. AND *MOMORDICA CHARANTIA* LINN.)

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Keywords:

Antidiabetic plants, Diabetes mellitus, Comparative pharmacognosy, Comparative phytochemistry, Medicinal plants

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ABSTRACT: Diabetes mellitus is becoming a threat to the world's population as it is spreading like an epidemic. *Pterocarpus marsupium* Roxb., *Azadirachta indica* A. Juss., *Trichosanthes dioica* Roxb., *Syzygium cumini* Linn. and *Momordica charantia* Linn. are well known for their properties in the management of diabetes. In recent times, there has been a significant growth in the field of Ayurvedic medicines because of their less side effects compared to synthetic drugs. Thus, study of medicinal plants is becoming an integral part to develop herbal medicines for the treatment of diabetes. Present study was performed to determine the pharmacognostic as well as phytochemical similarities and dissimilarities between root, stem and leaf of these plants. Extensive usages of specific plant parts may lead to extinction of plant species. In order to protect them, specific plant parts were thoroughly studied so that those plant parts can be replaced by other part(s) of the same plant. The comparative study included macroscopic observations, powder microscopy study, physicochemical and phytochemical analysis. Pharmacognostic analysis revealed the presence of starch grains in all the samples though compound starch grains were seen only in stem of *S. cumini*. Trichomes were only observed in stem and leaf of *P. marsupium*. Calcium oxalate crystals were seen only in stem of *A. indica* and root of *P. marsupium*. Pitted tracheid was seen in the leaf of *M. charantia*. Phytochemical analysis revealed the presence of flavonoids, saponin and carbohydrates in root, stem and leaves which are considered to be active constituents for antidiabetic properties of these medicinal plants.

INTRODUCTION: Diabetes mellitus is a "chronic disease" that occurs when the pancreas does not produce adequate amount of insulin to absorb blood sugar, or when the body cannot utilise the insulin it produces.

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DOI:

10.13040/IJPSR.0975-8232.IJP.5(8).475-87

Article can be accessed online on: www.ijpjournal.com

DOI link: http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.5(8).475-87

Hyperglycaemia is a result of uncontrolled diabetes which leads to serious damage to body's systems, especially the nerves and blood vessels. According to World health organization (WHO), diabetes is a chronic disease which causes about 5% of all deaths globally each year. India has the world's largest diabetes population with 50.8 million people affected by diabetes and 70% of diabetes cases have been reported to occur in low and middle income countries. According to American diabetes association (ADA), nearly 10% of the world's population has diabetes.

Ayurvedic medicine has been successfully used in the treatment of diabetes since ages. As the synthetic drugs are costly and cause more side effects among individuals than Ayurvedic medicines, the usage of antidiabetic plants is gaining popularity.

Due to over usage of particular plant parts, many plant species are in the verge of becoming endangered or extinct. Different plants possess different plant parts having antidiabetic property. A particular plant part has been used extensively for the manufacturing of antidiabetic herbal drugs leaving other plant parts unused.

The objectives of the current research include the phytochemical study of five different medicinal plants (which are well known for their antidiabetic property) in order to find out whether the active chemical constituents are present in their root, stem and leaf. The study aims to provide specific data whether the specific plant parts which are commercially used for the treatment of diabetes could be replaced by root, stem or leaf of the same plant. This result may help conserving the plant species from getting endangered. The plants studied in the research were *Pterocarpus marsupium* Roxb., *Azadirachta indica* A. Juss., *Trichosanthes dioica* Roxb., *Syzyguim cumini* Linn. and *Momordica charantia* Linn. The study also aims at comparing the pharmacognostic properties of root, stem and leaves of those plants as these could give important results regarding identifying characters of those plants.

Aqueous extract of the stem of *Pterocarpus marsupium* Roxb. (Beejak), belonging to the plant family Fabaceae, has been used for the treatment of diabetes. The active component present is 'epicatechin', a flavonoid [1, 2]. *Azadirachta indica* A. Juss. (Neem) belongs to plant family Meliaceae and leaf and seeds have 'nimbidin', a triterpenoid (saponin) shows antidiabetic property [3]. Fruits, seeds and leaves of *Syzygium cumini* Linn. (Family Myrtaceae), known as kalajam, showed antidiabetic properties (ethanolic extracts). The active constituent is mycaminose (deoxyhexose) [3]. *Trichosanthes dioica* Roxb., commonly known as patola, belongs to plant family Cucurbitaceae. Ethanolic and aqueous extracts of the whole plant has been used in the treatment of diabetes.

The active constituent is known to be cucurbitacin, a triterpene (saponin) [4, 5]. *Momordica charantia* Linn. belongs to family Cucurbitaceae and the active constituent is momordin (saponin). The methanolic, aqueous and chloroformic extracts of different plant parts showed antidiabetic activities [3]. *Momordica charantia* and *Pterocarpus marsupium* have been reported to have reduced blood sugar level during the treatment of type 2 diabetes. These plants showed to have stimulating or regenerating effect on beta cells of pancreas [12].

As the literature review showed no comparative pharmacognostic and phytochemical study between root, stem and leaves of those plant, the present study would evaluate their comparative analysis and can be of immense use for the researchers and pharmacognosists.

MATERIAL AND METHODS:

Collection and Identification of Plant Material: Root, stem and leaves of *Pterocarpus marsupium* (Beejak) [family Fabaceae], *Azadirachta indica* (Neem) [family- Meliaceae], *Syzygium cumini* (Jamun) [family- Myrtaceae], *Trichosanthes dioica* (Patol) [family- Cucurbitaceae] and *Momordica charantia* (Patol) [family- Cucurbitaceae] were collected from the medicinal plants garden, Institute of Post Graduate Ayurved Education and Research (IPGAER), Kolkata and identified by the Department of Dravyaguna, IPGAER, Kolkata.

Preparation of Samples: The root, stem and leaf samples were kept under sunlight for drying for seven days. The dried materials were powdered using a grinder (Hammer mill) and passed through no. 40 and no. 120 mesh sieve for phytochemical analysis study and pharmacognostic study respectively. The powders were packed in sealed plastic bottles for storage.

Macroscopic and Organoleptic study: Macroscopic and organoleptic characters of root, stem and leaves of those five antidiabetic plants were examined thoroughly.

Pharmacognostic Studies: The powders of root, stem and leaves of these five plants were passed through sieve # 120 and then mounted on clean grease - free glass slides for microscopic observations.

Physicochemical Study:

Total Ash Value: 5 grams of each air dried plant samples were weighted separately and incinerated in muffle furnace at 450 ºC. The ash was cooled and weighted. The percentage of ash with reference to the air dried samples were calculated.

Acid Insoluble Ash Value: The total ash obtained from above study were boiled with 25 ml of dilute hydrochloric acid for 5 min. The insoluble residues were collected separately on ashless filter paper and washed with hot water. Then the residues were ignited, cooled and kept for desiccation. The residues thus obtained were weighted and percentages of acid insoluble ash with reference to air dried stem samples were calculated.

Water Soluble Ash Value: The ash obtained was boiled with 25 ml of distilled water for 5 min. The soluble matter was collected and washed with hot water, ignited and weighted. The percentage of water soluble ash with reference to air dried sample was calculated and recorded.

Extractive Value: 5 grams of each air dried powdered stem samples were macerated separately with 100 ml of each solvent (methanol and water) for 24 h. The filtrate was taken from each flask and kept for evaporation to dryness and weighted. The percentages of different soluble extractive values were calculated with reference to the air dried powder.

Phytochemical Screening: Each 5 g of dried and powdered form of root, stem and leaf samples of *Pterocarpus marsupium* (Beejak), *Azadirachta indica* (Neem), *Trichosanthes dioica* (Patol), *Syzyguim cumini* (Kalajam) and *Momordica charantia* Linn. (Karela) were mixed separately with 25 ml of different solvents *viz*. methanol and water. The different extracts were used for standard phytochemical studies. The methanolic and aqueous extracts of different plant parts were used to evaluate the presence of phytoconstituents such as alkaloids, flavonoids, phenols, saponins, tannins *etc*. This study was carried out by using standard procedures.

Tests for Alkaloids: To the extract, dilute hydrochloric acid was added, shaken well and filtered. With the filtrate, the following tests were performed.

Mayer's Reagent Test: To 2 ml of filtrate, few drops of Mayer's reagent were added along sides of tube. Formation of creamy precipitate indicates the presence of alkaloids.

Wagner's Test: To 2 ml of filtrate, few drops of Wagner's reagent were added in a test tube. Formation of reddish brown precipitate indicates the presence of alkaloids.

Hager's Test: To 2 ml of filtrate, few drops of Hager's reagent were added in a test tube. Formation of yellow color precipitate indicates the presence of alkaloids.

Tests for Flavonoids:

Lead Acetate Test: The extract was treated with few drops of lead acetate solution. Formation of yellow precipitate indicates the presence of flavonoids.

Tests for Carbohydrates:

Molisch Test: 2 ml of aqueous extract was treated with 2 drops of alcoholic α-naphthol solution in a test tube and then 1 ml of concentrated sulphuric acid was added carefully along the sides of the test tube.

Formation of violet ring at the junction indicates the presence of carbohydrates.

Barfoed's Test: 1 ml of extract and Barfoed's reagent were mixed in a test tube and heated on water bath for 2 min. Red color due to formation of cupric oxide indicates the presence of monosaccharide.

Tests for Reducing Sugars:

Fehling's Test: To 1 ml of aqueous extract, 1 ml of Fehling's A and 1 ml of Fehling's B solutions were added in a test tube and heated on a water bath for 10 min. Formation of red precipitate indicates the presence of reducing sugar.

Benedict's Test: Equal volume of Benedict's reagent and extract were mixed in a test tube and heated on a water bath for 5 - 10 min. Solution appears green, yellow or red depending on the amount of reducing sugar present in the test solution which indicates the presence of reducing sugar.

Test for Saponin:

Froth Test: The extract was diluted with distilled water and shaken in a graduated cylinder for 15 min. The formation of layer of foam indicates the presence of saponins.

Tests for Tannin and Phenolic Compounds:

Ferric Chloride Test: A small amount of extract was dissolved in distilled water. To this solution 2 ml of 5% ferric chloride solution was added. Formation of blue, green or violet colour indicates presence of phenolic compounds.

Lead Acetate Test: A small amount of extract was dissolved in distilled water. To this solution few drops of lead acetate solution were added. Formation of white precipitate indicates the presence of phenolic compounds.

Tests for Protein and Amino acids:

Ninhydrin Test: 3 ml of the test solution was heated with 3 drops of 5% Ninhydrin solution on a water bath for 10 min. Formation of blue colour indicates the presence of amino acids.

Biuret Test: The extract was treated with 1 ml of 10% sodium hydroxide solution in a test tube and heated. A drop of 0.7% copper sulphate solution was added to the above mixture. The formation of violet or pink colour indicates the presence of proteins.

RESULT:

Macroscopic and Organoleptic Study:

TABLE 1: MACROSCOPIC AND ORGANOLEPTIC CHARACTERISTICS OF *AZADIRACHTA INDICA* [FAMILY-MELIACEAE]

Characters	Observations					
	Root		Stem		Leaf	
	Fresh	Powder form	Fresh	Powder form	Fresh	Powder form
Colour	Brown	Light brown	Dark brown	Light brown	Dark green	Light green
Texture	Hard	-	Hard	-	Smooth	-
Odour	Odourless	Odourless	Odourless	Odourless	Aromatic	Aromatic
Taste	Astringent	Astringent	Astringent	Astringent	Very astringent	Very astringent
Type	-	-	-	-	Opposite, pinnately compound	-
Shape	Cylindrical	-	Cylindrical	-	Ovate to lanceolate	-
Apex	_	-	-	-	Acute	-
Surface	Smooth	-	Smooth	-	Smooth	-
Venation	-	-	-	-	Pinnately reticulate	-
Length	-	-	-	-	6-15 cm (each leaflet)	-
Width	-	-	-	-	5-8 cm (each leaflet)	-

Fresh root and stem of *Azadirachta indica* (Neem) appeared brown and dark brown in colour respectively and their taste was astringent. Fresh leaf was aromatic and taste was very astringent.

TABLE 2: MACROSCOPIC AND ORGANOLEPTIC CHARACTERISTICS OF *TRICHOSANTHES DIOICA* [FAMILY- CUCURBITACEAE]

Characters	Observations					
	Root		Stem		Leaf	
	Fresh	Powder form	Fresh	Powder form	Fresh	Powder form
Colour	Brown	Light brown	Dark brown	Light brown	Dark green	Light green
Texture	Hard	_	Soft	-	Coarse	-
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Taste	Tasteless	Tasteless	Tasteless	Tasteless	Astringent	Astringent
Type	-	-	Creeping	-	Opposite, pinnately compound	-
Shape	Cylindrical	-	Cylindrical	-	Cordate (heart shaped)	-
Apex	-	-	_	-	Acute to acuminate	-
Surface	Smooth	-	Rough with hairs	-	Rough with hairs	-
Venation	-	-	-	-	Palmately reticulate	-
Length	-	-	-	-	6-11 cm	-
Width	-	-	-	-	5-7 cm	-

The root and leaf of *Trichosanthes dioica* (Patol) were hard and coarse whereas the stem was soft and creeping. Hairs were seen in the stem and leaf of the plant.

TABLE 3: MACROSCOPIC AND ORGANOLEPTIC CHARACTERISTICS OF *SYZYGIUM CUMINI* [FAMILY-MYRTACEAE]

Characters	Observations					
	Root		Stem		Leaf	
	Fresh	Powder form	Fresh	Powder form	Fresh	Powder form
Colour	Brown	Light brown	Dark grey	Light grey	Pink to dark green	Light green
Texture	Hard	-	Hard	-	Smooth, leathery	-
Odour	Odourless	Odourless	Odourless	Odourless	Aromatic (turpentine like)	Aromatic
Taste	Tasteless	Tasteless	Tasteless	Tasteless	Astringent	Astringent
Type	-	-	-	-	Simple	-
Shape	Cylindrical	-	Cylindrical	-	Ovate	-
Apex	-	-	-	-	Acuminate	-
Surface	Smooth	-	Smooth	-	Smooth and glossy	-
Venation	-	-	-	-	Pinnately reticulate	-
Length	-	-	-	-	7-11 cm	-
Width	-	-	-	-	5-8 cm	-

Syzygium cumini (Kalajam) was seen to bear brown and light grey root and stem respectively. It carried pink to dark green leathery leaves.

TABLE 4: MACROSCOPIC AND ORGANOLEPTIC CHARACTERISTICS OF *PTEROCARPUS MARSUPIUM* [FAMILY- FABACEAE]

Characters	Observations					
	Root		Stem		Leaf	
	Fresh	Powder form	Fresh	Powder form	Fresh	Powder form
Colour	Brown	Light brown	Yellow to grey	Light grey	Pink to dark green	Light green
Texture	Hard	-	Hard	-	Smooth, leathery	-
Odour	Odourless	Odourless	Odourless	Odourless	Aromatic (turpentine like)	Aromatic
Taste	Tasteless	Tasteless	Astringent	Astringent	Astringent	Astringent
Type	-	-	_	-	Imparipinnate	-
Shape	Cylindrical	-	Cylindrical	-	Oblong	-
Apex	-	-	_	-	Acuminate	-
Surface	Smooth	-	Glabrous	-	Smooth and glossy	-
Venation	-	-	-	-	Pinnately reticulate	-
Length	-	-	-	-	5-12 cm	-
Width	-	-	-	-	4-8 cm	-

Pterocarpus marsupium (Beejak) had aromatic leaf. The stem and leaves tasted astringent.

TABLE 5: MACROSCOPIC AND ORGANOLEPTIC CHARACTERISTICS OF *MOMORDICA CHARANTIA* [FAMILY- CUCURBITACEAE]

Characters	Observations					
	Root		Stem		Leaf	
	Fresh	Powder form	Fresh	Powder form	Fresh	Powder form
Colour	Brown	Light brown	Dark green	Light green	Dark green	Light green
Texture	Hard	-	Hard, pubescent	-	Coarse	-
Odour	Odourless	Odourless	Odourless	Odourless	Odourless	Odourless
Taste	Tasteless	Tasteless	Astringent	Astringent	Astringent	Astringent
Type	-	-	_	-	Simple, alternate	-
Shape	Cylindrical	-	Angular with five edges	-	Oblong	-
Apex	-	-	_	-	Acuminate	-
Surface	Smooth	-	Rough	-	Rough	-
Venation	-	-	-	-	Pinnately reticulate	-
Length	-	-	-	-	15-19 cm	-
Width	-	-	-	-	16-18 cm	-

The stem of *Momordica charantia* (Karela) was seen to have characteristic five edges (angular). The stem and leaf tasted astringent.

Pharmacognosy: Powder microscopy study of root, stem and leaves of these plants revealed the presence of lignified cork cells, single celled trichome, simple and compound starch grains, lignified fibre, tracheids with narrow lumen and tapering ends, xylem vessels with scalariform, reticulate and spiral thickenings, calcium oxalate crystals and stomata. The findings have been described in **Table 6**, **Fig. 1, 2, 3, 4** and **5**.

TABLE 6: POWDER CHARACTERS OF ROOT, STEM AND LEAVES OF DIFFERENT ANTIDIABETIC PLANTS

Name of plant	Plant parts	Powder characters					
		Cork cells	Trichome	Starch grains	Fibre	Tracheid	Vessel element
Azadirachta indica (Neem)	Root	Lignified with brown pigments	-	Simple	Libriform, tapering towards ends	short	Short, pitted
	Stem	Lignified with brownish pigments	-	simple	Short, pits present, round at the tips	short	Short with reticulate thickening
	Leaf	-	-	simple	Short, round at the tips	Short	Scalariform thickening
Trichosanthes dioica (Patol)	Root	Cells lignified	-	Simple	Short, tapering towards ends	Long	Scalariform thickening
	Stem	Cells lignified	-	Simple and compound	Short, tapering towards ends	Long, in bundles	Reticulate thickening
	Leaf	-	-	Numerous, simple and compound	Short, tapering towards ends	Long	Short, scalariform thickening
Syzygium cumini (kalajamun)	Root	Cells lignified	-	simple	Short with narrow lumen	Long	Short, spiral thickening
	Stem	Cells lignified	-	simple	Long with narrow lumen, in bundles	Short	Short, scalariform thickening
	Leaf	-	-	simple	Short, parenchyma cells attached	short	Short, scalariform thickening
Pterocarpus marsupium (Beejak)	Root	Cells lignified	-	simple	Libriform, tapering end	Vasicentric, reticulate thickening	Simple, pitted, broad, perforated
	Stem	Cells lignified	Single celled	simple	Libriform, tapering end	Long, reticulate thickening	Broad, reticulate thickening
	Leaf	Cells lignified	Single celled	simple	Libriform, round or tapering end	Long	Broad, reticulate thickening
Momordica charantia (Karela)	Root	Cells lignified	-	simple	Lignified, narrow lumen	Long, reticulate thickening	Broad
	Stem	Cells lignified	-	simple	Lignified	Long, reticulate thickening	Broad, reticulate and annular thickening
	Leaf	-	-	simple	-	Long, reticulate thickening	Short, pitted

Comparative Pharmacognostic Characters: There were similarities and dissimilarities between powder characters of root, stem and leaves of these plants. Starch grains were commonly seen in all the samples. Root samples showed different types of thickening in xylem vessels. Scalariform thickening was seen in xylem vessel of *T. dioica* whereas spiral thickening in *S. cumini*. Lignified cork cells were seen in all root samples. Calcium oxalate crystals were seen only in stem samples of *A. indica* and root of *P. marsupium.* Cork cells were observed in all stem samples. Compound starch grains were only seen in stem sample of *S. cumini*. The fibre of *M. charantia* was lignified among stem samples. Among leaf samples, lignified cells were only observed in *P. marsupium*. Pitted tracheid was seen in the leaf sample of *M. charantia*. Anisocytic stomata were observed in the leaf samples of *T. dioica* and *M. charantia*.

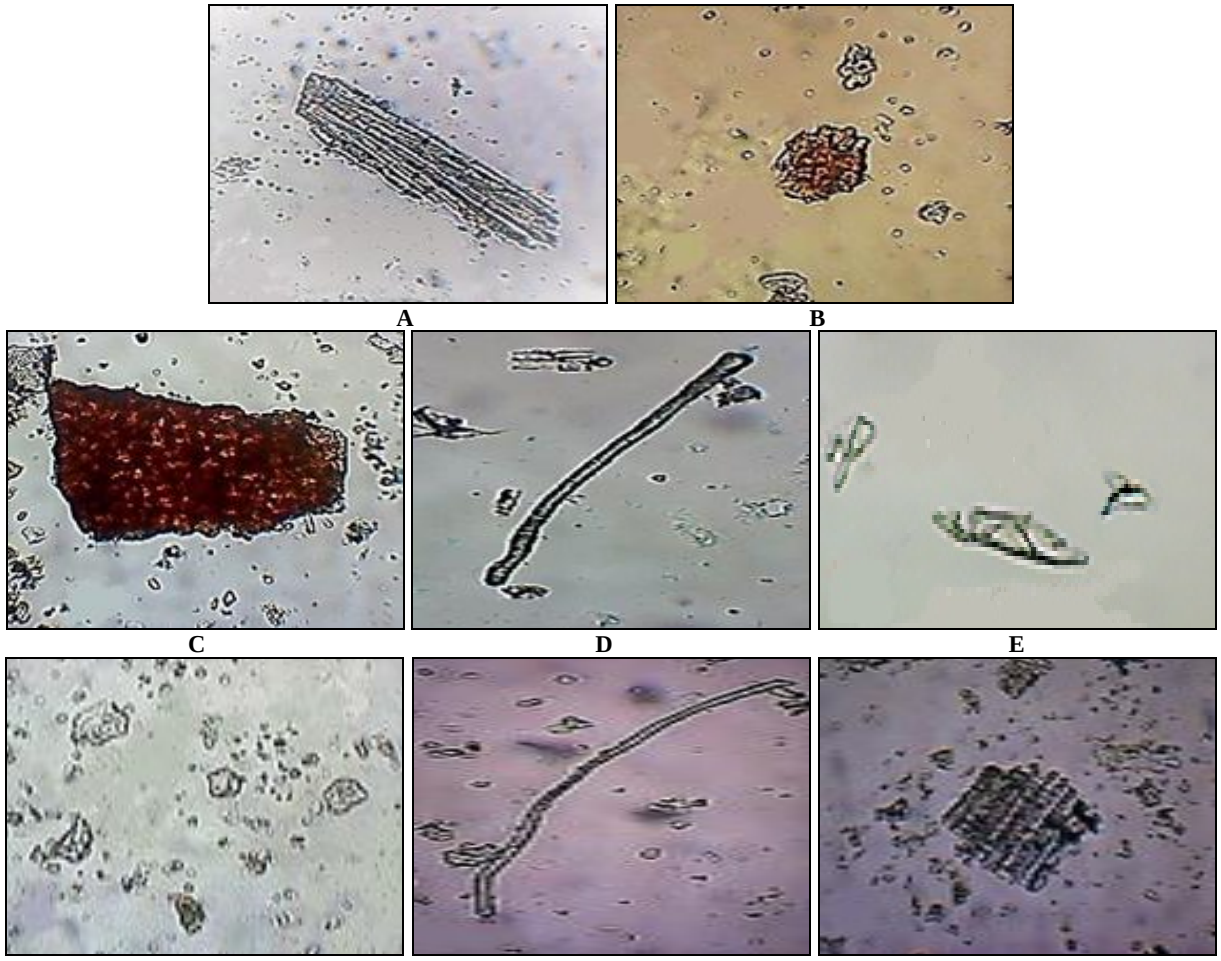

FIG. 1: POWDER MICROSCOPY OF *AZADIRACHTA INDICA* (NEEM)

A) Fibres in bundle in root, B) Epidermal cells with brown pigments in root, C) Cork cells with brown pigments in stem, D) Fibre with round ends in stem, E) Crystals of calcium oxalate in stem, F) Stomata in leaf (transverse view), G) Fibre in leaf, H) Vessel with scalariform thickening in leaf

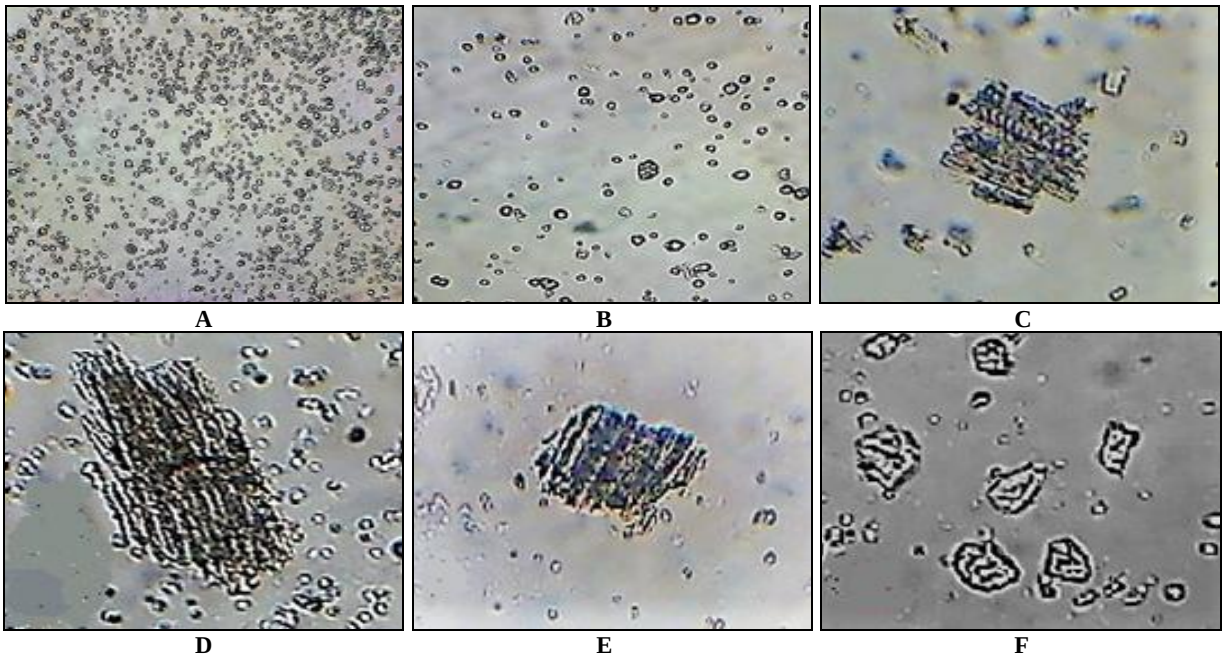

FIG. 2: POWDER MICROSCOPY OF *TRICHOSANTHES DIOICA* (PATOL)

A) and B) Numerous simple and compound starch grains in root, C) Transverse section of vessel with scalariform thickening in stem, D) Cluster of fibres in stem, E) Transverse section of vessel in stem, F) Stomata (transverse section) in leaf

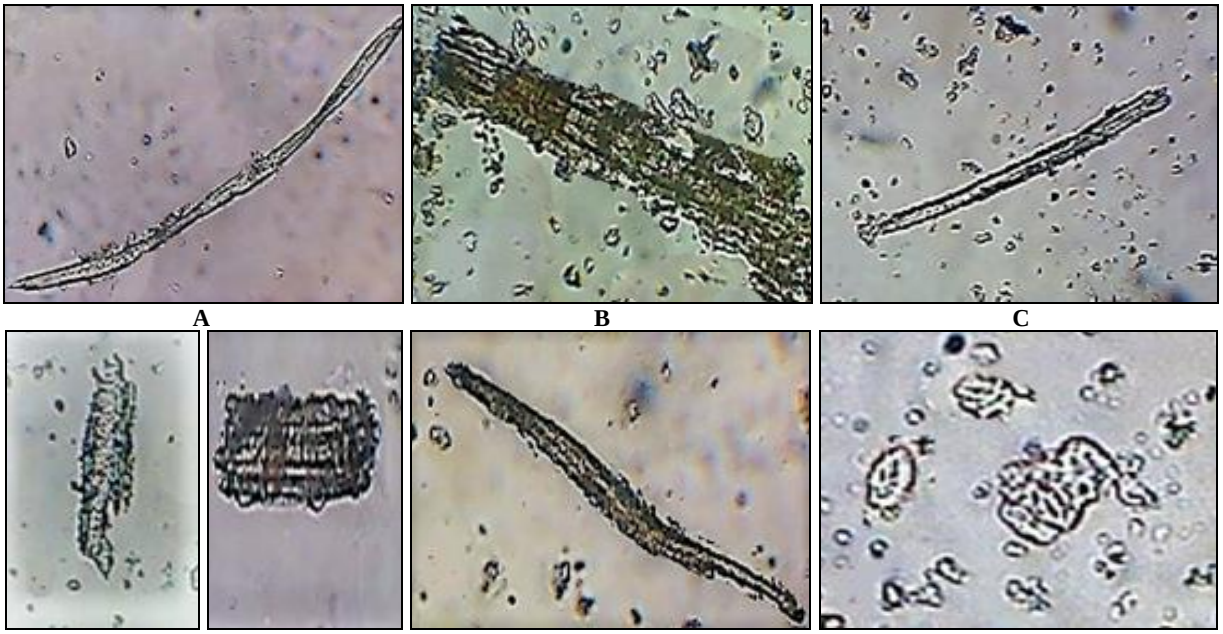

FIG. 3: POWDER MICROSCOPY OF *SYZYGIUM CUMINI* (KALAJAMUN)

A) Pitted fibre with tapering ends in root, B) Cluster of vessels with parenchyma cells in stem, C) Fragment of fibre with narrow lumen in stem, D) Transverse section of part of vessel with reticulate thickening, E) Phloem fibre with tapering ends, F) Anisocytic stomata in leaf

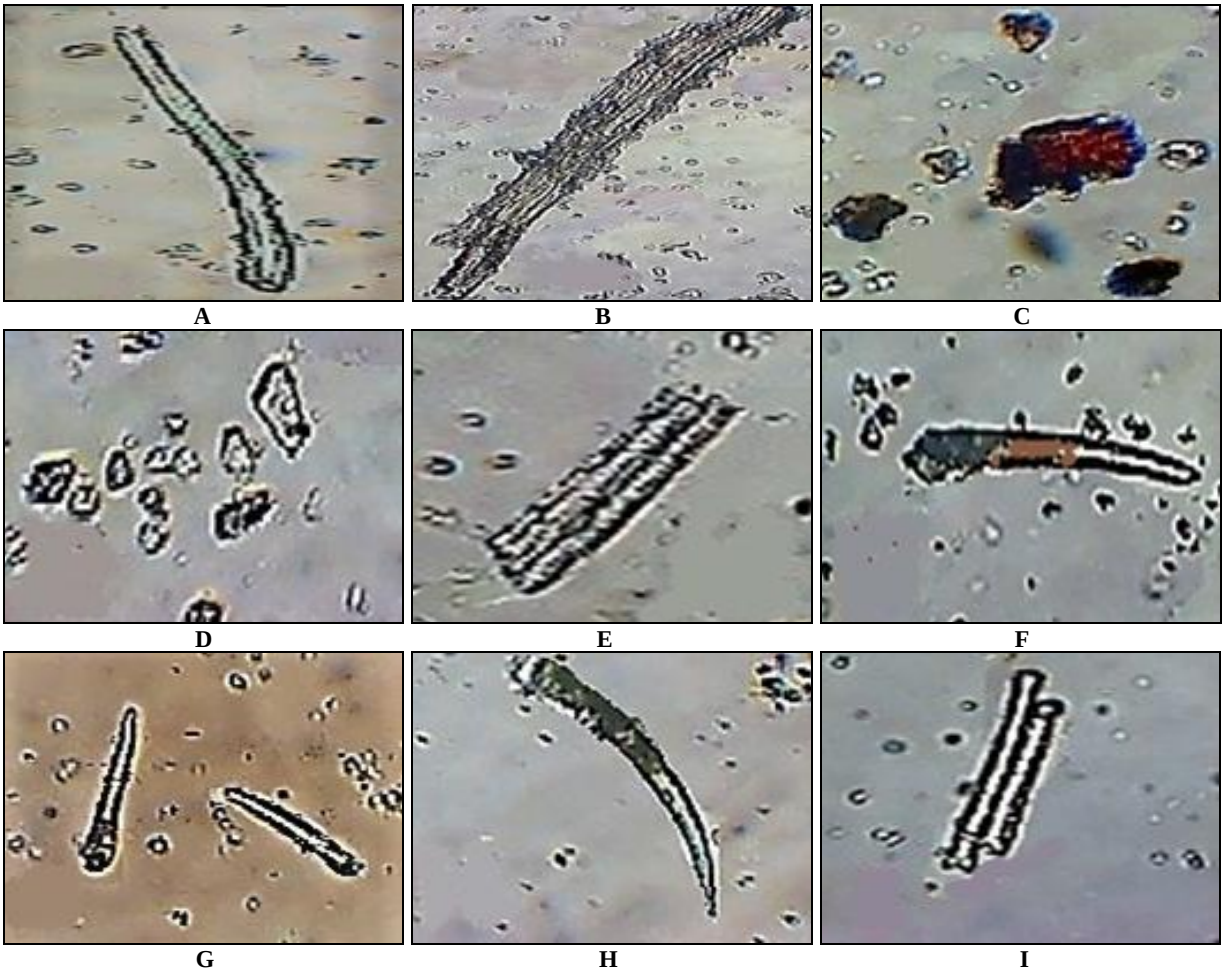

FIG. 4: POWDER MICROSCOPY OF *PTEROCARPUS MARSUPIUM* (BEEJAK)

A) Fibre with tapering ends in root, B) Cluster of fibres in root, C) Cells containing brown pigments in root, D) Calcium oxalate crystals in root, E) Transverse section of part of vessel in stem with reticulate thickening, F)Unicellular trichome in stem, G) and H) Trichomes in leaf, I) Portion of leaf fibres

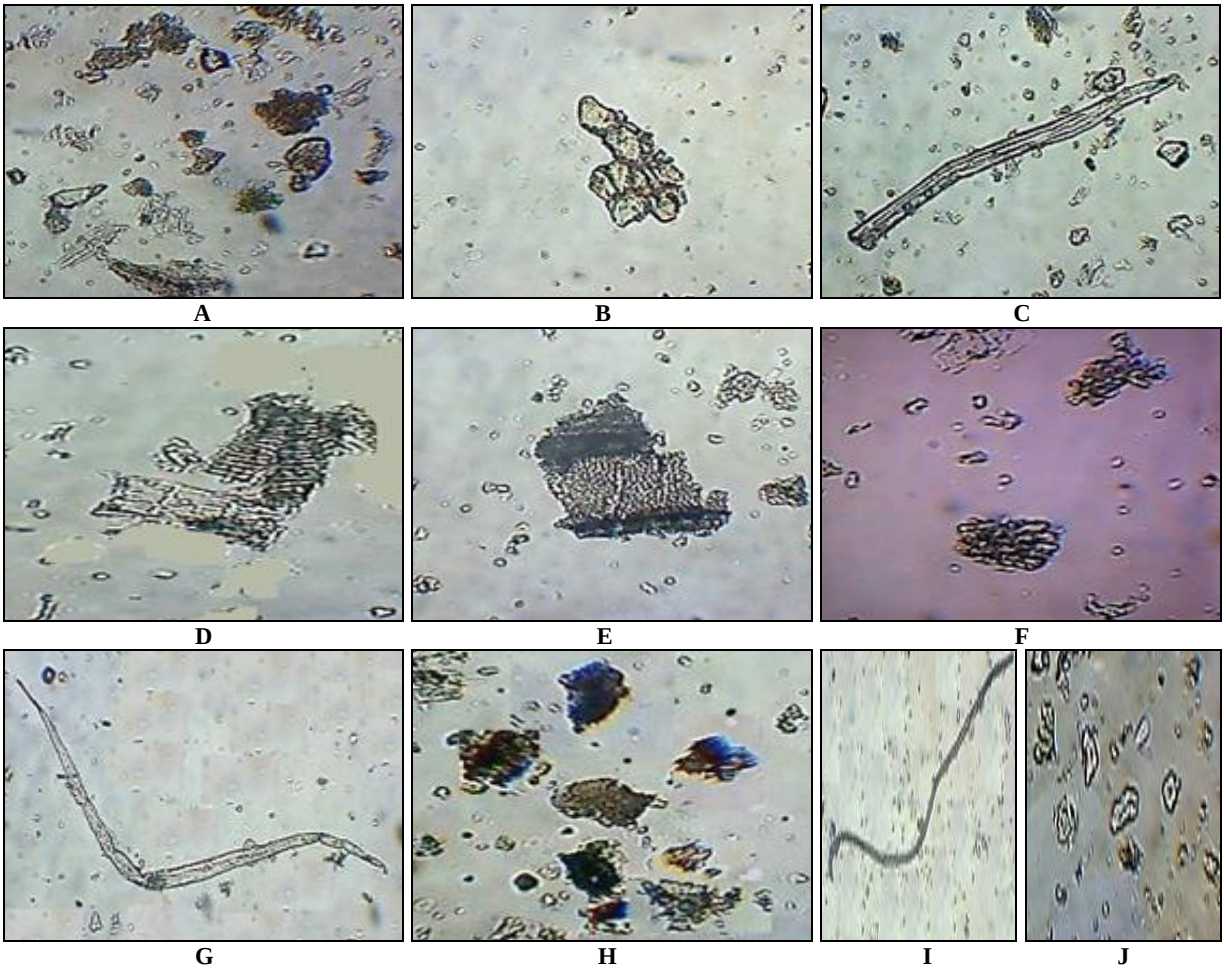

FIG. 5: POWDER MICROSCOPY OF *MOMORDICA CHARANTIA* (KARELA)

A) Cells containing brown pigments in root, B) Cork cells in root, C) Lignified fibre with narrow lumen in root, D) Xylem vessel with annular thickening and E) vessel with reticulate thickening in stem, F) Cork cells in stem, G) Pitted tracheid in leaf, H) Cells containing brown pigments in leaf, I) Phloem fibre in leaf, J) Anisocytic stomata (Transverse section view) in leaf

Physico-chemical Properties:

TABLE 7: PHYSICO-CHEMICAL PROPERTIES OF ROOTS OF DIFFERENT ANTIDIABETIC PLANTS

Parameter	Result % w/w				
	***Azadirachta indica* (Neem)**	***Trichosanthes dioica* (Patol)**	***Syzygium cumini* (Kalajamun)**	***Pterocarpus marsupium* (Beejak)**	***Momordica charantia* (Karela)**
Loss on drying	19.78	8.34	18.52	13.07	15.21
Total ash value	11.2	8.8	10.2	7.2	10.6
Acid insoluble ash	3.0	1.2	5.6	1.8	3.6
Water soluble ash	9.8	7.4	8.0	9.4	10.2
Alcohol soluble extractive value	17.07	12.89	12.20	12.78	17.29
Water soluble extractive value	22.3	18.46	20.78	17.20	26.19

TABLE 8: PHYSICO-CHEMICAL PROPERTIES OF STEMS OF DIFFERENT ANTIDIABETIC PLANTS

Parameter	Result % w/w				
	***Azadirachta indica* (Neem)**	***Trichosanthes dioica* (Patol)**	***Syzygium cumini* (Kalajamun)**	***Pterocarpus marsupium* (Beejak)**	***Momordica charantia* (Karela)**
Loss on drying	13.67	5.69	12.98	16.20	15.27
Total ash value	11.8	10.4	9.6	11.2	8.8
Acid insoluble ash	1.7	1.8	3.8	2.2	3.4
Water soluble ash	9.8	8.6	7.8	9.0	7.2
Alcohol soluble extractive value	17.72	14.97	19.66	16.08	18.56
Water soluble extractive value	22.51	17.59	24.62	21.89	23.76

In case of root samples, loss on drying at 105 ºC and total ash value were maximum for *A. indica*, acid insoluble ash value was noted maximum for *S. cumini*, water soluble ash was seen maximum for *M. charantia.* Both alcohol and water soluble extractive values were seen maximum in case of *M. charantia*.

In case of stem samples, loss on drying at 105 ºC was maximum in case of *P. marsupium*, total ash value was maximum in *A. indica*, acid insoluble ash value and water soluble ash were seen maximum for *S. cumini* and *A. indica* respectively. Both alcohol and water soluble extractive values were seen maximum in case of *S. cumini.*

TABLE 9: PHYSICO-CHEMICAL PROPERTIES OF LEAVES OF DIFFERENT ANTIDIABETIC PLANTS

Parameter	Result % w/w				
	Azadirachta indica **(Neem)**	***Trichosanthes dioica*** **(Patol)**	***Syzygium cumini*** **(Kalajamun)**	***Pterocarpus marsupium*** **(Beejak)**	***Momordica charantia*** **(Karela)**
Loss on drying	12.07	11.68	19.26	16.87	10.45
Total ash value	7.2	11.4	12.0	9.4	9.6
Acid insoluble ash	1.3	4.4	1.6	2.8	3.8
Water soluble ash	5.4	6.5	11.2	7.6	8.0
Alcohol soluble extractive value	19.0	14.97	11.62	15.08	17.56
Water soluble extractive value	23.81	21.84	24.54	24.76	23.11

In case of leaf samples, loss on drying at 105 ºC was maximum in case of *S. cumini*, total ash value was seen maximum in *A. indica*, acid insoluble ash value and water soluble ash were maximum in *T. dioica* and *S. cumini.* Alcohol and water soluble extractive values were seen maximum in case of *A. indica* and *P. marsupium* respectively.

Comparative Physico-chemical Properties: Plant samples from different plant parts showed significant results when compared on the basis of their physico-chemical properties. In case of root samples, loss on drying and total ash value were maximum for *A. indica*, acid insoluble ash value was noted maximum for *S. cumini*. Water soluble ash value was maximum in case of *M. charantia.* Both alcohol and water soluble extractive values were maximum in case of *M. charantia*. In case of stem samples, loss on drying value was maximum in case of *P. marsupium*, total ash value was maximum in *A. indica*, acid insoluble ash value and water soluble ash were maximum for *S. cumini* and *A. indica* respectively. Both alcohol and water soluble extractive values were seen maximum in case of *S. cumini.* In case of leaf samples, loss on drying was maximum in case of *S. cumini*, total ash value was seen maximum in *A. indica*, acid insoluble ash value and water soluble ash were maximum in *T. dioica* and *S. cumini.* Alcohol and water soluble extractive values were maximum in case of *A. indica* and *P. marsupium* respectively.

Phytochemical Properties: Alkaloid, flavonoid, carbohydrates, phenol, tannin, saponin, protein and amino acids were present in all plant samples in different quantities **Table 10** and **11**.

TABLE 10: PHYTOCHEMICAL SCREENING (METHANOLIC EXTRACT)

Antidiabetic plants	Plant part	Group						
		Alkaloid	**Flavonoid**	**Carbohydrate**	**Phenol**	**Tannin**	**Saponin**	**Protein and amino acid**
Azadirachta indica	Root	++	++	+	++	+++	+	-
	Stem	+	++	++	+	+	-	-
	Leaf	++	+++	-	+	+	-	-
Trichosanthes dioica	Root	+	++	-	-	-	-	+
	Stem	++	+	-	+	+	+	+
	Leaf	++	+++	-	++	++	+	-
Syzygium cumini	Root	+++	+	-	++	++	-	-
	Stem	++	+	-	++	++	-	-
	Leaf	+	++	-	+	++	+++	-
Pterocarpus marsupium	Root	_	++	+	+++	++	-	++
	Stem	+	++	+	+	+	-	-
	Leaf	+	+	-	++	-	-	-
Momordica charantia	Root	++	++	-	+	+	++	-
	Stem	+	++	-	++	+	-	-
	Leaf	+	+	-	+	+	+	-

[Highly positive +++, Moderately positive ++, Present in less quantity +, Absent -]

TABLE 11: PHYTOCHEMICAL SCREENING (AQUEOUS EXTRACT)

Antidiabetic plants	Plant part	Group						
		Alkaloid	Flavonoid	Carbohydrate	Phenol	Tannin	Saponin	Protein and amino acid
Azadirachta indica	Root	+	-	-	+	+	-	-
	Stem	+	+	-	++	+	++	-
	Leaf	+	+	-	++	+	++	-
Trichosanthes dioica	Root	-	-	-	+	+	+	-
	Stem	+	-	-	-	-	++	-
	Leaf	-	+	-	-	-	+	-
Syzygium cumini	Root	+++	-	-	-	+++	-	-
	Stem	++	-	-	++	-	-	-
	Leaf	+	-	-	-	++	++	-
Pterocarpus marsupium	Root	++	+	+	+	+	-	+
	Stem	+	+	+	++	+	-	-
	Leaf	-	+	-	-	-	+	+
Momordica charantia	Root	-	-	++	+	+	-	-
	Stem	+	+	-	+	+	+	+
	Leaf	+	+	+	-	-	++	-

[Highly positive +++, Moderately positive ++, Present in less quantity +, Absent -]

Comparative Phytochemical Properties: Methanolic extracts showed absence of carbohydrates in *T. dioica*, *S. cumini* and *M. charantia*. Protein and amino acid were not found in *A. indica* and *S. cumini*. In case of aqueous extracts, flavonoid was not found in any part of *S. cumini*. Only *A. indica* and *P. marsupium* showed the presence of carbohydrate. Saponin was not present in *P. marsupium.* Protein and amino acid were present only in *T. dioica* and *P. marsupium*.

DISCUSSION: Diabetes mellitus is a metabolic disorder which is caused by deficiency in production of insulin by the pancreas or by the ineffectiveness of the insulin which has been produced. Diabetes affected about 371 million people throughout the world, according to International Diabetes Federation (2012) and the number is increasing every year. Diabetes results in hyperglycemia which damages blood vessels, kidney, heart, eyes and vital organs of our body. The management of diabetes has become a global issue in today's world.

The traditional system of medicine proved to treat diabetes with great efficiency. Some bioactive drugs of plant origin showed better result than oral hypoglycemic agents during the treatment of diabetes. The traditional medicine is showing a promising future to treat diabetes. Because of its natural origin and less side effects on human body, Ayurvedic medicine is gaining popularity worldwide.

There were many similar and dissimilar properties found while studying root, stem and leaves of *Pterocarpus marsupium* (Beejak), *Azadirachta indica* (Neem), *Trichosanthes dioica* (Patol), *Syzygium cumini* (Kalajam) and *Momordica charantia* (Karela) in detail. The aim of the study was to compare the active constituents present in the root, stem and leaf of these five medicinal plants which are already being used extensively in Ayurveda in the treatment of diabetes.

It is previously documented that active constituents are mostly derived from leaves and used for the preparation of the herbal medicines. The study focused to find out whether root and stem of the same plant has same active constituents as that of the leaf so that leaf extracts can be replaced by root and stem extracts in order to reduce extensive use of leaves. The result showed that all three plant parts - root, stem and leaf of *A. indica* contain saponin.

So, all root, stem and leaf plant parts may be used (instead of only leaf and seed) for the treatment of diabetes. *M. charantia* and *T. dioica* also showed the presence of saponin in root, stem and leaves. So, all three plant parts can be utilized for the making of Ayurvedic medicines. Samples of *S. cumini* did not show any presence of carbohydrates. All root, stem and leaf extracts of *P. marsupium* showed the presence of flavonoid. Thus, root and leaf extracts may also be used in the treatment of diabetes instead of only stem extract.

The macroscopic and organoleptic study showed prominent characteristics of powdered plant parts. Powder microscopic study revealed the differences between different plant samples. Starch grains were commonly seen in all the samples. Root samples showed different types of thickening in xylem vessels. Scalariform thickening was seen in xylem vessel of *T. dioica* whereas spiral thickening in *S. cumini*. Lignified cork cells were seen in all root samples. Calcium oxalate crystals were seen only in stem samples of *A. indica* and root of *P. marsupium* which may be considered as distinguishing character. Cork cells were observed in all stem samples. Compound starch grains were only seen in stem sample of *S. cumini* which can be considered as a unique character. The fibre of *M. charantia* was lignified among stem samples.

Among leaf samples, lignified cells were only observed in *P. marsupium*. Pitted tracheid was seen in the leaf sample of *M. charantia*. Anisocytic stomata were observed in the leaf samples of *T. dioica* and *M. charantia*. Phytochemical analysis revealed different properties of plant samples. Methanolic extracts showed absence of carbohydrates in *T. dioica*, *S. cumini* and *M. charantia*. Protein and amino acid were not found in *A. indica* and *S. cumini*. In case of aqueous extracts, flavonoid was not found in any part of *S. cumini*. Only *A. indica* and *P. marsupium* showed the presence of carbohydrate. Saponin was not present in *P. marsupium.* Protein and amino acid were present only in *T. dioica* and *P. marsupium*.

CONCLUSION: Diabetes is one of the leading cause of people's suffering throughout the world. The number of people affected by diabetes may reach over 366 million by 2030 (According to WHO). Diabetes is increasing in alarming rate in developing countries, mostly affecting the people aged between 45 and 64 years. As the synthetic medicines have distinct side effects, Ayurvedic drugs are becoming popular among people because of their very less side effects on human body.

The present study revealed significant results related to pharmacognostic as well as phyto-chemical properties of different medicinal plants having antidiabetic property. Pharmacognostic analysis of *Pterocarpus marsupium* (Beejak) showed the presence of trichomes and crystals as key characters for identification. In case of *Azadirachta indica* (Neem), cork cells with brownish pigments, calcium oxalate crystals and anisocytic stomata were seen as identifying characters. *Trichosanthes dioica* (Patol) revealed the presence of compound starch grains which has been considered as a unique character. *Syzygium cumini* (Kalajam) showed to have phloem fibre and *Momordica charantia* (Karela) showed pitted tracheid and anisocytic stomata as the distinguishing characters. The present study was very useful in the identification of root, stem and leaves of these plant species as well as their differentiations from each other.

Phytochemical study has shown the presence of different compounds in root, stem and leaves of these plants in different quantities. The result clearly indicated that instead of using only a specific plant part, root, stem or leaf can be used alternatively for the production of Ayurvedic medicines.

Thus, the plant species can be saved from becoming endangered / extinct. *Momordica charantia* and *Pterocarpus marsupium* have been reported to have reduced blood sugar level while treating type 2 diabetes. These plants are claimed to have stimulating or regenerating effect on beta cells of pancreas.

Further research related to this study would include comparative chemical analysis between modern drugs and extracts of plant parts used in traditional Ayurvedic medicine. The analysis would aim at finding similarities between chromatograms and other factors related to antidiabetic property. The study would be very much helpful to continue further researches related to antidiabetic activity of medicinal plants.

ACKNOWLEDGEMENT: The authors would like to thank Ms. Saswati Sasmal and Ms. Nandita Karmakar, Department of Dravyaguna, IPGAER, Kolkata, West Bengal for their help in the study. The authors also acknowledge the help of Mr. Tapan Seal, Scientist, Plant Chemistry Department, Central National Herbarium, Botanical Survey of India, A.J.C. Bose Indian Botanic Garden P.O. Botanic Garden, Howrah - 711103, West Bengal, India.

CONFLICT OF INTEREST: There are no conflicts of interest.

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How to cite this article:
Manda A, Gupta M and Maity C: Comparative pharmacognosy and phytochemical analysis of medicinal plants with antidiabetic activity (*Pterocarpus marsupium* roxb., *Azadirachta indica* A. juss., *Trichosanthes dioica* roxb., *Syzygium cumini* linn. and *Momordica charantia* linn). Int J Pharmacognosy 2018; 5(8): 475-87. doi link: http://dx.doi.org/10.13040/IJPSR.0975-8232.IJP.5(8).475-87.