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Analysis of the leaf veins and areoles in different medicinal leaves by using image processing techniques

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Abstract: The present study deals with the study of leaf characteristics of medicinal plants of micro and macro levels . The leaves considered are cast roil leaf, betel leaf etc by using the techniques of Image processing. Leaf vein forms the basis of characterization and classification. Different species have different leaf vein patterns. The aim of the work is to classify and authenticate the medicinal plant materials and herbs which are widely used for Indian herbal medicinal products. The quality and authenticity of these leaves are to be ensured for the preparation of herbal medicines. Images play a major role in human perception. The results reveal that is species belonging to the same family exhibit different medicinal properties and species belonging to different families exhibit similar leaf characteristics at the micro and macro levels. The results are presented, discussed and found to be very interesting.

Keywords: Image Processing, Peepal Leaf, Betel Leaf medicinal, Digital Image.

1. INTRODUCTION

Nowadays image processing is becoming an important assisting tool in many branches of science such as computer science, electrical and electronic engineering, robotics, physics, chemistry, environmental science, biology, and psychology. Due to this importance it is good to increase your knowledge in image processing so that you can develop new ideas in that field or introduce a new application of computer vision in your research.

Medicinal Plants have been part of our lives since the beginning of time. We get numerous products from plants, most of them not only good and beneficial for our health, but also crucial to our existence. In this essay we will explore the connection between plants, medicine, our food, and modern science.

Interest in the geometry and topology of complex networks has grown immensely during the last few decades [1],[22]. Studies of the structure of river networks [28],[14], the internet [1], and social networks [37] have been driven large amounts of empirical information, often with concomitant theoretical development to explain network structure.

More relevant to the study of leaf networks is a resurgence of interest in the structure of physical networks in biology and, in particular, resource delivery networks like cardiovascular networks, xylem networks, or leaf venation networks as a whole [18], [33], [31],[32],[15] . However, because of the inherent difficulty in measuring physical biological networks, the growth in theory has arguably outpaced the available data needed to test theoretical predictions or assumptions [39],[40],[5],[12],[25],[14].

Given the importance of physical networks in regulating the flow of biological fluid, one might think that libraries of data should exist with detailed measurements on their geometry from which one could evaluate theoretical predictions: this is not the case. While some data exist quantifying the dimensions of mammalian networks in their entirety [42], less work has been done on plants [18],[20],and those descriptions that do exist are usually of a part of the network, not the whole. For example, there is a long history of measurements of components of the aboveground structure of xylem networks. Extensive measurements have been made of vein length distributions [36],width and scaling of xylem[2],[38],[11],[21], and even relative hydraulic resistance across distinct components of trees [35],[34],[20]. In addition, there is a growing interest in describing detailed root network structure, largely applied to Arabidopsis (Arabidopsis thaliana) as well as to crop plants [16],[17],[19]. Most attempts to quantify the hydraulic structure of physical networks in leaves have focused on quanti-fication of the geometry of part of the leaf vascular network. By network we mean the hierarchical vessel bundles that pervade leaves and contain xylem, phloem, and structural elements. Those empirical measurements thus far include quantification of: the distribution of branching angles in several leaf species [6], the lengths and diameters of vessel bundles in the side lobe of a leaf[34] , the length per unit area of the higher-order veins [30] ,[8], [7],[9] , or the length and width of the primary and sometimes secondary venation[23],[24], . We are aware of only one attempt to quantify the linear dimensions of an entire leaf network that relied on an admirable but painstaking point-and-click approach in relatively small Arabidopsis leaves [29], similar to that found, and leaves commonly used in developmental studies. Quantifying the geometry of entire leaf networks has remained elusive in part because of the sheer number of measurements required and because of the difficulties in automated image segmentation.

Quantifying the geometry of leaf networks has significant implications for many areas of plant biology. (1) The structure of leaf networks has been implicated in the leaf economics spectrum, with several authors speculating that increased hydrodynamic and structural demands may lead to increased investment in vein networks as leaves become larger [23],[24].(2) Changes in leaf venation structure have the potential to influence mass- or area-based leaf photosynthetic rates via a reduction in specific leaf area, which is one of the principle dimensions underlying the leaf economics spectrum [27],[41]. (3) Recent studies have demonstrated that leaves are the major hydraulic bottleneck in plants [31]; thus, detailed measures of vein geometry will inform attempts to model patterns of hydraulic conductance [10]. (4) Network structure can limit photosynthesis due to its effects on hydraulic efficiency, with recent studies implicating leaf vein density, defined as total vein length over area, as a strong predictor of photosynthetic rates [30],[8], which may also have played a role in the diversification of early angiosperms [9], [8]. (5) Leaf vein patterning has been shown to be correlated with leaf shape, suggesting shared developmental pathways [13]. (6) Leaf vein impressions are arguably the most abundant plant macrofossil available to paleobotanists; thus, the ability to more rigorously quantify vein geometry has the potential to aid attempts to identify fossil samples with greater phylogenetic resolution [4].

Interest in the structure and function of physical biological networks has spurred the development of a number of theoretical models that predict optimal network structures across a broad array of taxonomic groups, from mammals to plants. In many cases, direct tests of predicted network structure are impossible given the lack of suitable empirical methods to quantify physical network geometry with sufficient scope and resolution. There is a long history of empirical methods to quantify the network structure of plants, from roots, to xylem networks in shoots and within leaves. However, with few exceptions, current methods emphasize the analysis of portions of, rather than entire networks[43].

2. PROBLEM SPECIFICATION

The main objective of the present study is to make a detailed analysis of the structure of veins in different Indian Medicinal leaves in particular, Peepal Leaf, Betel Leaf ,Hibiscus Leaf etc by using the techniques of image processing methodologies. Different samples are taken and the experiments are conducted.

The Medicinal properties of the samples are given in briefly in Table 1.

3. METHODOLOGY

The main goal of preprocessing is to identify the leaf in an image and discarding all other information other than the leaf shape.

In order to make a detailed analysis of the macroscopic structure of veins in Peepal Leaf,Betel Leaf, Hibiscus Leaf and also to predict the other character tics like Areole and Area characteristics of the leaves and the codes are written in Matlab 7.0/7.4 Version.

4. EXPERIMENTS AND RESULTS

The experiments are conducted on the data, codes are written and six major steps are performed by using Matlab(7.0/7.4) version . The results are presented in Table 2.

LEAF GUI is an interactive software program [44] built in MATLAB. The purpose of the software is to dramatically increase the speed and accuracy of the extraction and processing of vascular and areole structure from digital images of leaves. The program incorporates many image processing and analysis tools into a single graphical user interface. The software is modular in construction, including preprocessing, image cleanup, and leaf network extraction steps. The overall process that a user might take to process a leaf image and measure structure within the leaf network can be broken down into five major steps: (1) setting the scale of the leaf image, (2) initial image cropping, (3) image thresholding, (4) binary image cleaning and processing, and (5) extracting leaf network features. In this study and in the software.

Table 1

Sl. No	Name of the Leaf	Medicinal Properties
01	Betel Leaf	The leaf contains certain poly-phenols that battle organisms, as well as go about as agony relievers and mitigating operators. Late reviews have demonstrated that the leaf contains tannins, sugar, diastases and a fundamental oil. A specific phenol called ˜chavicol, show in it has intense sterile properties. The leaf has pain relieving and cooling properties, and can be connected on the agonizing range for brief alleviation. Betel leaves have great diuretic properties. The betel leaves are likewise valuable in treating apprehensive torments and debility. Betel leaf has been being used since old circumstances for mending wounds. Ayurveda has firmly put stock in this property of the leaf.. Additionally, late reviews have demonstrated that the leaf contains segments that have chemo-preventive and hostile to tumor properties.
02	Castoril Leaf	The castor plant or Eranda is perennial shrub and used for treating various ailments. Castor plant has anti-oxidant, anti-inflammatory, antimicrobial, liver protecting and various other medicinal properties. Castor oil or eranda taila (eranda oil) is extracted from castor beans is very good laxative, anti -inflammatory and cures skin problems. It is highly recommended to use this oil only occasionally for constipation. Although there are countless medicinal use of different part of this plant here are some of them that can be used at home without any side effect, if taken in recommended doses. Ayurvedic Properties and Action on body For medicinal purpose the leaves and dried mature roots of plant are used. Below is given the Ayurvedic properties and action of fresh

		leaf and dried roots of castor.
03	Papaya Leaf	Papaya Leaves contain capable recuperating exacerbates that are essential for awesome wellbeing and essentialness... what's more, to cure tumor and dengue fever. Papaya Leaves are awesome for disposing of attacking microscopic organisms that cause irritated stomach issues since they contain karpain which eliminates microorganisms. What's more, it contains loads of papain, protease chemical, and amylase catalyst which help to separates proteins, carbs, and sooth the GI tract... what's more, assists with heartburn. Papaya Leaves lessen aggravation of the stomach lining and mend gastric ulcers by slaughtering H. pylori microorganisms. What's more, Papaya Leaf tea alleviates away colon irritation from IBS and other fiery gut ailments
04	Mango Leaf	The mango leaves are extremely valuable for treating diabetes. The delicate leaves of the mango tree contain tannins called anthocyanidins, which treats early diabetes. The leaves are dried and powdered or utilized as an imbuement to treat the same. It likewise treats angiopathy diabetes and diabetic retinopathy The mango leaves are ruddy or purplish when delicate and new, and develop into a dim green shading and have a pale underside. These leaves are rich in vitamin C, B and A. They are additionally rich in different supplements. The mango leaves have capable cell reinforcement properties as they have a high substance of flavonoids and phenols.
05	Coriander Leaf	**Coriander** or **cilantro** is a wonderful source of dietary fiber, manganese, iron and magnesium as well. In addition, **coriander leaves** are rich in Vitamin C, Vitamin K and protein. They also contain small amounts of calcium, phosphorous, potassium, thiamin, niacin and carotene. It helps in lowering blood glucose levels in diabetics. Coriander is rich in phytonutrients and flavonoids. It helps in curing anemia.
06	Lemon Leaf	Among the **health benefits of lemon** highlights its value as anticatarrhal, benefits blood circulation, capillary protector, antihypertensive, antispasmodic, diuretic, applied to the skin and mucous membranes is antibacterial and antifungal. Lemon leaves are used all over the world to season dishes and entrees. Added to beer and wine, lemon leaves create a citric tang. Chop them up and let them float around in homemade soups or in your hot tea for a flavor blast. Lemon leaves, which are high in vitamin C, are a natural way to assist the body in fighting infections. When choosing lemon leaves, make sure they are organic and have not been mixed with chemicals or dyes. Fresh is always better, but you can also dry out the leaf.
07	Peepal Leaf	Peepal tree is of extraordinary restorative esteem. Its leaves fill in as a superb diuretic and in addition tonic for the body. It is particularly valuable for patients experiencing Jaundice. It controls the over the top measure of pee discharged amid jaundice. The leaves of Peepal are exceptionally compelling in treating heart issue. It controls the palpitation of heart and subsequently battle the cardiovascular shortcoming. Ayurveda makes a broad utilization of the leaves of peepal because of the various advantages it gives. To find out about the restorative advantages of Peepal, perused on. Peepal has extraordinary restorative incentive too. It is broadly utilized as a part of Ayurveda. All aspects of this tree is eatable and offers various advantages. Peepal is utilized as a part of treatment of different contaminations, recuperating of wounds, enhance ripeness and treat harming. The leaves are laxative and tonic.

Table 2

Sl. No	**Description**	**Betel Leaf**	**Cast roil Leaf**	**Papaya Leaf**	**Mango Leaf**	**Coriander Leaf**	**Lemon Leaf**	**Peepal Leaf**
	Name of the Family	**Piperace**	**Euphorbiaceae**	**Caricaceae**	**Anacardiaceae**	**Apiaceae**	**Rutaceae**	**Moraceae**
1	Leaf Area(mm^2)	398.31	356.632	22.734	87.068	14.348	14.876	72.473
2	Leaf Perimeter(mm)	83.173	69.92	22.94	42.36	15.56	15.52	34.32
3	Number of Nodes	4399.333	800.5	428.5	1121	151	107.666	70
4	Number of Edges	5095.333	987.5	448.5	1289	205	146.333	84
5	Edges/Node	1.158	1.234	1.047	1.150	1.358	1.359	1.200
6	Number of Areoles	2866.333	569.25	130.666	888	150	117.666	79
7	Total Network Length(mm)	1913.185	3874.03	101.3	268.054	47.371	36.492	50.339
8	Total Network Area(mm^2)	401.685	356.987	28.184	88.096	14.404	14.918	72.49
9	Areoles/Area	7.196	1.596	5.748	10.199	10.454	7.910	1.090

10	Edges/Area	12.792	2.769	19.728	14.805	14.288	9.837	1.159
11	Network Area/Area	1.008	1.001	1.240	1.012	1.004	1.003	1.000
12	Mean Area(mm^2)	0.033	0.008	0.003	0.004	0.003	0.001	0
13	Mean Convex Area(mm^2)	0.067	0	0.007	0.005	0.005	0.002	0
14	Mean Eccentricity	0.5553	0.337	0.182	0.335	0.404	0.372	0.236
15	Mean Solidity	1.286	0.987	0.645	0.988	0.965	0.978	0.989
16	Mean Perimeter(mm)	0.306	0.037	0.095	0.067	0.126	0.068	0.029
17	Mean Equiv diameter(mm)	0.069	0.029	0.027	0.035	0.044	0.033	0.028
18	Mean Major axis(mm)	0.12	0.014	0.043	0.047	0.066	0.048	0.034
19	Mean Minor axis(mm)	0.057	0.025	0.025	0.031	0.038	0.029	0.027
20	Mean Distance (mm)	0.027	0.02	0.013	0.02	0.02	0.02	0.02
21	Mean Edge Length(mm)	0.269	0.27	0.213	0.49	0.179	0.364	1.082
22	Mean Width(mm)	0.202	0.185	0.133	0.224	0.123	0.162	0.596
23	Mean 2DArea(mm^2)	0.268	0.198	0.0725	0.35	0.059	0.162	1.314
24	Mean 3DSurface Area(mm^2)	0.842	0.622	0.228	1.1	0.186	0,511	4.129
25	Mean Volume (mm^2)	0.694	0.447	0.064	0.652	0.052	0.144	3.091
26	Centroid1	580.156	118.071	88.305	147.266	56.591	79.036	169.586
27	Centroid2	616.767	154.796	82.98	404.174	69.889	81.825	194.314

Table 2 displays the leaf characteristics with regard to the species like Betel leaf , Castroil Leaf , Papaya Leaf, Mango Leaf, Corridor Leaf , Lemon Leaf , Peepal Leaf. These values provide a clear knowledge about the micro as well as macro characteristics aspects of the medicinal leaves under considerations

5. TERMINOLOGY

1. Areole Number: The unbelievable abode ID situated that areole , from 1 to the abode areoles.
2. Areole Area(mm2):The place of business of pixels in each areole times the outlook of a base hit pixel
3. Eccentricity (dimensionless, chain between no one at all and one): This is the share of the eclipse between the foci of an ellipse and its hobby axis. The ellipse has the agnate normalized instant second of outlook as the region.
4. Solidity(dimensionless, alps between no one at all and one): This is the pro portion of the Areole Area to its Convex Area
5. Perimeter (mm): The eclipse everywhere the boundary of areole.
6. Equivalent Diameter (mm): This is the cross measure of a take off that has the cognate normalized breath central moments as the region.
7. Major Axis and Minor Axis (mm): Major Axis and Minor Axis (mm) of the ellipse that has the related normalized second central moments as the region.
8. Mean Distance(mm): The cooking with gas Euclidean transcend between each areole pixel and the nearest artery pixel
9. Edge Number: The incredible number diffuse to catch a glimpse of that upset , from 1 to the number of edges.
10. Length (mm): The period of time of the edge. This is expected as the eclipse overall the cold meat by bodily of the eclipse between pixels show and tell a boundary as 1 and the distance between pixels show and tell a boundary as 1 and the distance between pixels installed by their corners as the return root of 2
11. Centroid1: Centroid 1 is the perform of bodily x-coordinates for the corpse pixels in a if and only if edge.
12. Centroid2: Centroid 2 is the produce of all y-coordinates for the skeleton pixels in a if edge.

Figures 1 to 27 clearly give the Pie-chart representation of the values presented in Table 2. These figures enable us to understand the facts in a quantitative manner as well as the qualitative manner. These graphical representations are self explanatory.

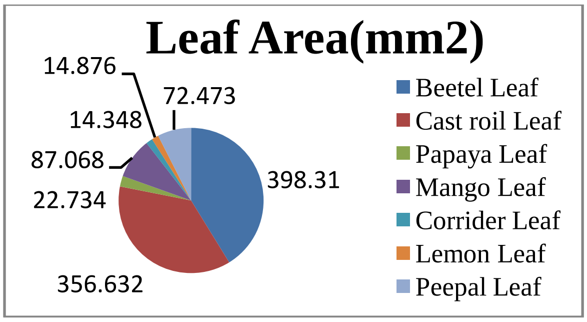

Figure 1 Leaf Area (mm^2) of Seven medicinal leaves

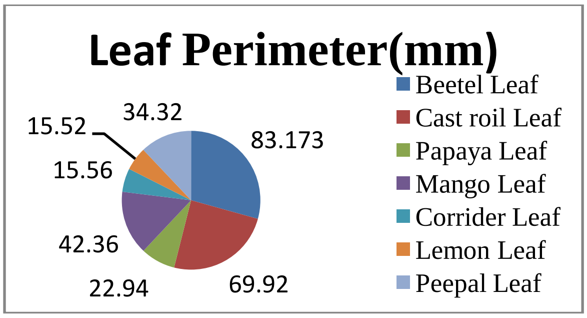

Figure 2 Leaf Perimeter (mm) of Seven medicinal leaves

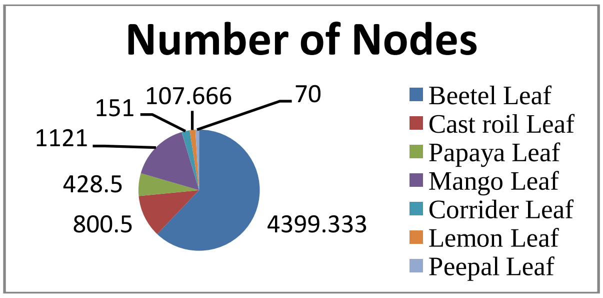

Figure 3 Number of Nodes of Seven medicinal leaves

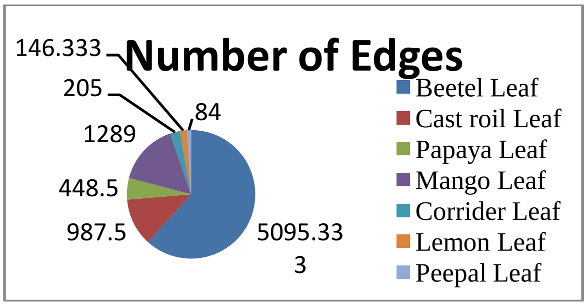

Figure 4 Number of Edges of Seven medicinal leaves

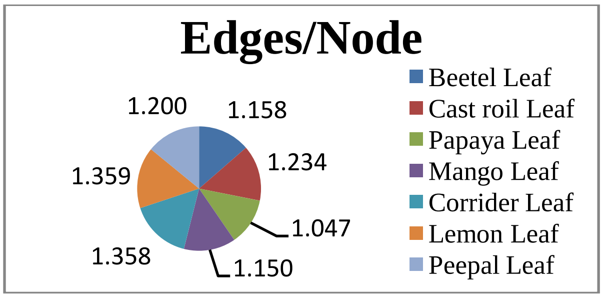

Figure 5 Edges/Nodes of Seven medicinal leaves

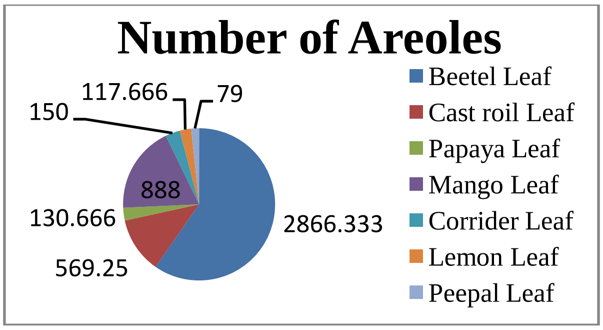

Figure 6. Number of Areoles of Seven medicinal leaves

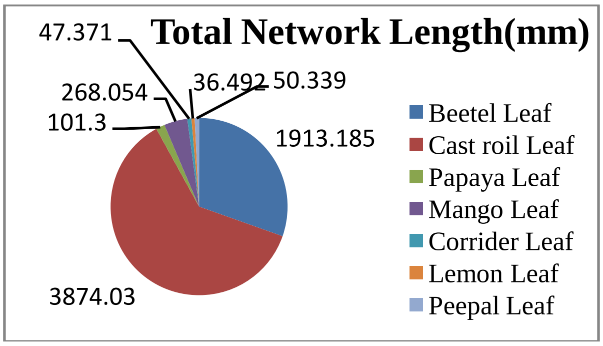

Figure 7 Total Network Length (mm) of Seven medicinal leaves

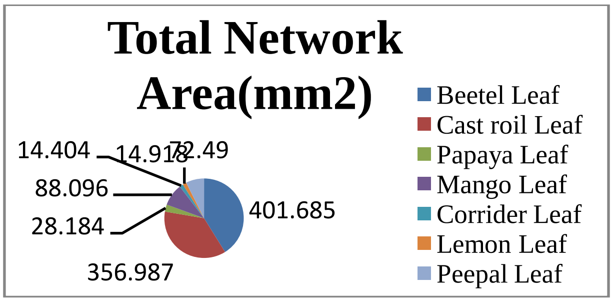

Figure 8 Total Network Area(mm^2) of Seven medicinal leaves

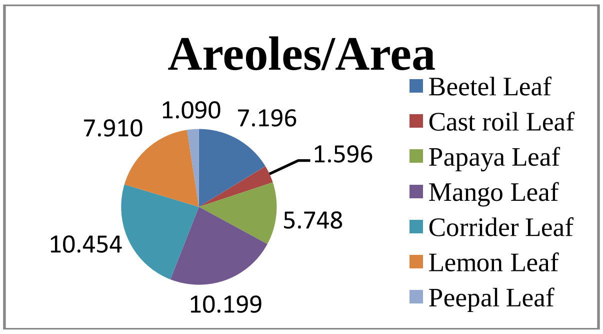

Figure 9 Areoles/Area of Seven medicinal leaves

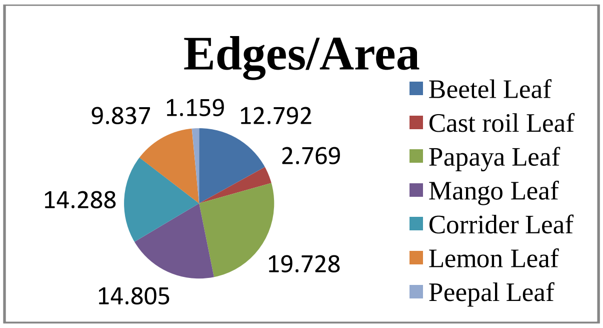

Figure 10 Edges/Area of Seven medicinal leaves

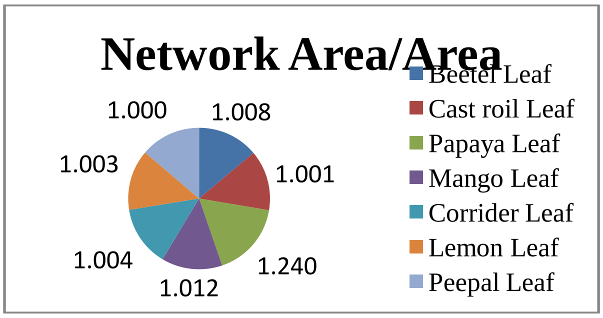

Figure 11 Network Area/Area of Seven medicinal leaves

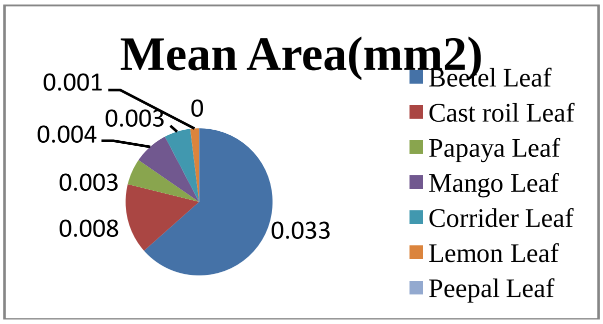

Figure 12 Mean Area(mm^2) of Seven medicinal leaves

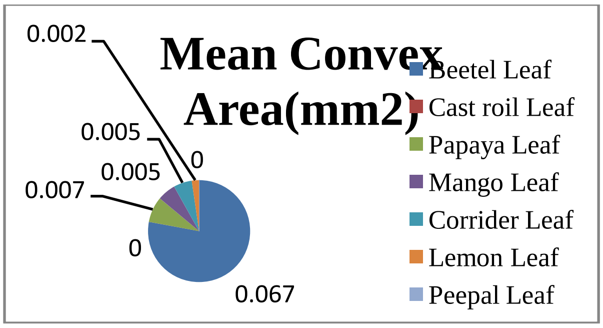

Figure 13 Mean Convex Area(mm^2) of Seven medicinal leaves

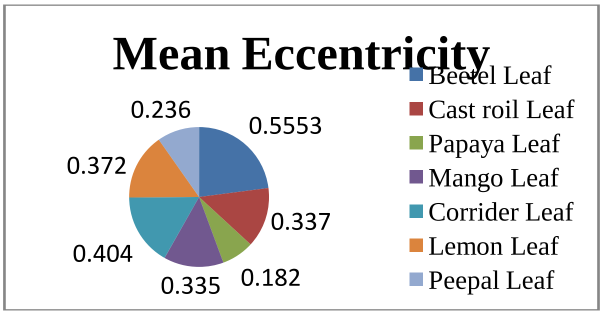

Figure 14 Mean Eccentricity of Seven medicinal leaves

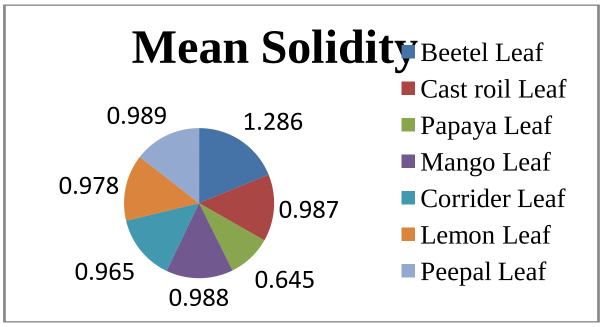

Figure 15 Mean Solidity of Seven medicinal leaves

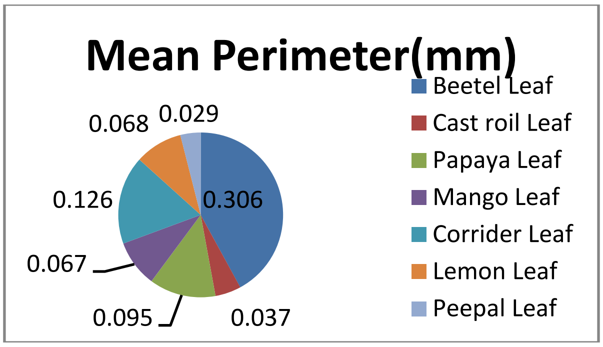

Figure 16 Mean Perimeter of Seven medicinal leaves

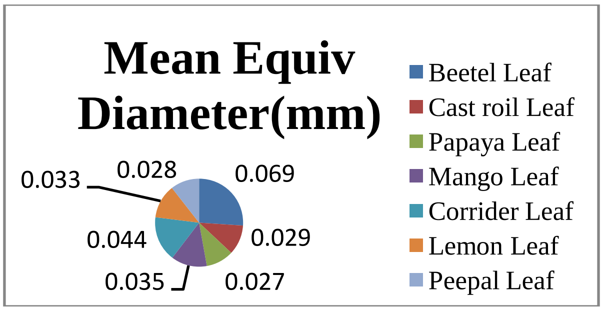

Figure 17 Mean Equiv Diameter of Seven medicinal leaves

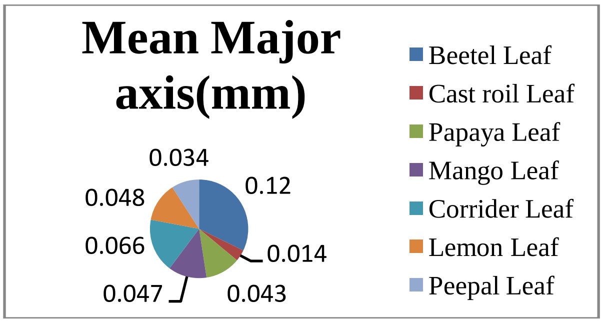

Figure 18 Mean Major axis(mm) of Seven medicinal leaves

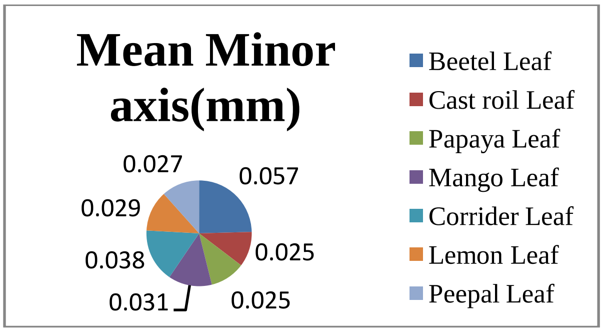

Figure 19 Mean Minor axis(mm) of Seven medicinal leaves

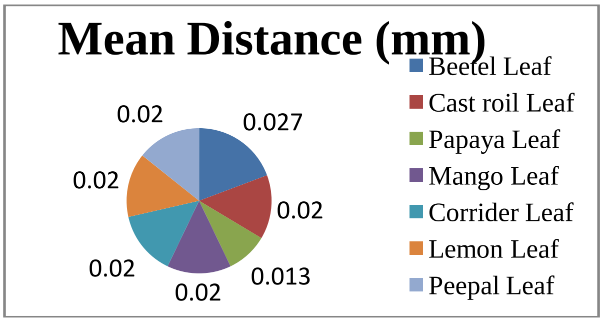

Figure 20 Mean Distance of Seven medicinal leaves

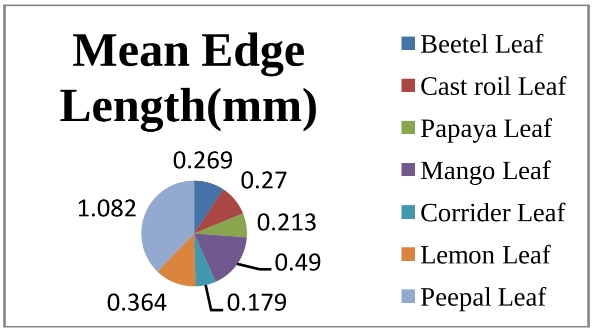

Figure 21 Mean Edge Length(mm) of Seven medicinal leaves

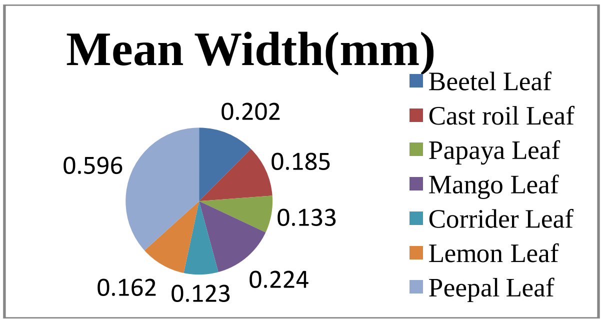

Figure 22 Mean Width(mm) of Seven medicinal leaves

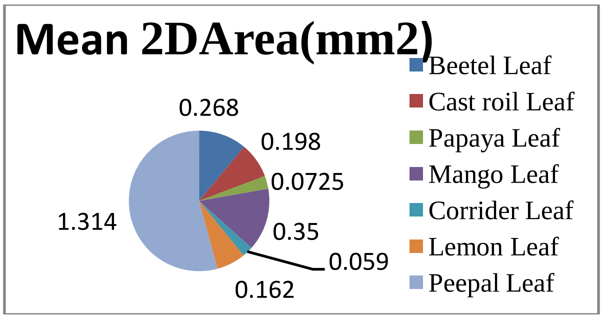

Figure 23 Mean 2DArea of Seven medicinal leaves

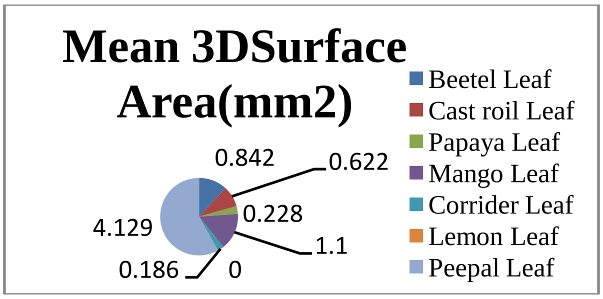

Figure 24 Mean 3 D Surface of Seven medicinal leaves

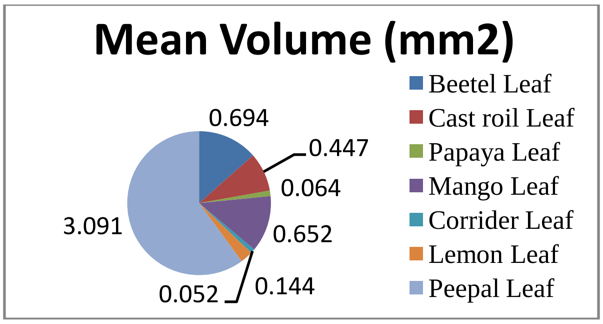

Figure 25 Mean Volume(mm^2) of Seven medicinal leaves

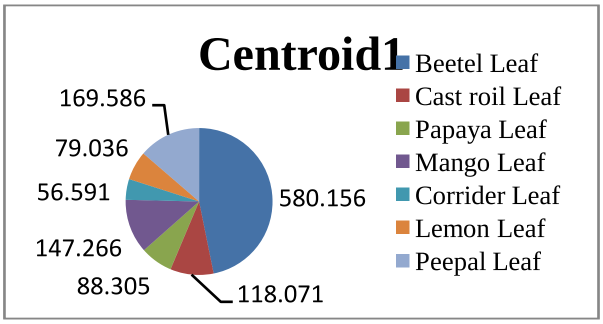

Figure 26 Centroid1 of Seven medicinal leaves

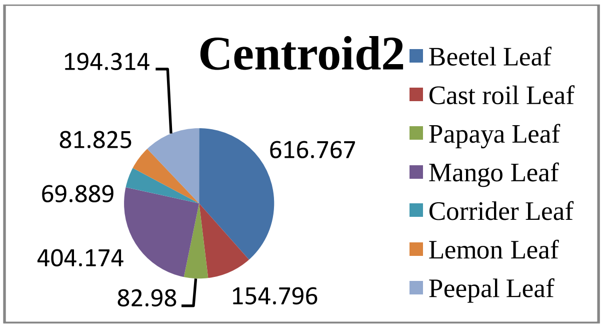

Figure 27 Centroid2 of Seven medicinal leaves

From the present investigation the following observations are made:

i) Species belonging to the same family exhibit leaf characterics of drastically difference.
ii) **S**pecies belonging to the same family exhibit different medicinal properties and species belonging to different families exhibit similar leaf characteristics at the micro and macro levels.

6. CONCLUSION

In this paper the shapes, sizes and details of leaves are discussed. The Important observations made are the differences in the number of edges, total network area, number of areoles, eccentricity which are due to their bio-structure bio-medicinal and physical structure which cannot be performed through naked eyes

7. ACKNOWLEDGEMENTS

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44. LEAF GUI is an interactive software program built in MATLAB.

