Chapter - 4

EXPERIMENTAL

4.1. Survey of Dakshin Dinjapur district for information on uses of plants in local medicine

The present investigation has been undertaken to know the traditional knowledge about the uses of medicinal plants, generally predominant in the selected areas of Dakshin Dinajpur district. The investigation has carried out on the 48 villages of 4 blocks of Dakshin Dinajpur district. The villagers of Dakshin Dinajpur district depends mainly on cultivation. The information on scientific name, local name of the plant part used to cure and method of dosage has been provided (Table 1). The herbarium specimens of the plants with voucher specimen number have been deposited in the North Bengal University herbarium.

The data on medicinal plants, which was collected from inhabitants in and around the villages in the Dakshin Dinajpur district, were pooled and analyzed. The present course of investigations has revealed the usage of 107 medicinal plant species used by the villagers, especially Santal, Munda tribes from the Dakshin Dinajpur district of West Bengal. The investigation revealed the medicinal plants of 107 species and 96 genera belonging to 48 families, which are commonly used for the various diseases by various tribes (Santal, Munda, etc.) of the selected area (Table 2, Fig I and plates XIII to XVI).

According to the information gained from villagers, the medicinal plants used by them for kidney and other urinary problems are *Kalanchoe pinnata, Tribulus terretris, Saraca indica, Abroma augusta.* Jaundice is treated with the plants, *Achyranthes aspera, Andrographis paniculata, Swertia chirata., Cajanus indicus, Saccharum officinarum, Piper betle* etc.

For the treatment of dysentry the plants used by the villagers are *Coccinia cordifolia, Enhydra fluctuans, Clerodendrum viscosum, Punica granatum, Syzygium cumini, Tamarindus indica, Aegle marmelos, Kalanchoe pinnata, Acacia arabica, Centratherum anthelminticum., Cynodon dactylon., Piper betle, Psidium guyava, Centela asiatica, Lannea grandis, Murraya paniculata, Pterocarpus santalinus, Basella alba, Averrhoe carambola, Paederia foetida., Glycyrrhiza glabra* etc.

Table 1: Plants used for the treatment of various diseases in the villages of Dakshin Dinajpur, West Bengal

Sl. No.	Scientific name	Local name	Parts used	Uses
1	*Acacia arabica.* Wild. Leguminaceae	Babla	Fruit, bark, gum	Dysentery, stomach/ liver problem, gallbladder infection, reduces urine sugar, mail sterility, mumps, ulcer
2	*Achyranthes bidentata Blume* Amaranthaceae	Apang, Chatchatia	Root, leaf, plant body	Joining of bones, rheumatism, reduces urine sugar, mail sterility, piles, periodic problem, hum, urinary track infection
3	*Adhatoda vasica* Acantheceae	Basak	Leaf, root, flower, stem, bark	Cold-cough, fever, asthma
4	*Aegle marmelos* Rutaceae	Bel	Leaf, root, bark, fruit,	Reduces blood sugar, dysentery, stomach/ liver problem
5	*Allium sativum. Linn.* Liliaceae	Rasun	Bulbils, clove	Rheumatism,
6	*Aloe Barbadensis* Mill.(=*Aloe vera* Linn.) Burm.f Liliaceae	Ghritokumari, Kumari	Leaf	Headache, dysentery, reduces urine sugar, mail sterility
7	*Alstonia scholaris.* R.Br. Apocynaceae	Chhatim	Bark	Reduces urine sugar, mail sterility,
8	*Andrographis paniculata* Nees. Acanthaceae	Kalmegh	Leaf, whole plant	Fever, worm, stomach/ liver problem
9	*Asparagus racemosus.* Wild. Liliaceae	Satamuli/ Satavari	Root, leaf	Gallbladder infection, blood purifier, reduces urine sugar, mail sterility
10	*Averrhoe carambola* Linn. Oxalidaceae	Kamranga	Root, leaf, fruit, Bark	Diarrhea, fever, impotency, asthma
11	*Bacopa monniera* (Linn) Pennell. Scrophulariaceae	Brahmi	Whole plant, root, leaf	Memory increases, nervous disorder,
12	*Basella alba* Linn. Basellaceae	Pui	Leaf, stem	Tumor, white dysentery, blood dysentery
13	*Blumea lacera.* De. Asteraceae	Kukursoka	Whole plant	Stomach/ liver problem, loss of appetite
14	*Boerhavia difusa.* Linn. Ficoidaceae	Purnanaba	Leaf	Rheumatism, urinary track infection

Sl. No.	Scientific name	Local name	Parts used	Uses
15	*Borassus flabellifer.* Linn. Palmae	Tal	Leaf bud, fruit, endosperm	Insomnia, gonorrhea, leucorrhea, acidity, piles,
16	*Butea monosperma* (L) Tanb *B. Frondosa* Koen ex Roxb Pappilionaceae	Palash	Leaf, bark, flower, gum, seed	Skin care, urinary problem, worm, piles
17	*Cajanus cajan* (L.) Huth. Leguminaceae	Arhar	Leaf, root, seed	Reduces blood sugar, jaundice, dyspepsia, cough
18	*Calotropies procera* Asclepedaceae	Akanda	Leaf, flower, root, dried bark and gum	Cold-cough, rheumatism, piles, snake bite, asthma, headache
19	*Cariandrum sativum.* Linn. Apiaceae	Dhane	Plant body, leaf, fruit	Gallbladder infection, bile
20	*Cassia sophera* Ceasalpinaceae	Kalkasunde	Leaf, entire plant	Stomach/ liver problem, mail sexual problem
21	*Catheranthus roseus* Apocynaceae	Nayantara	Leaf	Reduces blood sugar, cancer, leukemia, hypertensive, antispasmodic.
22	*Hydrocotyle asiatica* (Linn) Urban. Apiaceae	Thankuni	Pod, leaf	Dysentery, anti-inflammatory, jaundice, diuretic, diarrhea.
23	*Centratherum anthelminticum.* Wild. Asteraceae	Somraj	Leaf, seed	Dysentery, stomach/ liver problem, Cold-cough, worm,
25	*Cinnamomum tamala* (Hamilton) Nees and Ebermaier. Lauraceae	Tejpata	Leaf, bark	Reduces blood sugar, cold-cough, memory decrease, quench thirst, skin care,
26	*Cissus quadrangularis.* Linn. Vitaceae	Harjora	Whole plant, leaf	Joining of bones, rheumatism, piles, periodic problem, worm
27	*Clerodendrum viscosum* Vent. Verbenaceae	Bhati, Ghetu	Leaf, bud, root, Whole plant	Malarial fever, any fever, worm, dysentery, stomach/ liver problem, piles
28	*Clitoria ternatea* Linn. Papilionaceae	Aparajita	Root	Epilepsy, headache, memory increase, migraine, eye problem
29	*Coccinia cordifolia* Cogn. Cucurbitaceae	Telakutcha	Leaf	Reduces blood sugar, dysentery, stomach/ liver problem, cold-cough, contraception, cardiac problem, reduce blood pressure

Sl. No.	Scientific name	Local name	Parts used	Uses
30	*Cucurbita maxima* Duchesue. Cucurbitaceae	Kumra	Whole plant, flower, fruit, seed	Gallbladder infection, loss of appetite, mail sterility, increase of milk in breast
31	*Curcuma amada* Roxb. Zingiberaceae	Aam ada	Whole plant	Cold-cough, fever, piles, rheumatism
32	*Curcuma longa* Linn. Zingiberaceae	Halud, Haridra	Rhizome	Bacterial infection, skin protection, liver problem, worm, filaria, allergy, asthma, ulcer
33	*Cynodon dactylon.* (Linn.) Pers. Gramineae	Durba	Grass	Dysentery, blood purifier, piles, periodic problem, leucorrhoea
34	*Cyperus rotundus* Linn Cypreraceae	Motha	Plant body, bulbous root	Dysentery, poison bite
35	*Datura metel* Linn. Solanaceae	Dhutura	root, Leaf,	Hydrophobia, mental handicap, rheumatism,
36	*Eclipta alba* Asteraceae	Bhimraj, Vringraj	Leaf, seed	Stomach/ liver problem, anti-inflammatory, digestive, hair tonic.
37	*Enhydra fluctuans* Asteraceae	Helencha	Plant body	Reduces blood sugar, dysentery, stomach/ liver problem, blood purifier
38	*Erythrina variegate* Linn. Leguminaceae	Kantamother/ Mother	Root, root bark, leaf	Rheumatism, mail sexual problem, rickets, worm, periodic problem
39	*Ficus bengalensis.* Linn. Moraceae	Bat	Gum, bark	Reduces urine sugar, mail sterility
40	*Ficus carica* Moraceae	Dumur	Fruit, leaf	Reduces blood sugar, anemia
41	*Ficus religiosa.* Linn. Moraceae	Aswatha	Bark	Gallbladder infection, blood purifier, sexual disease- female
42	*Foeniculum vulgare.* Mill. Apiaceae	Mouri	Leaf, root	Periodic problem
43	*Glinus oppositifolia* Linn. Aizoaceae	Geema	Leaf, whole plant	Blood purifier
44	*Glycyrrhiza glabra* Linn. Leguminaceae	Jastimadhu	Roots and runner	Cold-cough, fever, diarrhea, allergy in respiratory track
45	*Heliotropium indicum* Linn. Boraginaceae	Hatisur	Leaf	Rheumatism, fever, typhoid, cold-cough
46	*Hemidesmus indicus.* R.Br. Asclepiadaceae	Anantamul	Root	Stomach/ liver problem, menstrual problem, piles, asthma,

Sl. No.	Scientific name	Local name	Parts used	Uses
47	*Hibiscus rosa sinensis* Linn. Malvaceae	Jaba	Leaf	Vomiting, menstrual problem, periodic problem
48	*Holarrhena antidycenterica* Well. Apocynaceae	Kurchi	Bark, seed	Scabies, antipyretic, amoebic dysentery
49	*Hygrophylla spinosa.* Nees. Acantheceae	Kulekhara	Leaf, branch	Blood purifier, rheumatism, anemia, liver disease, mail sexual problem
50	*Ipomoea reptans* (Linn.) Poir. Convolvulaceae	Kalmi	Whole plant, leaf, flowering twig	Ulcer, insomnia
51	*Justicia gendarussa* Burm. Acantheceae	Bishalyakarani	Leaf	Stop bleeding, ulcer
52	*Kalanchoe pinnata* Pers. Crassulaceae	Patharkutchi	Leaf	Dysentery, stomach/ liver problem, kidney/ urinary infection, gallbladder infection, piles, cardiac problem
53	*Lannea grandis* Dennst. Anacardaceae	Ziga (Ziol)	Leaf, bark, Gum	Dysentery, diarrhea, cardiac problem
54	*Leucas indica* (L.) Vatke. Lamiaceae	Kesta, Swetdrone	Leaf, flower	Jaundice, fever, cough, worm
55	*Linum usitatissimum* Linn. Linaceae	Atashi, Tishi	Leaf, flower, seed, seed oil	Reduces blood sugar, urinary infection, headache
56	*Marsilea minuta* Linn. Marsileaceae	Sushni	Leaf, whole plant	Asthma, memory increases, blood pressure, nervous disorder
57	*Melia azadirecta* Linn. Meliaceae	Neem	Leaf, bark, root bark, flower, fruit, seed	Reduces blood sugar, fever, contraception
58	*Mimosa pudica* linn. Mimosoidae	Lajjabati	Root	Reduces blood sugar, stomach/ liver problem, reduces urine sugar, mail sterility, sexual disease- female, periodic problem
59.	*Modhuca longifolia* (Koenig) *Macbrwar latifolia* A. Chevb. *Bassia longifolia* Sapotaceae	Mahua	flower	Piles, nervous disorder
60	*Momordica charanta* Cucurbitaceae	Karola	Fruit, seed	Reduces blood sugar, stomach/ liver problem, gallbladder infection, blood purifier
61	*Moringa oleifera.* Lamk Moringaceae	Sagina	Leaf, fruit	Reduces blood sugar, rheumatism, cardiac problem
62	*Mucuna prurita* Hook. Leguminaceae	Alkushi	Root, seed	Reduces urine sugar, mail sterility, mail sexual problem, sexual disease-female, rheumatism

Sl. No.	Scientific name	Local name	Parts used	Uses
63	*Murraya koenigi* Rutaceae	Currypata	Leaf	Reduces blood sugar
64	*Murraya paniculata (L.)* Jack. Rutaceae	Kamini	Leaf	Dysentery, inflammation of ear, black fever
65	*Musa paradisiaca* Musaceae	Kala	Fruit, seed, flowering twig	Reduces blood sugar, reduces urine sugar, mail sterility, cholera,
66	*Nyctanthes arbortristis.* Linn. Nyctanthaceae	Sewli	Leaf, seed	Fever, worm, rheumatism, decrease sexuality, irregular stool
67	*Occimum sanctm* Lamiaceae	Tulshi	Leaf, root	Cold-cough, malaria general debility, reduces urine sugar, mail sterility
68	*Oxalis corniculata.* Linn. Oxalidaceae	Amrul	Leaf, whole plant	Dysentery, cold-cough
69	*Paederia foetida.* Linn. Rubiaceae	Gandal	Leaf	Stomach/ liver problem, dysentery, spermatorrhoea, paralysis, rheumatism
70	*Phyllanthus emblica* Linn Euphorbiaceae	Amlaki	Dried fruit, seed	Acidity, blood sugar, purging, leucorrhoea, biliary colic, insomnia,
71	*Piper betle* Linn. Piperaceae	Pan	Leaf, root	Stomach problem, dysentery, gallbladder infection, contraception
72	*Piper longum* Linn. Piperaceae	Pipul	Root, stem, fruit	Reduces blood sugar, periodic pain, colic pain, cold-cough
73	*Pongamia pinnata* Vent. Leguminaceae	Karanj	Bark, seed, leaf	Worm, cough, reduces blood sugar
74	*Psidium guyava* Linn. Myrtaceae	Piara	Leaf, root, fruit, bark	Dysentery, sexual disease- female, loss of appetite, pyorrhea,
75	*Pterocarpus santalinus* Linn. Leguminaceae	Chandan	Bark, stem	Reduces urine sugar, mail sterility
76	*Punica granatum* Linn. Punicaceae	Dalim	Fruit, flower, leaf, root	Reduces blood sugar, dysentery, blood purifier, cough
77	*Ricinus communis.* Linn. Euphorbiaceae	Reri (Erond)	Root, root bark, leaf, seed oil	Stomach/ liver problem, rheumatism, eye problem, headache, biliary colic
78	*Rowolfia serpentina* Apocynaceae	Sarpagandha	Bark	Cardiac problem, mentally handicap, hyper tension, insomnia.

Sl. No.	Scientific name	Local name	Parts used	Uses
79	*Saccharum officinarum* Linn. Gramineae	Aankh	Stem	Jaundice, liver problem
80	*Bombax ceiba* Linn. Schoott and Endl. Bombaceae	Shimul	Bark, gum, leaf, flower, fruit, root	Cold-cough, reduces urine sugar, mail sterility, rheumatism, semen increase
81	*Saraca indica.* Linn. Leguminaceae	Ashok	Leaf, bark, seed	Stomach/ liver problem, kidney/ urinary infection, sexual disease-female
82	*Sida cordata* (Burm.f.)Borss =*Sida veronicufolia* Lamk. Malvaceae	Berala/ Bala	Leaf	Rheumatism, reduces urine sugar, mail sterility
83	*Solanum nigram* Solanaceae	Got begun, Makoi (H) Kakamachi	Root	Rheumatism, dropsy, general debility, diuretic, anti dysenteric
84	*Solanum virginianum* Linn. *S. surattense* Burm. f, *S xanthocarpum* Sch. and Wendle. Solanaceae	Kantikari	Root	Cold-cough, rheumatism, fever, influenza, enlargement of liver and spleen
85	*Stephania hernandifolia Walp.* Menispermaceae	Aagnati, Aagnadi	Root, whole plant	Cholera, fever, dysentery, cough, stomachache, contraception, irregular stool, leucorrhea
86	*Swertia chirata.* Ham. Gentianaceae	Chirata	Leaf, whole plant	Stomach/ liver problem, spermatorrhoea, worm, asthma, influenza,
87	*Syzygium cumini* Myrtaceae	Jam	Bark	Reduces blood sugar, dysentery, rheumatism
88	*Tamarindus indica* Linn. Leguminaceae	Tetul	Leaf, bark, fruit, seed	Reduces blood sugar, dysentery, stomach/ liver problem, pox, rheumatism
89	*Termanalia arjuna* (Roxb.ex Dc.) Wight. and Arn. Combretaceae	Arjun	Bark, leaf, fruit	Blood pressure, spermatorrhoea, blood dysenteries, joining of bones
90	*Terminalia belerica.* Retz. Combretaceae	Bahera	Fruit (ripe and unripe)	Cold-cough, insomnia, dropsy, vomiting, ulcer, trifala

Sl. No.	Scientific name	Local name	Parts used	Uses
91	*Terminalia chebula.*Retz. Combretaceae	Haritaki	Fruit, seed	Trifala, wound ulcer, leprosy, inflammation, cough. piles, fever
92	*Tinospora cordifolia* (Willd.) Hook.f. and Thoms. Menispermaceae	Gulancha	Branch	Stomach/ liver problem, jaundice, loss of appetite, fever, rheumatism, gallbladder infection, blood purifier
93	*Tragia involucrate* Linn. Euphorbiaceae	Bichhutika	Root, fruit	Stomach/ liver problem, rheumatism, irregular stool, asthma
94	*Tribulus terretris.* Linn. Zygophyllaceae	Gokhur	Whole plant, fruit, spine	kidney/ urinary track infection, rheumatism, sexual disease-men, nervous disorder
95	*Trichosanthes dioica* Roxb. Cucurbitaceae	Patal	Leaf, fruit	Urinary track infection, liver disease, bile complain
96	*Trigonella foenum-graceum* Linn. Leguminaceae	Methi	Leaf, seed, whole plant	Gynecological problem, pox, loss of appetite, sexual problem
97	*Vanda roxburghi* R.BR. Orchidaceae	Rasna	Root	Rheumatism
98	*Vitex nigandu* Linn. Verbenaceae	Niscinda/ Narsingha	Root, fruit, flower, leaf and bark	Cold-cough, fever, rheumatism, memory increases
99	*Scoparia dulcis* L. Scrophulariaceae	Vassourinha, sweet broom	Leaf, plant body	Reduce blood sugar, anti inflammatory, sore, cough
100	*Abroma augusta* Sterculaceae	Ulatkamal	Leaf, bark	Reduces blood sugar, kidney/ urinary infection, reduces urine sugar, mail sterility, sexual disease- female
101	*Litsea glutinosa* Lauraceae	Malibabla	Leaf, bark	Dysentery, reduces urine sugar, mail sterility, sexual disease- female
102	*Amaranthus spinosus* Amaranthaceae	Katakhura	Whole plant, leaf	Reduces urine sugar, mail sterility
103	*Jatropha curcas* L. Euphorbiaceae	Bharenda	Stem, root	Dysentery, bad teeth, , amoebic dysentery, blood dysentery
104	*Clerodendrum indicum* Verbenaceae	Bamunhati/ Brahmajasti	Leaf, stem	Asthma, rheumatism, anthelmintic
105	*Coffea arabica* Rubiaceae	Coffee	Seed	Migraine, headache, fever, cardiac trouble
106	*Withania somnifera* Solanaceae	Aswagandha	Root	Nervous disorder, mail sterility, sexual disease- female
107	*Opuntia dilleni* L. Cactaceae	Fanimanasa	Leaf	General debility, reduces urine sugar, mail sterility

Table 2: Number of genera for the treatment of various diseases

Sl. No.	Family	Total No. of genera	Sl. No.	Family	Total No. of genera
1.	Acantheceae	4	25.	Linaceae	1
2.	Amaranthaceae	2	26.	Malvaceae	2
3.	Anacardiaceae	1	27.	Meliaceae	1
4.	Apiaceae	4	28.	Menispermaceae	2
5.	Apocynaceae	4	29.	Moraceae	1
6.	Asclepediaceae	2	30.	Moringaceae	1
7.	Asteraceae	4	31.	Musaceae	1
8.	Basellaceae	1	32.	Myrtaceae	2
9.	Bombaceae	1	33.	Nyctanthaceae	1
10.	Boraginaceae	1	34.	Orchidaceae	1
11.	Cactaceae	1	35.	Oxalidaceae	2
12.	Combretaceae	1	36.	Palmae	1
13.	Convolvulaceae	1	37.	Piperaceae	1
14.	Crassulaceae	1	38.	Punicaceae	1
15.	Cucurbitaceae	4	39.	Rubiaceae	2
16.	Cypreraceae	1	40.	Rutaceae	3
17.	Euphorbiaceae	4	41.	Sapotaceae	1
18.	Ficoideae	2	42.	Scrophulariaceae	2
19.	Gentianaceae	1	43.	Solanaceae	2
20.	Gramineae	2	44.	Sterculaceae	1
21.	Lamiaceae	2	45.	Verbenaceae	2
22.	Lauraceae	2	46.	Vitaceae	1
23.	Leguminaceae	14	47.	Zingiberaceae	1
24.	Liliaceae	3	48.	Zygophyllaceae	1

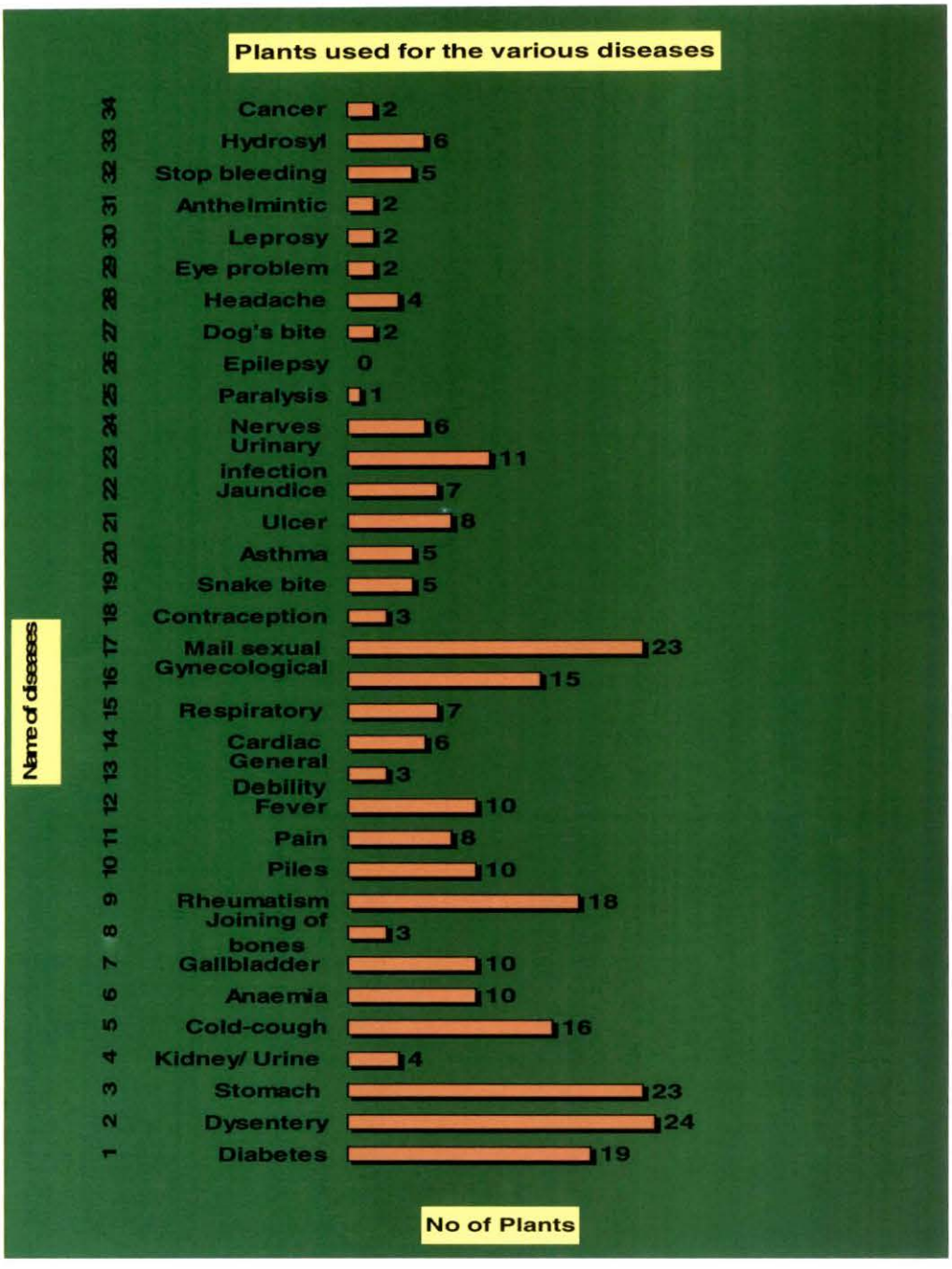


Fig-I: Number of plants for the treatment of various diseases

Abroma augusta

Acacia arabica

Achyranthes aspera

Adhatoda vasica

Aegle marmelos

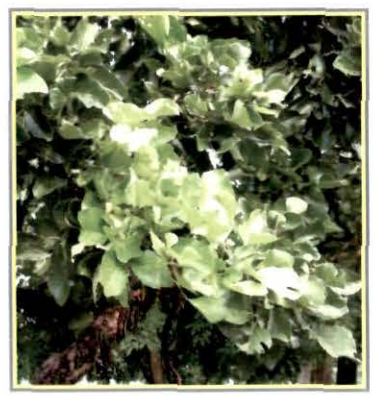
Aloe barbadensis

Alstonia scholaris

Amaranthus spinosus

Andrographis paniculata

Bacopa monniera



Butea monosperma

Cajanus indicus

PLATE-XIII : Medicinal plants of study area

Coffea arabica

Cynodon dactylon

Datura metel

Enhydra fluctuans

Erythrina variegate

Ficus bengalensis

Ficus carica

Ficus religiosa

Heliotropium indicum

Hydrocotyle asiatica

Hygrophylla spinosa

Ipomoea reptans

PLATE-XIV : Medicinal plants of study area.

Jatropha curcas

Justicia gendarussa

Kalanchoe pinnata

Lannea grandis

Leucas cephalotes

Litsea glutinosa

Marsilea minuta

Melia azadirecta

Mimosa pudica

Modhuca longifolia

Momordica charanta

Moringa oleifera

PLATE-XV : Medicinal plants of study area

Pterocarpus santalinus

Punica granatum

Ricinus communis

Rowolfia serpentina

Saccharum officinarum

Sida cordata

Solanum virginianum

Stephania hernandifolia

Swertia chirata

Syzigium cumini

Scoparia dulcis

Tamarindus indica

PLATE-XVI : Medicinal plants of study area

Medicinal plants used for the treatment of male sexual problems are *Aloe barbadensis, Mimosa pudica, Musa paradisiaca, Acacia arabica., Occimum sanctum, Salmalia malabaricum, Asparagus racemosus, Sida cordifolia, Mucuna prurita, Ficus bengalensis, Pterocarpus santalinus, Alstonia scholaris, Achyranthes aspera, Cassia sophera, Aegle marmelos, Clitoria ternatea, Piper betle, Coccinia cordifolia*, etc.

Diabetes is treated with the plants- *Abroma augusta, Aegle marmelos, Cajanus cajan, Catheranthus roseus, Cinnamomum tamala, Coccinia cordifolia, Enhydra fluctuans, Ficus carica, Melia azadirecta, Mimosa pudica, Momordica charanta, Moringa oleifera, Murraya koenigii, Musa paradisiaca, Piper longum, Punica granatum, Scoparia dulcis, Syzygium cumini, Tamarindus indica* etc (Table 3).

After analysis of investigated plants in the present study *Clerodendrum viscosum, Cinnamomum tamala, Moringa oleifera* and *Scoparia dulcis* were selected for detailed investigations (Table 4).

4.2. Description of the selected plants

4.2.1. *Clerodendrum viscosum*

A tall shrub; stem 4-angled; leaves simple, ovate, often form a cordate base, entire or dentate, blade 5-9, petiole 1-6 in. long. Flower white, tinged with pink, in an ample terminal trichotomous corymbiform thyrsus. Calyx cleft to near the base, segments lanceolate. Corolla-tube longer than calyx-segments. Stamens 4, didynamous, long exserted. Ovary globose, 4-celled, 4-ovuled, style filiform, stigma bifid. Fruits drupe fleshy (Plate XVII).

It is propagated by seeds and vegetative method.

4.2.2. *Moringa oleifera*

A small or medium sized, deciduous, perennial tree. Trunk straight, bark thick, corky; Leaves feathery, pale green, alternate, decompound, usually tripinnate, leaflets on short slender petiolules, ovate or obovate, obtuse, green above, paler beneath; Flower strongly honey-scented, white or creamy-white in axillary or terminal panicles; bracts linear, shorter than pedicels; Calyx 5- partite, segments petaloid, unequal; Petals 5 free, linear- spathulate, unequal; Stamens yellow 10, in two series; Ovary tricarpellary, ovary and base of filaments

Table 3 : Medicinal plants for the treatment of Diabetes

Sl. No.	Scientific name	Local name	Part(s) used
1	*Abroma augusta* Sterculaceae	Ulatkamal	Leaf, bark
2	*Aegle marmelos*, Rutaceae	Bel	Leaf, root, bark, fruit,
3	*Cajanus cajan* Leguminaceae	Arhar	Leaf, root, seed
4	*Catheranthus roseus* Apocynaceae	Nayantara	Leaf
5	*Cinnamonum tamala* Lauraceae	Tejpata	Leaf, bark
6	*Coccinia cordifolia* Cucurbitaceae	Telakutcha	Leaf
7	*Enhydra fluctuans* Asteraceae	Helencha	Plant body
8	*Ficus carica* Moraceae	Dumur	Fruit, leaf
9	*Melia azadirecta* Meliaceae	Neem	Leaf, bark, root bark, flower, fruit, seed
10	*Mimosa pudica* Mimosoidae	Lajjabati	Root
11	*Momordica charanta* Cucurbitaceae	Karola	Fruit, seed
12	*Moringa oleifera* Moringaceae	Sagina	Leaf, fruit
13	*Murraya koenigii* , Rutaceae	Currypata	Leaf
14	*Musa paradisiaca* Musaceae	Kala	Fruit, seed, flowering twig
15	*Piper longum* Piperaceae	Pipul	Root, stem, fruit
16	*Punica granatum* Punicaceae	Dalim	Fruit, flower, leaf, root
17	*Scoparia dulcis* Scrophulariaceae	Vassourinha, sweet broom	Leaf, plant body
18	*Syzygium cumini* Myrtaceae	Jam	Bark
19	*Tamarindus indica* Leguminaceae	Tetul	Leaf, Bark, fruit, seed

Table 4 : Ethnobotanical uses of the selected plants

Sl. No.	Scientific name	Local name	Part(s) used	Reported Uses
1.	*Cinnamomum tamala* (Hamilton) Nees and Ebermaier. Acc. No. 9490 Lauraceae	Tejpata	Leaf, bark	Reduces blood sugar, cold-cough, memory decrease, quench thirst, skin care,
2.	*Clerodendrum viscosum* Vent. Acc. No. 9489 Verbenaceae	Bhati, Ghetu	Leaf, bud, root, whole plant	Malarial fever, any fever, worm, dysentery, stomach/ liver problem, piles
3.	*Moringa oleifera* Lamk. Acc. No. 9492 Moringaceae	Sagina	Leaf, fruit	Reduces blood sugar, rheumatism, cardiac problem
4.	*Scoparia dulcis* L. Acc. No. 9491 Scrophulariaceae	Vassourinha, sweet broom	Leaf, plant body	Reduce blood sugar, anti inflammatory, sore, cough

PLATE-XVII : A: *Clerodendrum viscosum*; B: Leaves of *C. viscosum;* C and D: Flowering stage of *C. viscosum.*

hairy, stipulate with numerous ovules; Fruit an elongate, pendulous, cylindrical longitudinally ribbed, loculicidal capsule; Seeds rounded- trigonous with broad wings at the angles (Plate XVIII).

In India, the plant is propagated by planting limb cuttings 1–2 m long, from June to August, preferably. The plant starts bearing pods 6–8 months after planting but regular bearing commenced after the second year. The tree bears for several years and flowers at January- February.

4.2.3. *Scoparia dulcis*

Annual herbaceous plant, Stem woody at the base, much branched, quadrangular when young, leaves small 3-verticiIate or opposite, coarsely toothed-serrate. Flower white, crowded in the axils of the leaves. Capsule small, globosely, many seeded (Plate XIX).

It is propagated by seeds and vegetative method.

4.2.4. *Cinnamomum tamala*

A moderate sized evergreen tree 7.5 m in height with dark brown or blackish rough bark and pinkish or reddish brown blaze; leaves simple, opposite, sub-opposite or alternate, ovate-lanceolate or ovate-oblong, acuminate, coriaceous, glabrous, 3-nerved from base to apex; flowers pale yellowish in axillary and terminal panicles; fruits ovoid, fleshy, black drupe, supported by enlarged perianth tube (Plate XX).

It is propagated by seeds only.

4.3. Qualitative analysis of the phytochemical compounds of the selected plants

Leaves of *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum and Scoparia dulcis* were subjected to screen phytochemical characters and to evaluate phytochemical constituents. Results presented in Table 5 showed that the various phytochemical constituents on various solvent of *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum* were rich in alkaloid, tannin, saponin, steroid, terpenoid, flavonoid and cardiac glycoside. Alkaloid, tannin, saponin, terpenoid, flavonoid, and cardiac glycoside were present in *Scoparia dulcis* but steroid was absent in *Scoparia dulcis.*

PLATE-XVIII : A: Plant of Moringa oleifera, B and C: Flowering stage of Moringa oleifera, D: Fruits of Moringa oleifera

PLATE-XIX : A: Plant of *Scoparia dulcis*, B: Flowering stage of *Scoparia dulcis*, C: Leaves of *Scoparia dulcis*, D: Flower of *Scoparia dulcis*.

PLATE-XX : A: Plant of *Cinnamomum tamala,* B: Leaves of *Cinnamomum tamala,* C and D: Flowering stage of *Cinnamomum tamala.*

Table 5 : Qualitative analysis of the phytochemical compounds of the selected plants

Plants	Alkaloids	Tannin	Saponin	Steroid	Terpenoid	Flavonoid	Cardic Glycoside
CV	+	+	+	+	+	+	+
MO	+	+	+	+	+	+	+
CT	+	+	+	+	+	+	+
SD	+	+	+	-	+	+	+

(CV = *Clerodendrum viscosum*, MO= *Moringa oleifera*, CT = *Cinnamomum tamala*, SD = *Scoparia dulcis*; '+' = Present, '-'= Absent)

4.4. Quantitative analysis of the biochemical constituents of the selected plants

4.4.1. Alkaloids

Quantitative analysis of the percentage crude alkaloids in *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum and Scoparia dulcis* leaves extracts were done. Results (Table 6) revealed that *Cinnamomum tamala* contained the highest percentage crude yield of alkaloid (4.92%) while *Scoparia dulcis* contained the lowest yield of alkaloid (0.84%). *Moringa oleifera* also contained the moderate percentage crude yield of alkaloid followed by *Clerodendrum viscosum.*

Table 6: Alkaloid contents of leaves of different study plants

Sample	Content (% of alkaloid/g leaf tissue)
Clerodendron viscosum	1.76 ± 0.08
Moringa oleifera	2.56 ± 0.25
Cinnamomum tamala	4.92 ± 0.04
Scoparia dulcis	0.84 ± 0.02

Each value represents mean ± SE

4.4.2. Proteins

Estimation of contents of proteins extracted from the *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum, Scoparia dulcis* leaves were done and results (Table 7) revealed that *Moringa oleifera* contained the highest amount of protein (55 mg/g tissue)

among the four studied leaves extracts and *Clerodendrum viscosum* contained the least amount (7.5 mg/g tissue). *Cinnamomum tamala* and *Scoparia dulcis* contained the moderate amount of protein in their tissue.

Table 7 : Protein Contents of leaves of different study plants

Sample	Protein content (mg/g tissue)
Clerodendron viscosum	10.83 ± 2.20
Moringa oleifera	59.17 ± 2.20
Cinnamomum tamala	23.33 ± 1.67
Scoparia dulcis	19.50 ± 0.29

Each value represents mean; ± =SE

4.4.3. Carbohydrates

4.4.3.1. Total sugar

Carbohydrates were extracted from the leaves of *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum, Scoparia dulcis* and estimations of total and reducing sugar contents were done. Results revealed that *Moringa oleifera* contained the highest amount of total sugar (40.5mg/g tissue) while *Clerodendrum viscosum* contained the least amount (5mg/g tissue) of total sugar. Another two studied plants *Cinnamomum tamala, Scoparia dulcis* also contained the moderate amount (29mg/g tissue and 31mg/g tissue respectively) (Fig II).

4.4.3.2. Reducing sugar

Results for reducing sugar revealed the same trend ie., leaves of *Moringa oleifera* contained maximum reducing sugar (15mg/g tissue), *Cinnamomum tamala, Scoparia dulcis* also contained the moderate amount (11.5mg/g and 10.5mg/g tissue respectively) but *Clerodendrum viscosum* contained the least amount (4mg/g tissue) (Fig II).

4.4.4. Phenols

Quantitative estimation of total phenol from leaves of *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum, Scoparia dulcis* were done. The spectrophotometric assay for the quantitative determination of phenol revealed that *Cinnamomum tamala* contained the

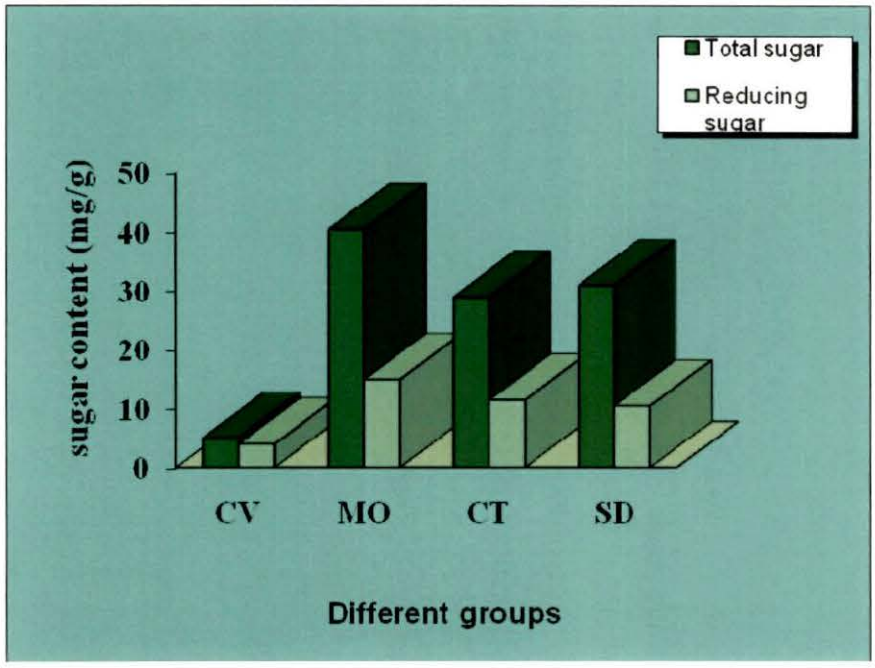


Fig-II : Sugar content of study plants (both total sugar and reducing sugar content; CV= *Clerodendrum viscosum*, MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*.

highest amount (20.83mg/g tissue) of phenol than other three and *Clerodendrum viscosum* contained the least amount (2.32mg/g tissue). *Moringa oleifera* and *Scoparia dulcis* contained 6.25mg/g tissue and 4.31mg/g tissue respectively (Table 9).

Table 9: Total phenol content of leaves of the study plants

Sample	Total phenol content (mg/g tissue)
Clerodendron viscosum	2.33 ± 0.36
Moringa oleifera	6.25 ± 0.07
Cinnamomum tamala	20.83 ± 0.11
Scoparia dulcis	4.31 ± 0.11

Each value represents mean; ± =SE

4.4.5. Ascorbic acid

Quantification of ascorbic acid of *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum, Scoparia dulcis* leaves was carried out and results revealed that *Cinnamomum tamala* contained the highest amount (22.3mg/g tissue) of ascorbic acid followed by *Moringa oleifera, Scoparia dulcis* (15.45mg/g tissue, 8.52mg/g tissue). The least amount of ascorbic acid found in the *Clerodendrum viscosum* (7.21mg/g tissue) (Table 10).

Table 10 : Ascorbic acid content of leaves of the study plants

Sample	Ascorbic acid content (mg/g tissue)
Clerodendron viscosum	7.22 ± 0.15
Moringa oleifera	15.46 ± 0.14
Cinnamomum tamala	22.30 ± 0.21
Scoparia dulcis	8.53 ± 0.11

Each value represents mean; ± = SE

4.4.6. Carotenoids

Results of quantitative estimation of carotenoids of *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum, Scoparia dulcis* leaves have been depicted in the Table 11. *Cinnamomum tamala* contained the higher amounts of carotenoids (1.85µg/g tissue) followed by *Moringa oleifera* and *Scoparia dulcis* (0.82 µg/g tissue and 0.41µg/g tissue).

Clerodendrum viscosum contained the least amount of carotenoids (0.082 μg/g tissue) among the four studied plants.

Table 11 : Carotenoid content of leaves of the study plants

Sample	Carotenoid content (mg/g tissue)
Clerodendrum viscosum	0.08 ± 0.01
Moringa oleifera	0.41 ± 0.03
Cinnamomum tamala	0.82 ± 0.04
Scoparia dulcis	1.85 ± 0.04

Each value represents mean; ±= SE

4.5. Analysis of protein patterns

Analysis of the soluble proteins of the leaves of all selected plants revealed that they contained proteins of different molecular masses ranging from 97,400 Da to 14,300 Da. *Moringa oleifera* contained proteins of different molecular masses viz., 47.77, 38.58, 36.25, 31.71, 29.90, 21.27, 18.72 Kd and 14.79. *Clerodendrum viscosum* contained proteins of 44.10, 29.0 and 17.87 Kd (molecular masses) and *Scoparia dulcis* contained 81.6, 72.68, 42.26, 34.43, 29.0, 19.57, 17.87, and 14.05 KD and in *Cinnamomum tamala* 51.45, 40.42, 34.43, 19.14, 13.56 Kd (Table 12 and Plate XXI).

Table 12 : Analysis of the soluble proteins of the leaves of study plants

Sl No	Sample	Molecular masses (Kd) of proteins
1	*Clerodendron viscosum*	44.10, 29.0, 17.87
2	*Moringa oleifera*	47.77, 38.58, 36.25, 31.71, 29.90, 21.27, 18.72, 14.79
3	*Cinnamomum tamala*	51.45, 40.42, 34.43, 19.14, 13.56
4	*Scoparia dulcis*	81.6, 72.68, 42.26, 34.43, 29.0, 19.57, 17.87, 14.05

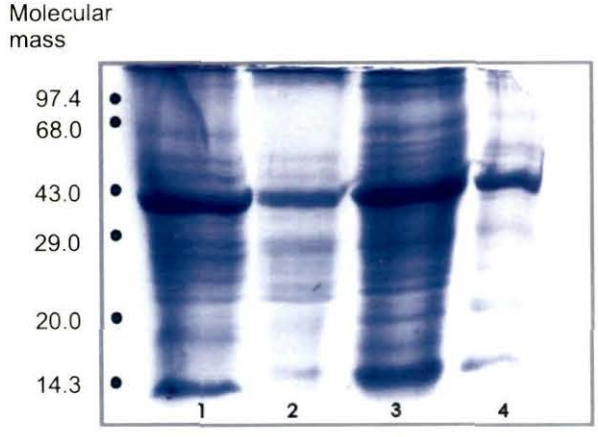


PLATE XXI: SDS-PAGE analysis of proteins from leaves of study plants; Lane 1: *Moringa oleifera*, Lane 2: *Clerodendrum viscosum,* Lane 3: *Scoparia dulcis*,Lane 4: *Cinnamomum tamala.*

4.6. TLC analysis of α-tocopherol

Tocopherols extracted from the different leaves samples were analyzed by TLC as described in Materials and Methods. Rf values were calculated and have been depicted in Fig III.

4.7. Antioxidant capacity of different plant extracts

The antioxidant capacities of *Cinnamomum tamala, Moringa oleifera, Clerodendrum viscosum, Scoparia dulcis* leaf extracts have been depicted in Fig IV. The results, expressed as mg α-tocopherol acetate/ g dry mass were 11.27 in *Cinnamomum tamala*, which was the highest among the other three plants which were 7.0 in *Moringa oleifera*, 5.92 in *Scoparia dulcis* and 4.58 mg α-tocopherol acetate/ g dry mass in *Clerodendrum viscosum.*

4.8. Partial characterization of solvent extracts

The different solvent extracts were analyzed by UV-spectrophotometry and the results have been depicted in Figs. V-VIII. Methanolic extracts had the highest concentration of compounds. All of the extracts had UV- absorption maxima in the range 200-208 nm, most of them having single peak. Different extracts of *S.dulcis* had 2 or more broad peaks other than the single sharp peak. .

4.9. Bio-assay of solvent extracts

Spore germination of the solvent extracts was carried out against different plant pathogenic fungi- *Poria hypobrunnea* (Fig IX), *Fusarium oxysporum, Curvularia lunata* and *Bipolaris sorokiana.* No inhibitory effects were observed, only very small inhibitory zone was observed against p. *hypobrunnea.* The extracts could not also inhibit growth of bacteria such as *Bacillus megaterium* and *Serratia marcescens* as tested by agar cup bioassay.

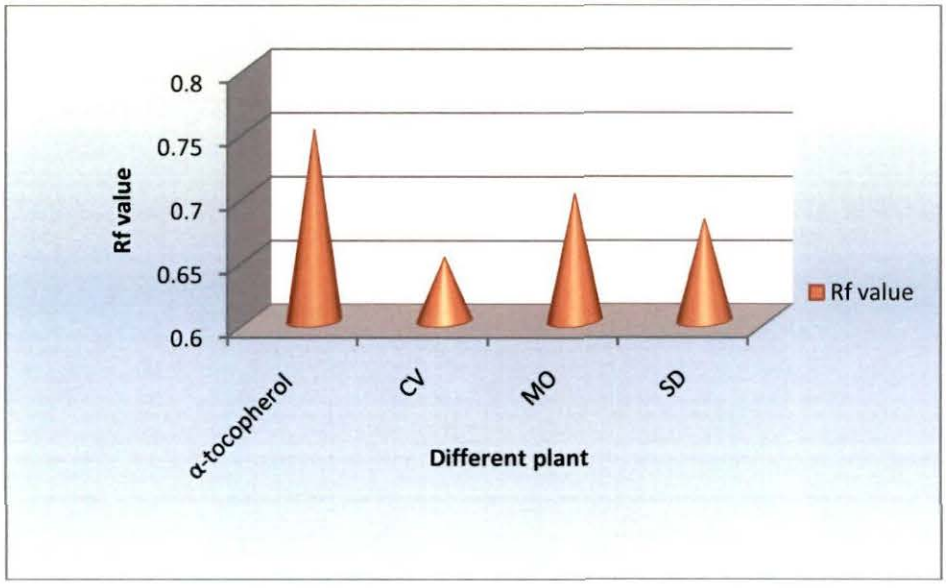


Fig III : Determination of α-tocopherol by TLC. (CV= *Clerodendrum viscosum*, MO= *Moringa oleifera*, SD= *Scoparia dulcis*.

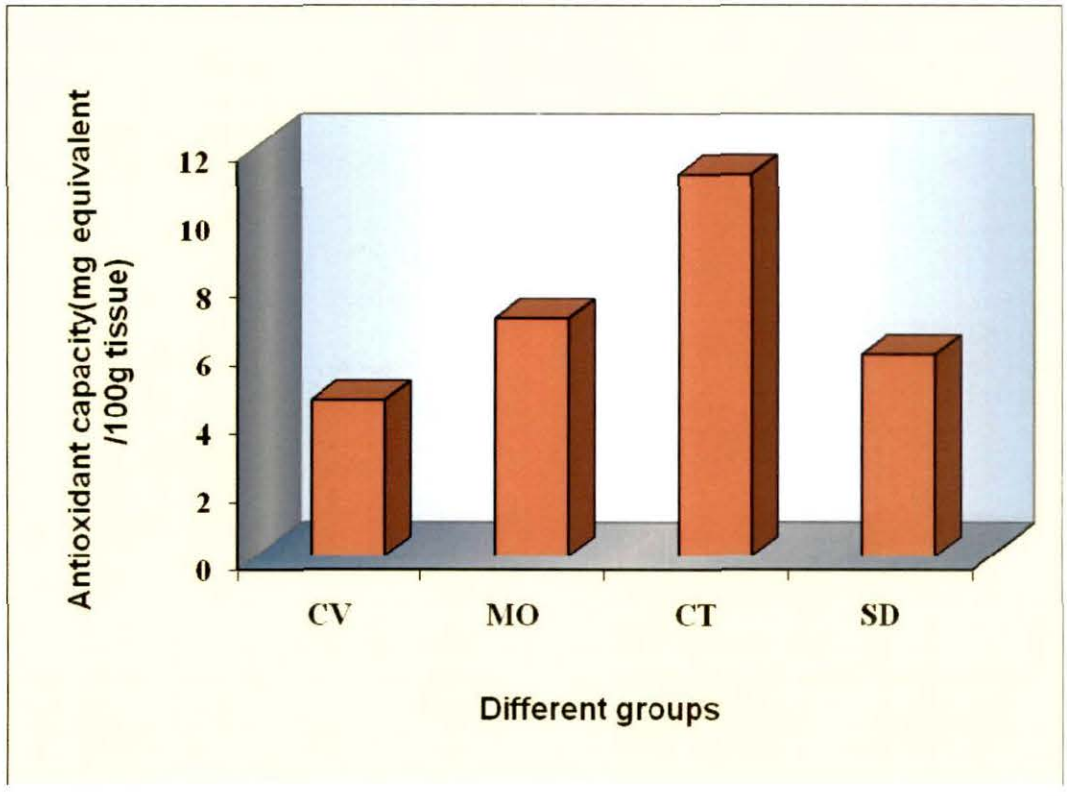


Fig-IV : Antioxidant capacity (CV= *Clerodendrum viscosum*, MO= *Moringa oleifera*, CT= *Cinnamonum tamala*, SD= *Scoparia dulcis*.

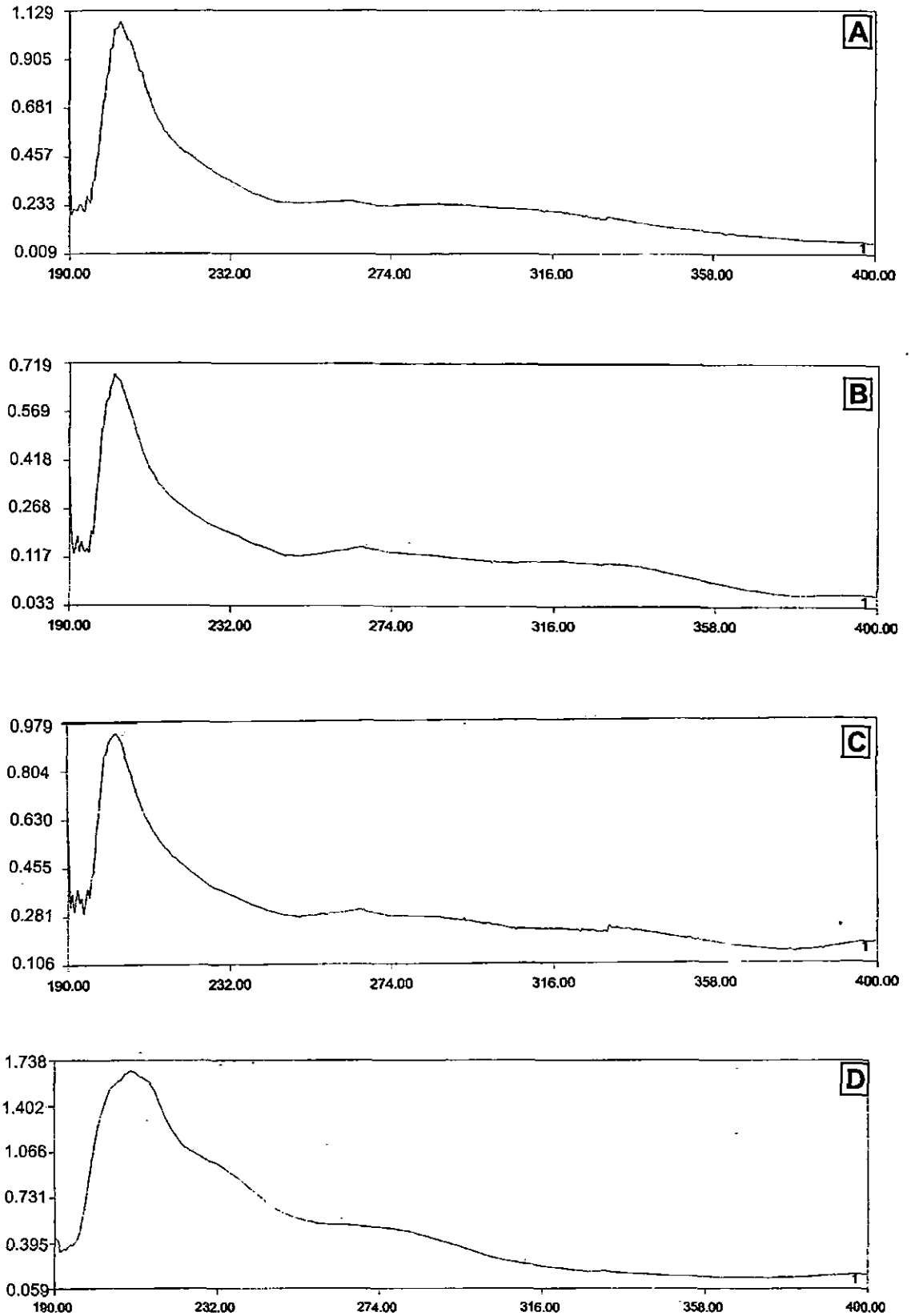


Fig. 5: UV-spectrophotometric analysis of solvent extracts from *Clerodendrum viscosum* (A) Diethyl ether; (B) Methanol; (C) Ethyl acetate and (D) Petrolium ether.

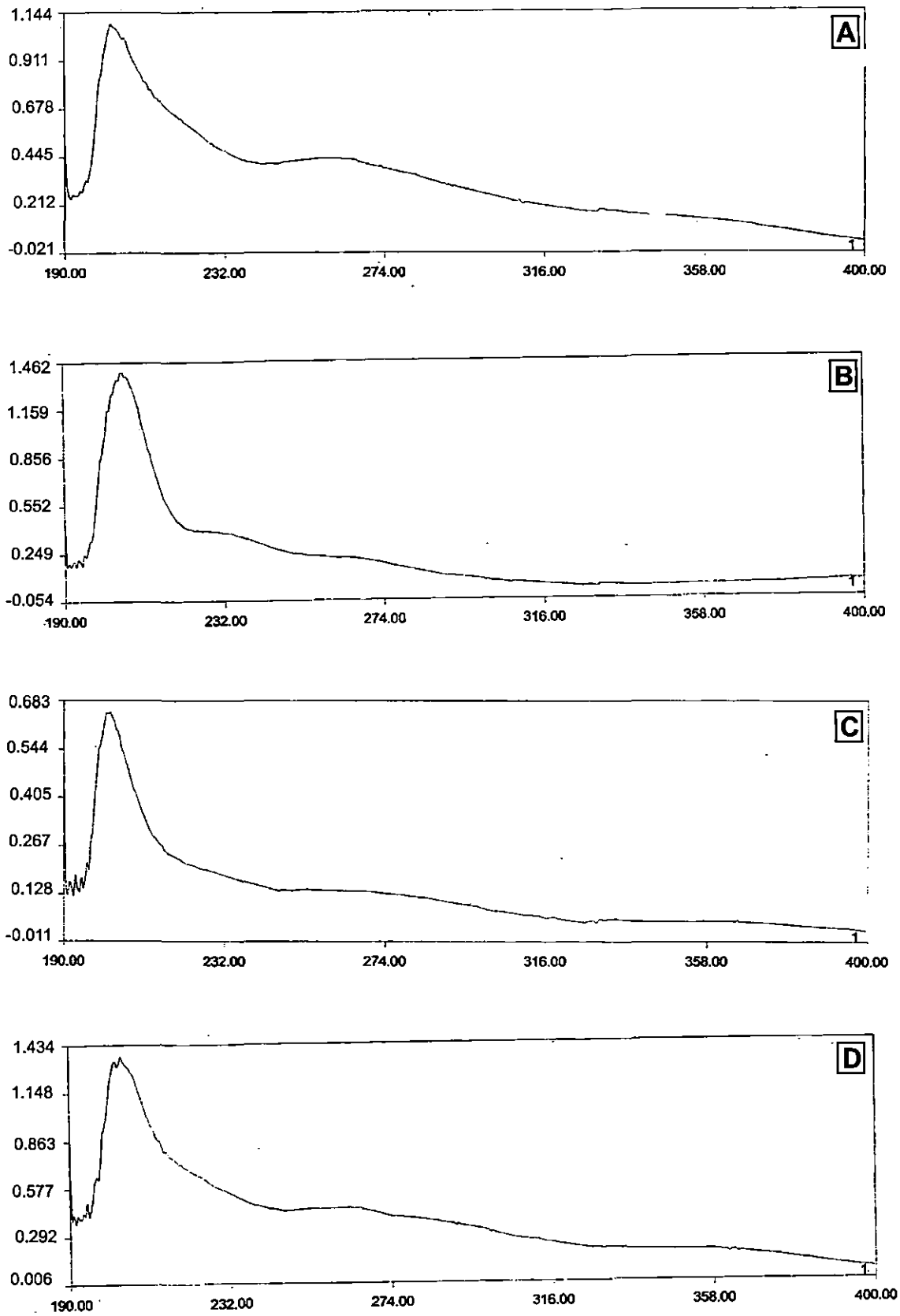


Fig.6: UV-spectrophotometric analysis of solvent extracts from *Moringa oleifera* (A)Methanol; (B) Petrolium ether; (C) Diethyl ether and (D) Ethyl acetate.

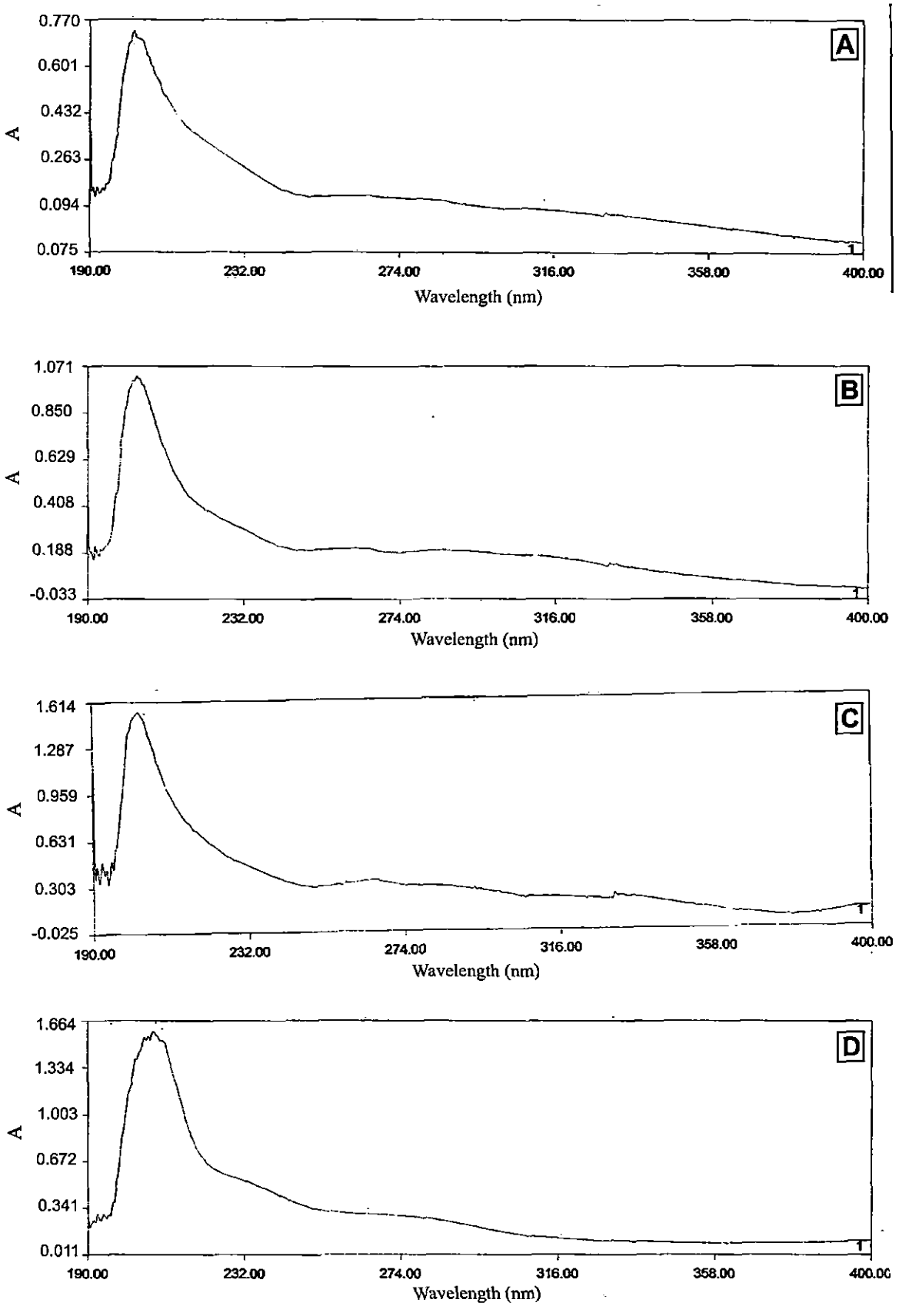


Fig. 7: UV-spectrophotometric analysis of solvent extracts from *Cinnamomum tamala* (A) Methanol; (B) Diethyl ether; (C) Ethyl acetate; and (D) Petrolium ether.

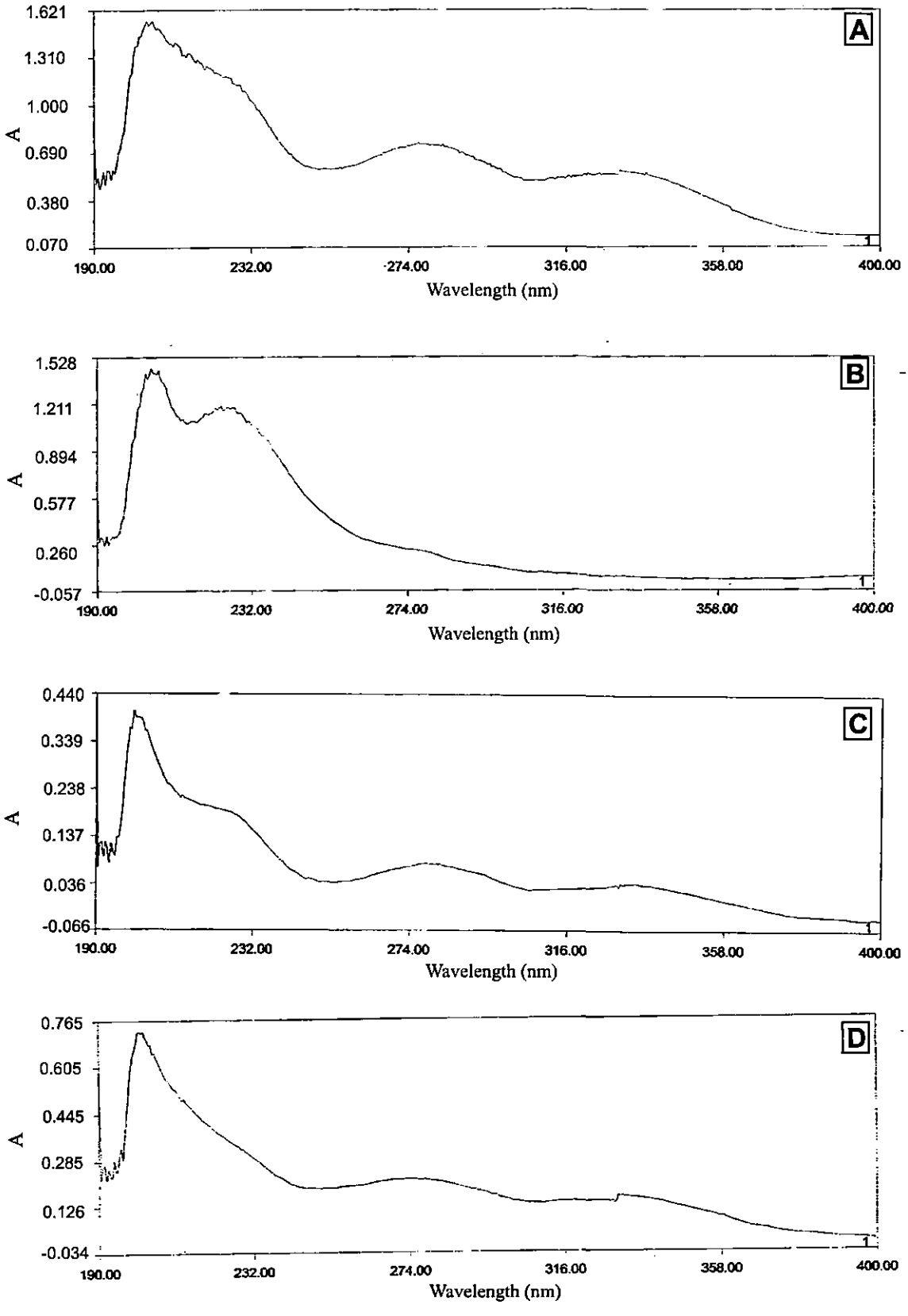


Fig.8 : UV-spectrophotometric analysis of solvent extracts from *Scoparia dulcis* (A) Ethyl acetate; (B) Petrolium ether; (C) Diethyl ethr and (D) Methanol.

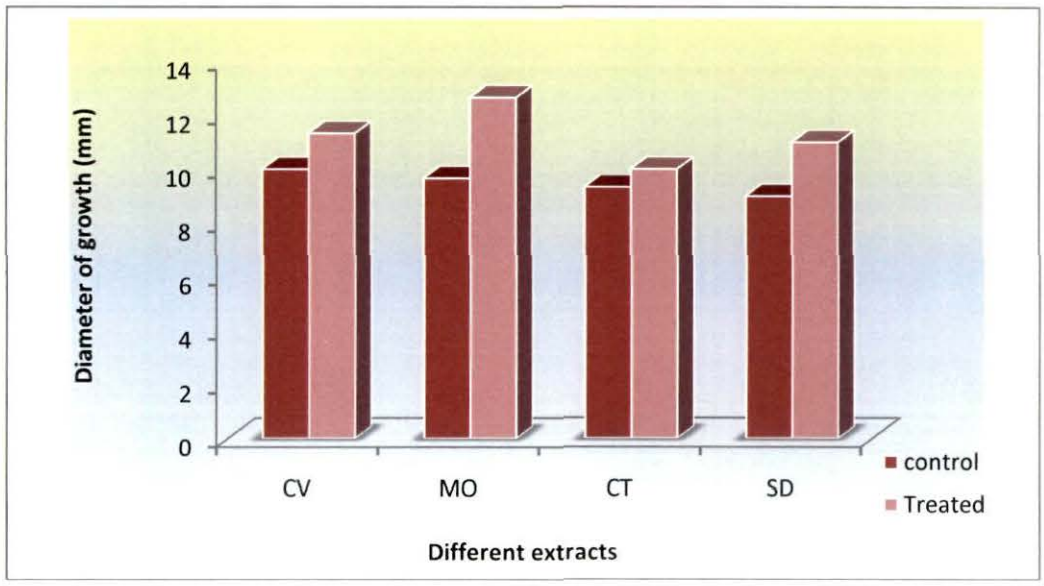


Fig-IX : Effect of different extracts on mycelial growth by Agar cup bioassay of *Poria hypobrunnea.* (CV= *Clerodendrum viscosum*, MO= *Moringa oleifera*, CT= *Cinnamonum tamala*, SD= *Scoparia dulcis*.

4.10. Effect of plant extracts on induced hyperglycemia in rats

Initially, the rats were injected with STZ to induce hyperglycaemia. After 2 days of STZ induction rats were found to be suffering from strong hyperglycemia. There was marked reduction in the body weight of the STZ treated rats, along with an increase in food craving and thirst. Subsequently, the rats were treated with extracts of the test plants and parameters associated with hyperglycaemia such as fasting blood glucose, urine sugar, glycogen content in liver tissue, TBARS and GSH of liver tissue, were tested. After 20 days of treatment with test plants most of the rats recovered from hyperglycemia and became healthy (Plate XXII).

4.10.1. Effect of different extracts on changes in body weight in normal and experimental rats

Changes in the body weight on the treatment of diabetic and normal rats with *Cinnamomum tamala, Moringa oleifera, Scoparia dulcis* leaves extracts have been demonstrated in Tables 14 and 15. The body weight of the diabetic rats decreased from 171g to 147g after the 20 days treatment with STZ (Fig X). The body weight of *Cinnamomum tamala* treated group (125mg/kg and 250mg/kg respectively) increased from 172.5g and 173 g to 190.5g and 200.5g respectively after the 20th day's treatment. Following *Cinnamomum tamala* treatment, the body weight increased and reached almost upto the level of control rats. The body weight of *Moringa oleifera* treated group (125mg/kg and 250mg/kg respectively) increased from 175g and 171.5g to 191.5g and 194.5g respectively after the 20th day's treatment. The body weight gain of diabetic rats by the treatment of *Moringa oleifera* was significant when compared with normal rats. The body weight of *Scoparia dulcis* treated group (125mg/kg and 250mg/kg respectively) increased from 169.5g and 172.5g to 186.5g and 196.5g respectively after the 20 days of treatment that was significantly increased ($p < 0.01$). Thus, it was observed that the body weight of rats, which had abruptly fallen due to induction of hyperglycaemia by STZ, increased following treatment of all test extracts and became almost similar to that of control.

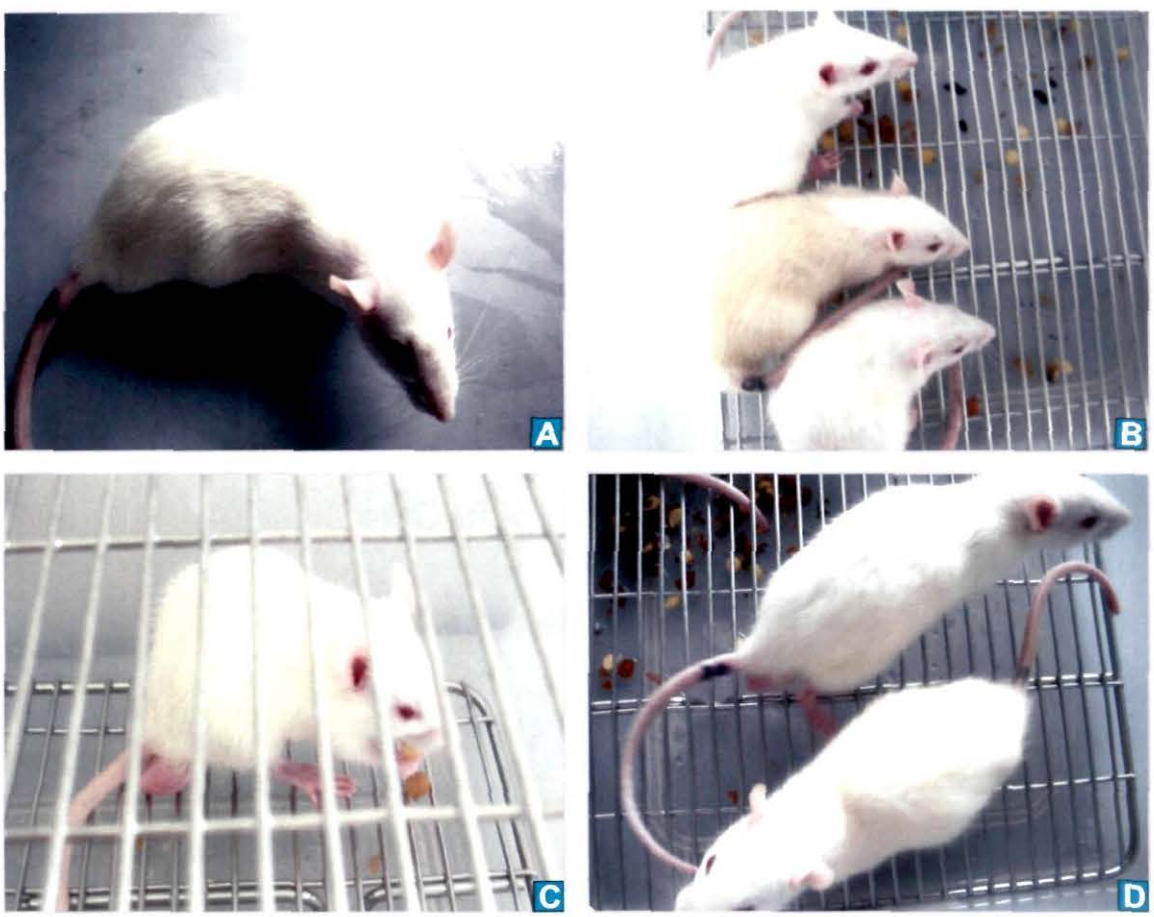


PLATE-XXII: A, B, C, D: Plant extracts treated healthy rats recovering hyperglycemia after 20 days treatment of different plant extracts.

Table 14 : Effect of different extracts on changes in body weight in normal and experimental rats

Group	Treatments	Body Weight (g)			
		First day	After 2 days of STZ induction	Days after plant extract treatment 10	20
I	Normal (only vehicle distilled water)	173.5 ± 4.73	175.0 ± 4.83	188.7 ± 5.54	202.5 ± 5.86
II	Citrate buffer treated	166.0 ± 4.99	167.0 ± 5.00	179.5 ± 4.50	191.5 ± 3.50
III	STZ (diabetic Control)	171.0 ± 1.15	167.6 ± 0.66	156.66 ± 0.88	147.0 ± 0.57
IV	STZ + MO (125mg/kg)	175.0 ± 2.00	177.5 ± 1.50	184.5 ± 1.50	191.5 ± 1.22
V	STZ +MO (250 mg/kg)	171.5 ± 0.50	172.5 ± 0.50	182.5 ± 2.50	194.5 ± 4.70
VI	STZ +CT (125mg/kg)	172.5 ± 4.50	174.0 ± 5.00	182.5 ± 5.50	190.0 ± 2.00
VII	STZ +CT (250mg/kg)	173.0 ± 4.00	176.5 ± 6.50	183.0 ± 5.00	201.0 ± 8.00
VIII	STZ +SD (125mg/kg)	169.5 ± 4.50	171.0 ± 4.00	178.0 ± 5.65	186.5 ± 3.50
IX	STZ +SD (250mg/kg)	172.0 ± 1.00	173.0 ± 2.00	185.0 ± 2.00	195.5 ± 2.50

Each value represents mean; ± =SE; MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*. Values were statistically significant at $p < 0.01$ as compared with diabetic control, $p < 0.01$ as compared with normal.

Table 15 : Effect of different plant extracts on changes in body weight in normal and experimental rats

Groups	Treatment	Body weight (g)	
		Initial	Final
I	Control	173.5 ± 4.73	202.5 ± 5.86
II	Citrate buffer control	166.0 ± 4.99	191.5 ± 3.50
III	STZ (Diabetic control)	171.0 ± 1.15	147.0 ± 0.57
IV	STZ +MO (125mg/kg)	175.0 ± 2.00	191.5 ± 1.22
V	STZ +MO (250 mg/kg)	171.5 ± 0.50	194.5 ± 4.70
VI	STZ +CT (125mg/kg)	172.5 ± 4.50	190.0 ± 2.00
VII	STZ +CT (250mg/kg)	173.0 ± 4.00	201.0 ± 8.00
VIII	STZ +SD (125mg/kg)	169.5 ± 4.50	186.5 ± 3.50
IX	STZ +SD (250mg/kg)	172.0 ± 1.00	195.5 ± 2.50

Each value represents mean; ± = SE. MO = *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*. Values were statistically significant at $p < 0.01$ as compared with diabetic control, $p < 0.01$ as compared with control.

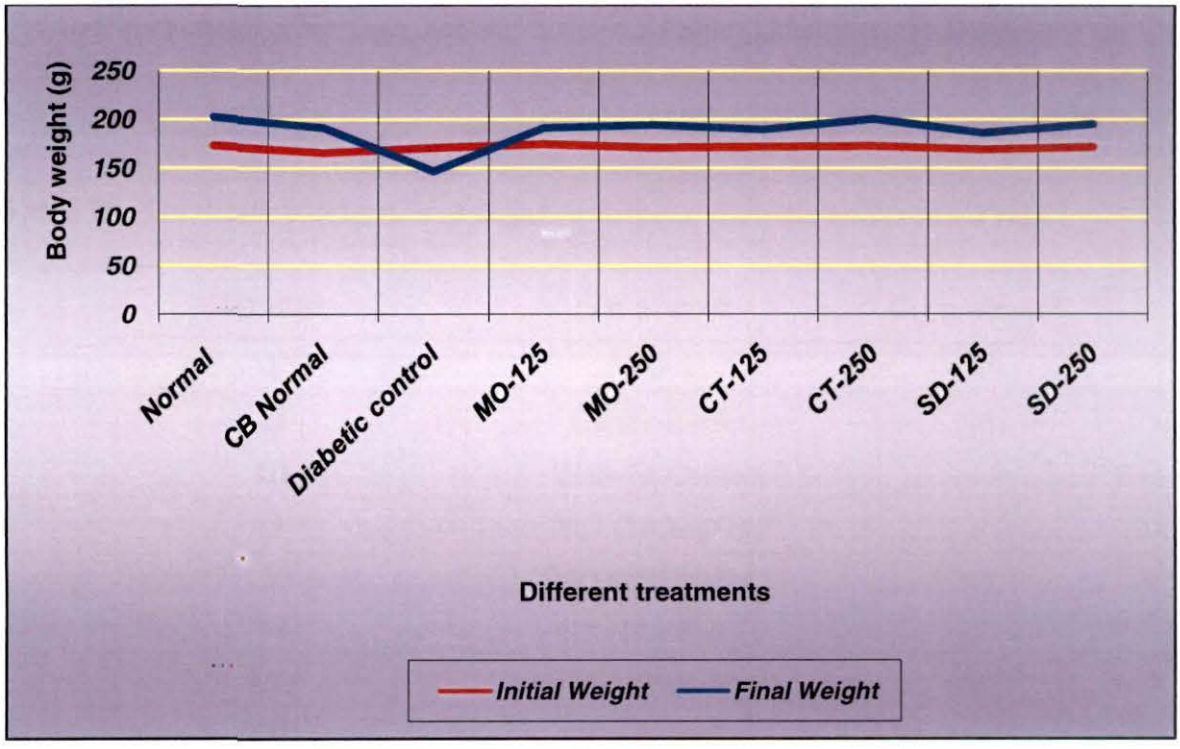


Fig- X : Effect of different extracts on changes in body weight; MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*.

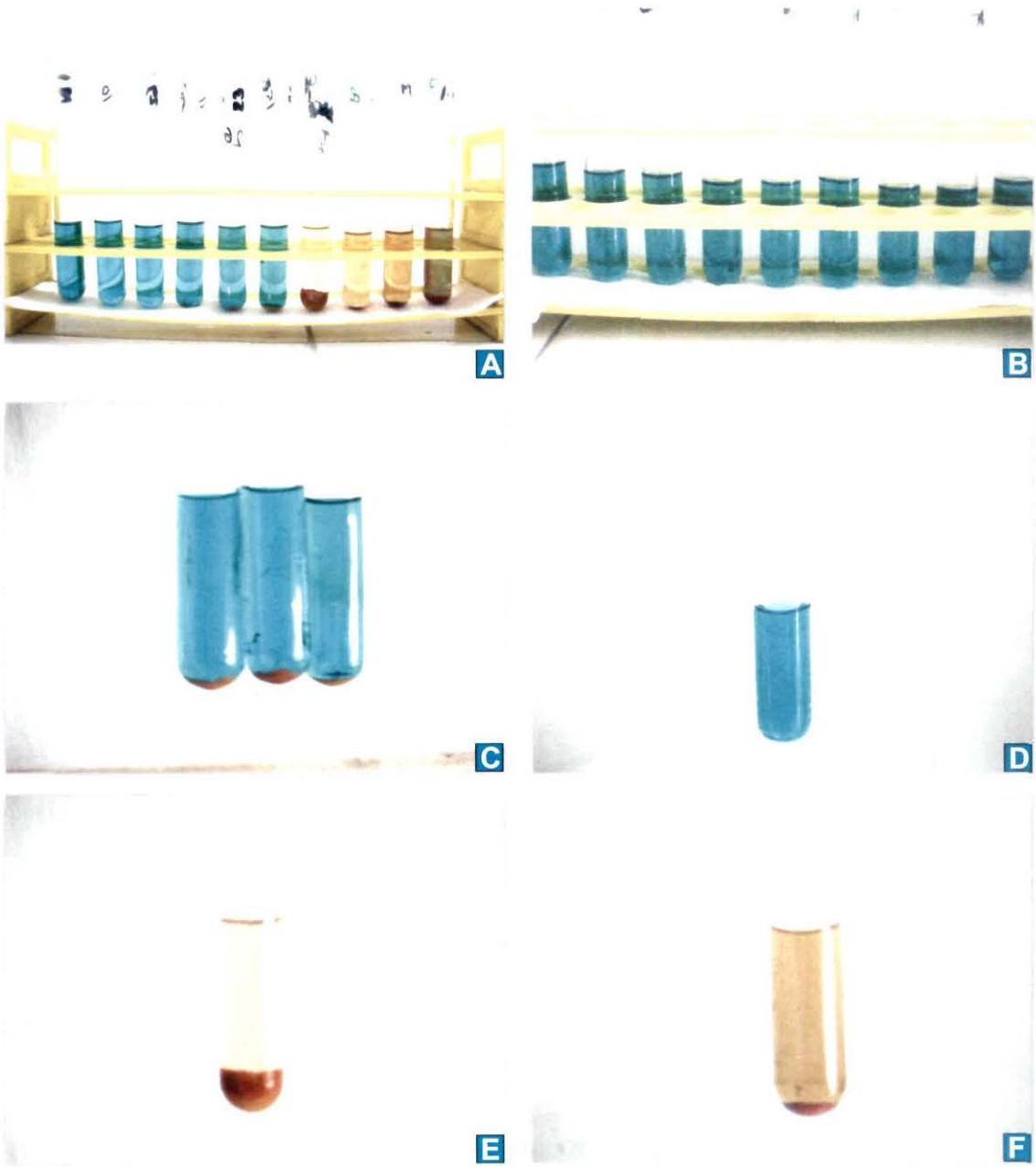


PLATE-XXIII : A: Result of urine test, B: Clear solution showing no sugar in the urine (after treatment with plant extract in the dose of 250 mg/kg, C: Minimum sugar in the urine in the STZ + plant extract (125 mg/ kg dose) treated rats, D: Clear solution showing no sugar in the urine of normal untreated rats, E and F: Maximum sugar in the STZ treated diabetic rats

4.10.3. Effect of different extracts on fasting blood glucose in control and diabetic rats

Tables 17 to 19 demonstrate the levels of blood glucose in normal and experimental rats (Fig XI to XIII). Fasting blood glucose levels in the control rats remained unchanged during the course of the experiment. There was a significant ($p< 0.05$) increase in blood glucose in diabetic rats after two days of STZ administration. The rats having blood glucose level more than 200 were considered for the study. In the study, all the extracts showed significant activity ($p< 0.05$) on the 20th day of treatment. *Cinnamomum tamala* reduced the fasting blood glucose level in the 20th day from STZ-2day by 72.52% (250mg/kg) and 54.20% (125mg/kg) followed by *Moringa oleifera* (250mg/kg- 68.50%, 125mg/kg- 42.93%), *Scoparia dulcis* (250mg/kg- 69.29%, 125mg/kg- 50.77%).

Table- 17 : Effect of different extracts on fasting blood glucose in normal and experimental rats

Group	Treatment	Fasting Blood Glucose (mg/dl) Days of STZ treatment	
		0	2
I	Normal (only vehicle distilled water)	76.10 ± 1.05	76.40 ± 0.25
II	Citrate buffer treated	76.85 ± 0.69	77.15 ± 0.83
III	Diabetic Control	76.40 ± 0.81	266.89 ± 1.38
IV	MO (125mg/kg)	75.96 ± 0.37	241.79 ± 1.98
V	MO (250 mg/kg)	77.49 ± 0.28	260.44 ± 0.69
VI	CT (125mg/kg)	78.20 ± 1.07	249.55 ± 0.92
VII	CT (250mg/kg)	77.52 ± 0.29	266.40 ± 0.28
VIII	SD (125mg/kg)	78.07 ± 0.29	238.09 ± 1.79
IX	SD (250mg/kg)	74.49 ± 0.49	259.43 ± 0.38
	SEM	0.5968	1.0636
	CD	1.9918	3.5498

Each value represents as mean± SE; MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*. Values were statistically significant at $p < 0.05$ as compared with diabetic control, $p < 0.05$ as compared with normal.

The effect of administration of *Cinnamomum tamala* (250mg/kg and 125mg/kg) leaves extracts decreased significantly ($p < 0.05$) the level of blood glucose near to normal. After the 20th day in STZ- diabetic control rats blood glucose increased to 337.07mg/dl that was increased by 26.29% from STZ-2day. Administration of *Scoparia dulcis* (250mg/kg and 125mg/kg) also significantly ($p < 0.01$) decreased the level of blood glucose.

Table- 18 : Effect of different extracts on fasting blood glucose in normal and experimental rats

Group	Treatment	Fasting Blood Glucose (mg/dl) Days of STZ treatment	
		10	20
I	Normal (only vehicle distilled water)	75.51 ± 0.52	76.40 ± 0.25
II	Citrate buffer treated	77.45 ± 0.60	77.15 ± 0.83
III	Diabetic Control	290.94 ± 1.69	266.89 ± 1.38
IV	MO (125mg/kg)	195.84± 3.08	241.79 ± 1.98
V	MO (250 mg/kg)	176.40 ± 1.82	260.44 ± 0.69
VI	CT (125mg/kg)	78.20 ± 1.07	249.55 ± 0.92
VII	CT (250mg/kg)	77.52 ± 0.29	266.40 ± 0.28
VIII	SD (125mg/kg)	78.07 ± 0.29	238.09 ± 1.79
IX	SD (250mg/kg)	74.49 ± 0.49	259.43 ± 0.38
	SEM	1.3997	2.1180
	CD	4.6716	7.0689

Each value represents as mean ± SE; Values were statistically significant at $p < 0.001$ as compared with diabetic control, $p < 0.01$ as compared with control. MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*.

Treatment with *Moringa oleifera* (250mg/kg and 125mg/kg) significantly ($p < 0.01$) decreased blood glucose and brought them near to normal level. The administration of *Cinnamomum tamala* to diabetic rat decreased the blood glucose to 73.20mg/dl and shown more effective than *Moringa oleifera, Scoparia dulcis.* Fasting blood glucose levels remain unchanged during the treatment.

Table-19 : Effect of different extracts on changes in fasting blood glucose in normal and experimental rats (Initial-final)

Group	Treatments	Initial	Final
I	Normal (only vehicle distilled water)	76.11 ± 1.05	77.75 ± 2.89
II	Citrate buffer treated	76.85 ± 0.68	76.85 ± 1.13
III	Diabetic Control	76.40 ± 0.81	337.07 ± 6.36
IV	MO (125mg/kg)	75.95 ± 0.37	137.97 ± 1.73
V	MO (250 mg/kg)	77.49 ± 0.28	82.02 ± 1.84
VI	CT (125mg/kg)	78.20 ± 1.07	114.26 ± 0.84
VII	CT (250mg/kg)	77.53 ± 0.29	73.20 ± 1.86
VIII	SD (125mg/kg)	78.08 ± 0.29	117.19 ± 1.18
IX	SD (250mg/kg)	74.49 ± 0.49	79.66 ± 0.97
	SEM	0.59	2.11
	CD	1.99	7.06

MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD=*Scoparia dulcis*. Values were statistically significant at $p < 0.01$ as compared with diabetic control, $p < 0.01$ as compared with normal.

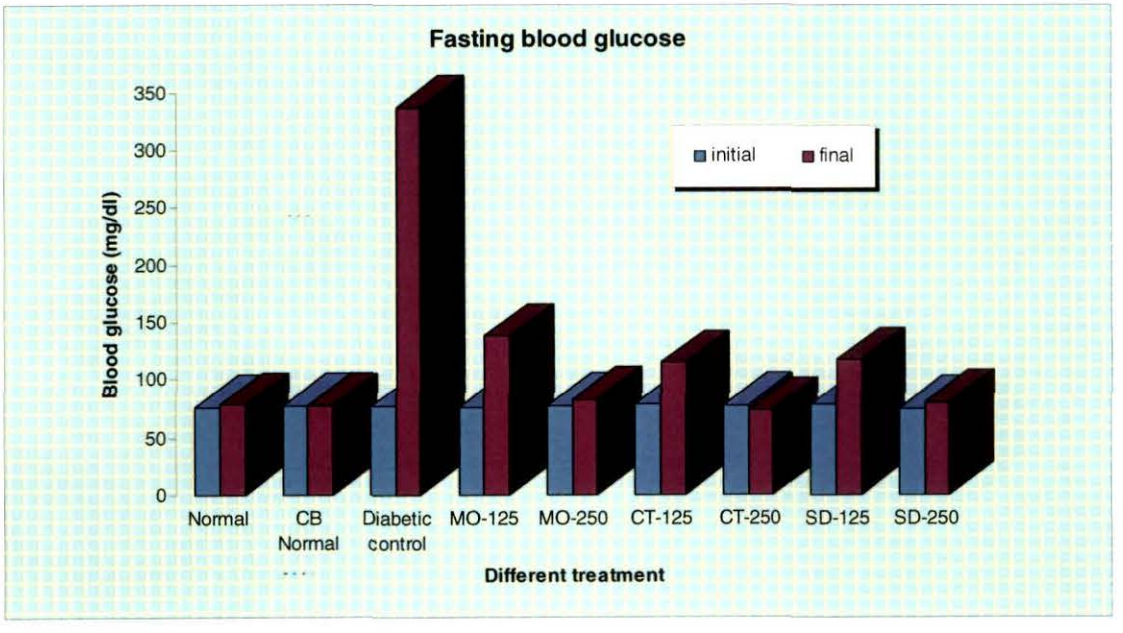


Fig- XI : Effect of different extracts on fasting blood glucose. MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*.

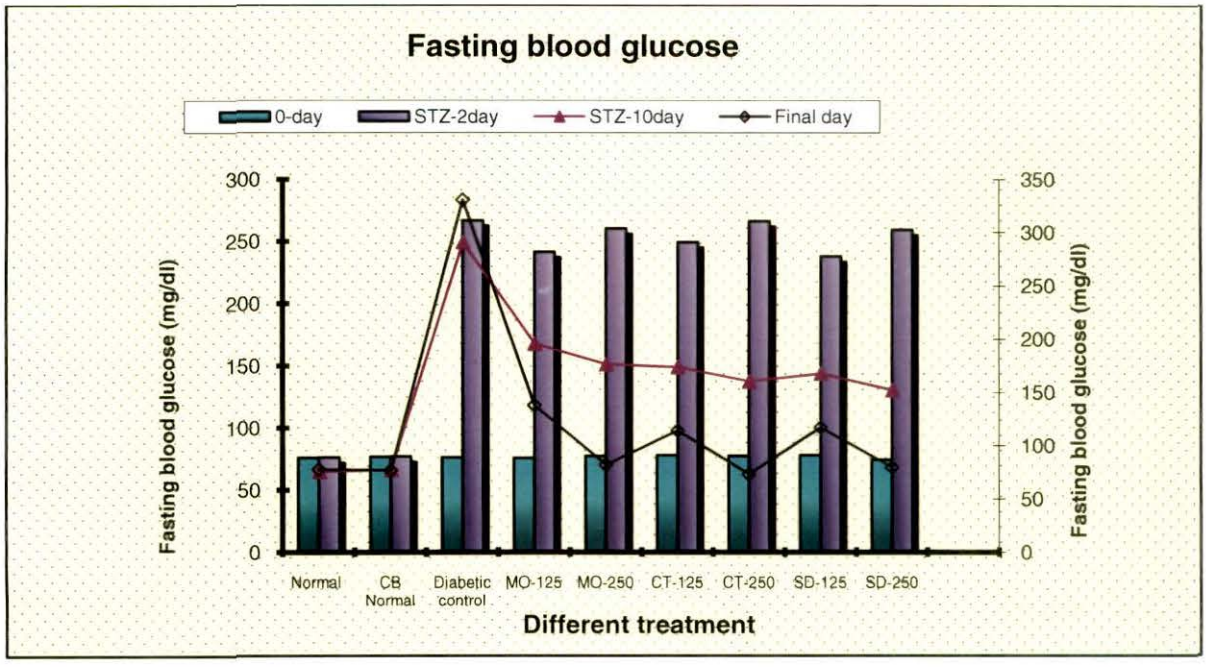


Fig-XII : Effect of different extracts on Fasting Blood glucose levels. MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*.

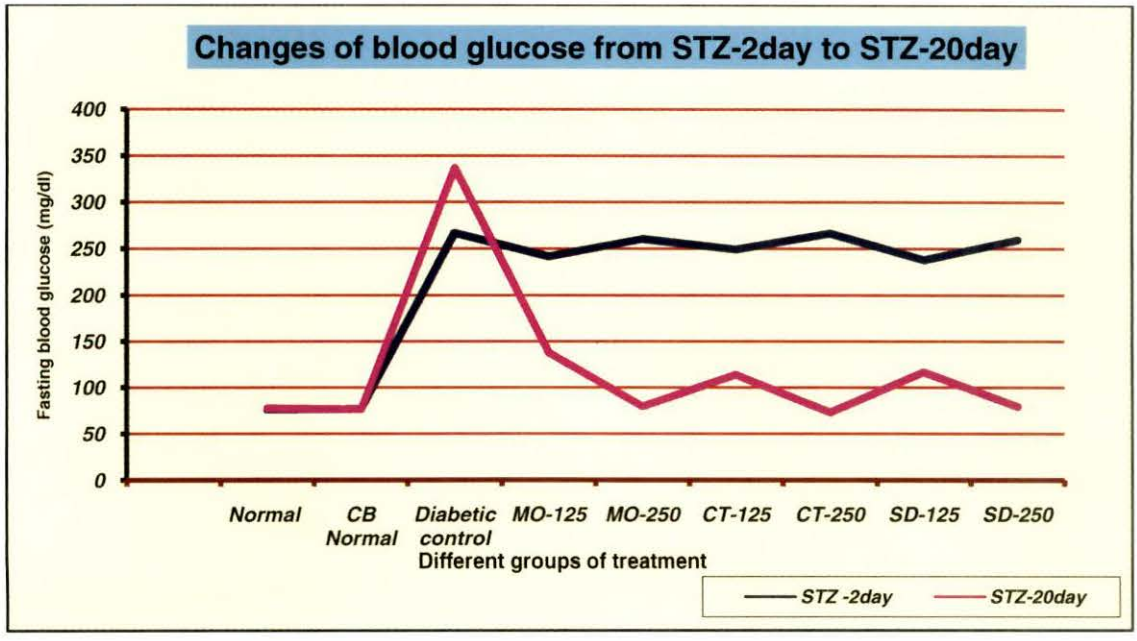


Fig-XIII : Effect of different extracts on fasting blood glucose (STZ-2day- STZ 20day).
MO= ***Moringa oleifera*****, CT=** ***Cinnamomum tamala*****, SD=** ***Scoparia dulcis.***

4.10.4. Effect of different extracts on glycogen in control and diabetic rats

The effects of *Cinnamomum tamala, Moringa oleifera, Scoparia dulcis* leaves extracts on Glycogen content are shown in the Table 20 and Fig XIV. The level of glycogen content decreased (21.17 mg/100g) significantly ($p< 0.001$) in the STZ-diabetic rats as compared to control (40.64 mg/100g). Administration of *Scoparia dulcis* (250mg/kg and 125mg/kg) increased the level of glycogen (41.33 and 30.53 mg/100g) in the liver significantly ($p< 0.001$). Treatment with *Cinnamomum tamala* (250mg/kg and 125mg/kg) significantly ($p< 0.001$) increase the glycogen (44.04 mg/100g and 33.41 mg/100g) and brought them near to normal level. Administration of *Moringa oleifera* (250mg/kg and 125mg/kg) increases the levels of glycogen (40.19 mg/100g and 30.16 mg/100g) in the liver ($p< 0.001$) during diabetes.

Table 20 : Effect of different extracts on glycogen in control and diabetic rats

Groups	Treatment	Glycogen (mg/100g)
I	Normal	40.65 ± 2.58
II	Citrate Buffer	41.40 ± 2.77
III	Diabetic Control	21.18 ± 2.66
IV	MO (125mg/kg)	30.16 ± 2.58
V	MO (250 mg/kg)	40.20 ± 1.39
VI	CT (125mg/kg)	33.41 ± 1.24
VII	CT (250mg/kg)	44.05 ± 1.24
VIII	SD (125mg/kg)	30.53 ± 1.46
IX	SD (250mg/kg)	41.33 ± 0.72
	SEM	1.61
	CD	5.38

Each value represents as mean± SE; Values were statistically significant at $p < 0.001$ as compared with diabetic control. MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*

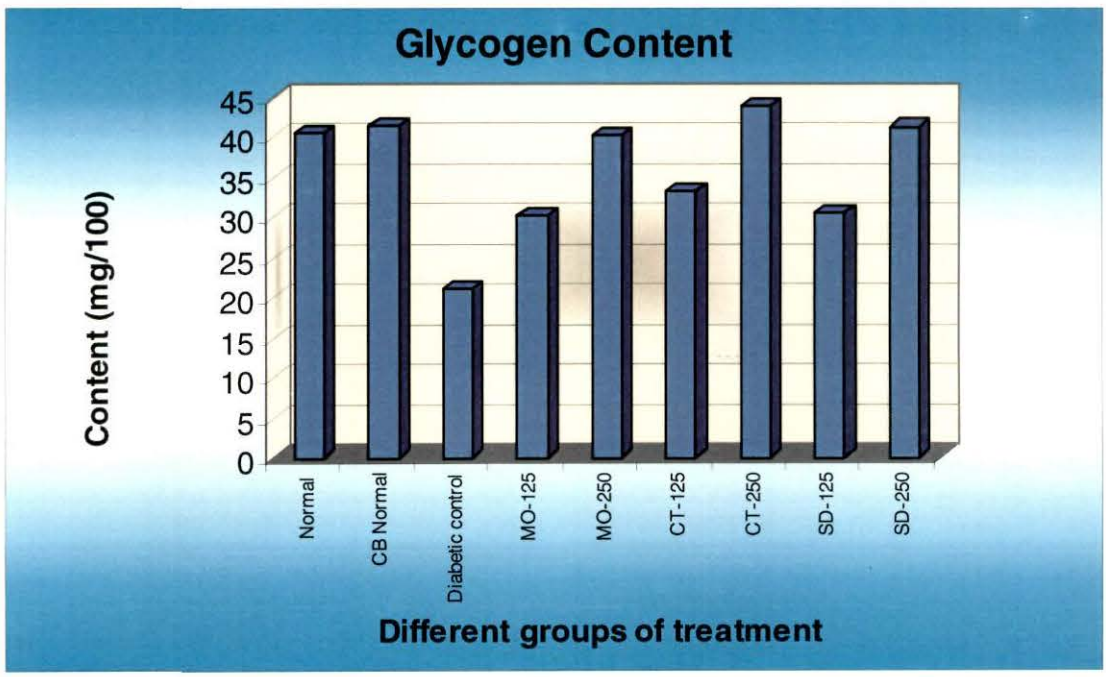


Fig-XIV : Effects of different extracts on glycogen levels. MO = *Moringa oleifera*, CT = *Cinnamonum tamala*, SD = *Scoparia dulcis*.

4.10.5. Effect of different extracts on TBARS level in control and diabetic rats

Changes in the concentration of TBARS in the liver of STZ-diabetic rats on the treatment with *Cinnamomum tamala, Moringa oleifera, Scoparia dulcis* leaves extracts are depicted in the Table 21 and Fig XV. The STZ-diabetic rats showed a significant increase in TBARS (1.84 mM/100g) when compared with normal ((d H_2O-0.81 mM/100g and citrate buffer-0.79 mM/100g) in liver. Thiobarbituric acid reactive substance levels were decreased in the *Cinnamomum tamala, Moringa oleifera, Scoparia dulcis* leaves extracts treated groups when compared with the normal rats. Treatment with *Moringa oleifera* (250mg/kg and 125mg/kg) significantly ($p< 0.001$) prevented the increase (0.90 mM/100g and 1.22 mM/100g) in TBARS levels and brought them near to normal level. Administration of *Scoparia dulcis* (250mg/kg and 125mg/kg) significantly ($p< 0.001$) decreased (0.84 mM/100g and 1.22 mM/100g) the level of TBARS in the liver. There was a significant ($p< 0.001$) reduction (1.00 mM/100g and 1.16 mM/100g) in the activity of TBARS in the liver of rats with the treatment of *Cinnamomum tamala* (250mg/kg and 125mg/kg) when compared with normal rats.

Table-21 : Effect of different extracts on TBARS level in control and diabetic rats

Groups	Treatment	TBARS (mM/100g)
I	Control	0.82 ± 0.03
II	Citrate buffer control	0.79 ± 0.05
III	Diabetic Control	1.84 ± 0.12
IV	MO (125mg/kg)	1.23 ± 0.01
V	MO (250 mg/kg)	0.91 ± 0.05
VI	CT (125mg/kg)	1.16 ± 0.02
VII	CT (250mg/kg)	1.01 ± 0.02
VIII	SD (125mg/kg)	1.22 ± 0.01
IX	SD (250mg/kg)	0.85 ± 0.06
	SEM	0.04
	CD	0.14

Each value represents as mean ± SE, MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*. Values were statistically significant at $p < 0.001$ as compared with diabetic control.

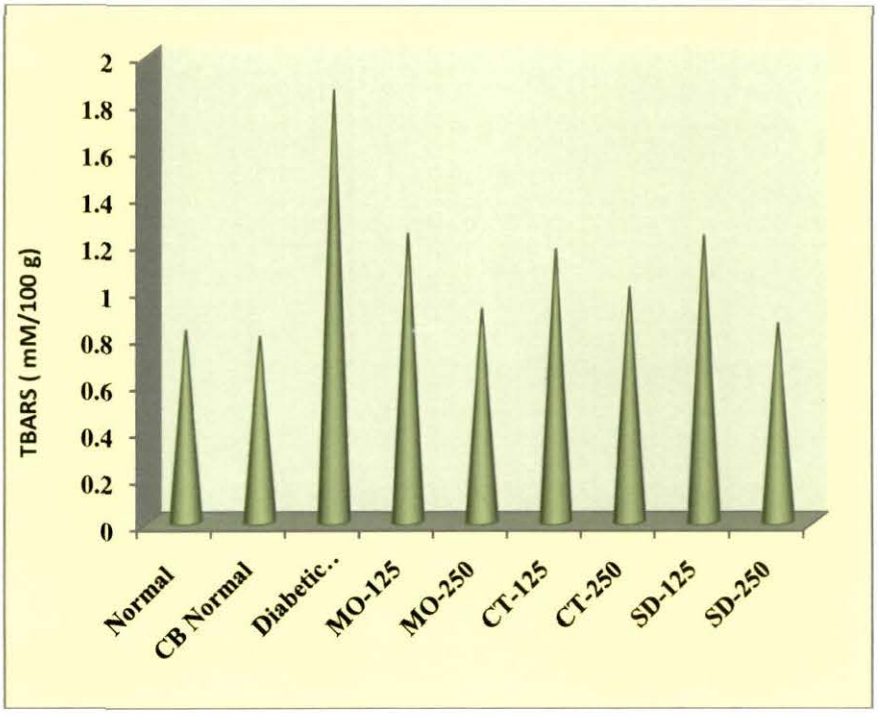


Fig-XV : Effects of Different extracts on TBARS levels
MO= ***Moringa oleifera*****, CT=** ***Cinnamomum tamala*****, SD=** ***Scoparia dulcis*****)**

4.10.6. Effect of different extracts on reduced glutathione (GSH) in control and diabetic rats

The concentrations of GSH in tissues in experimental diabetic rats are shown in Table 22 and Fig XVI. It was seen that the reduced glutathione level in the liver of STZ-diabetic rats were significantly ($p< 0.01$) decreased. Administration of *Cinnamomum tamala* (250mg/kg and 125mg/kg) increased the levels of GSH in the liver ($p< 0.01$) during diabetes. A significant ($p< 0.01$) increased of GSH level was observed in the *Moringa oleifera* (250mg/kg and 125mg/kg) treated group. Administration of *Scoparia dulcis* (250mg/kg and 125mg/kg) also significantly ($p< 0.01$) increased the level of GSH in the liver.

Table-22 : Effect of different extracts on Reduced Glutathione (GSH) in control and diabetic rats

Groups	Treatment	Reduced glutathione (mM/100g tissue)
I	Control (distilled water treated)	45.33 ± 1.76
II	Citrate buffer control	46.00 ± 1.52
III	Diabetic Control	25.66 ± 1.85
IV	MO (125mg/kg)	32.00 ± 1.15
V	MO (250 mg/kg)	39.33 ± 0.87
VI	CT (125mg/kg)	35.66 ± 1.2
VII	CT (250mg/kg)	45.00 ± 0.57
VIII	SD (125mg/kg)	33.33 ± 1.45
IX	SD (250mg/kg)	44.00 ± 1.15

Each value represents as mean ± SE; MO= *Moringa oleifera*, CT= *Cinnamonum tamala*, SD= *Scoparia dulcis*. Values were statistically significant at $p < 0.01$ as compared with diabetic control, $p < 0.01$ as compared with control.

4.10.7. Correlation analysis

Correlation and regression graphs are presented in Figs XVII and XVIII. Since results showed significant trends in body weight as well as other biochemical tests following hypergylcaemia induction and subsequent plant extract treatments, correlation between

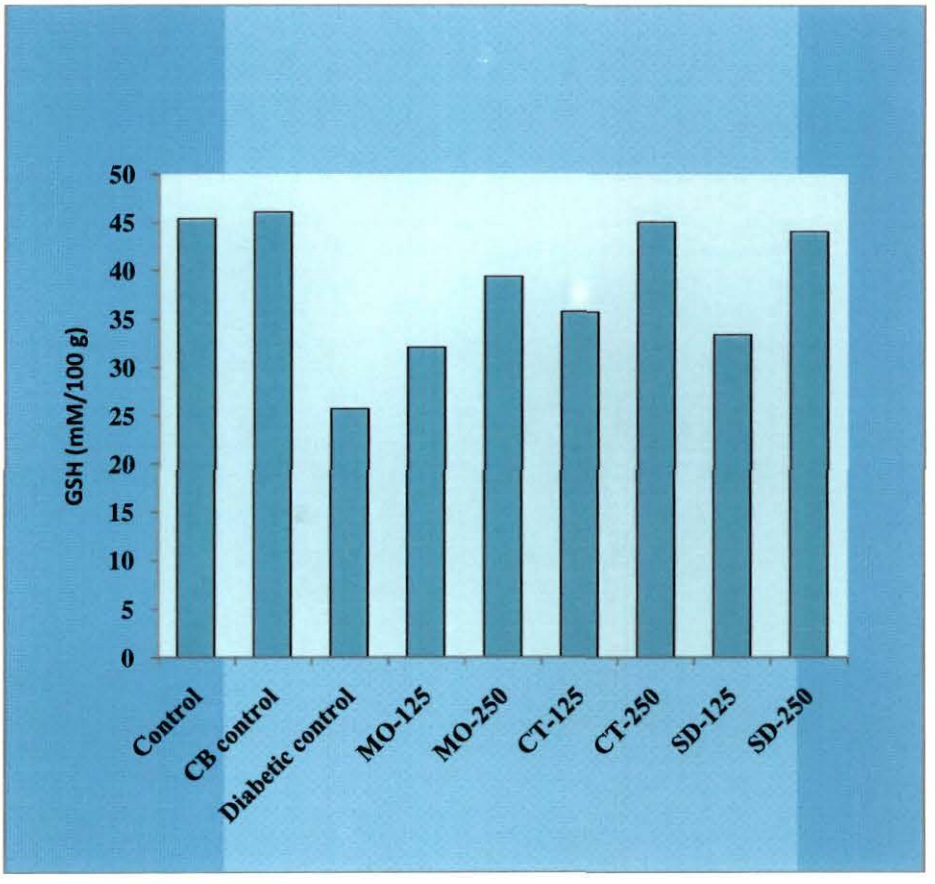
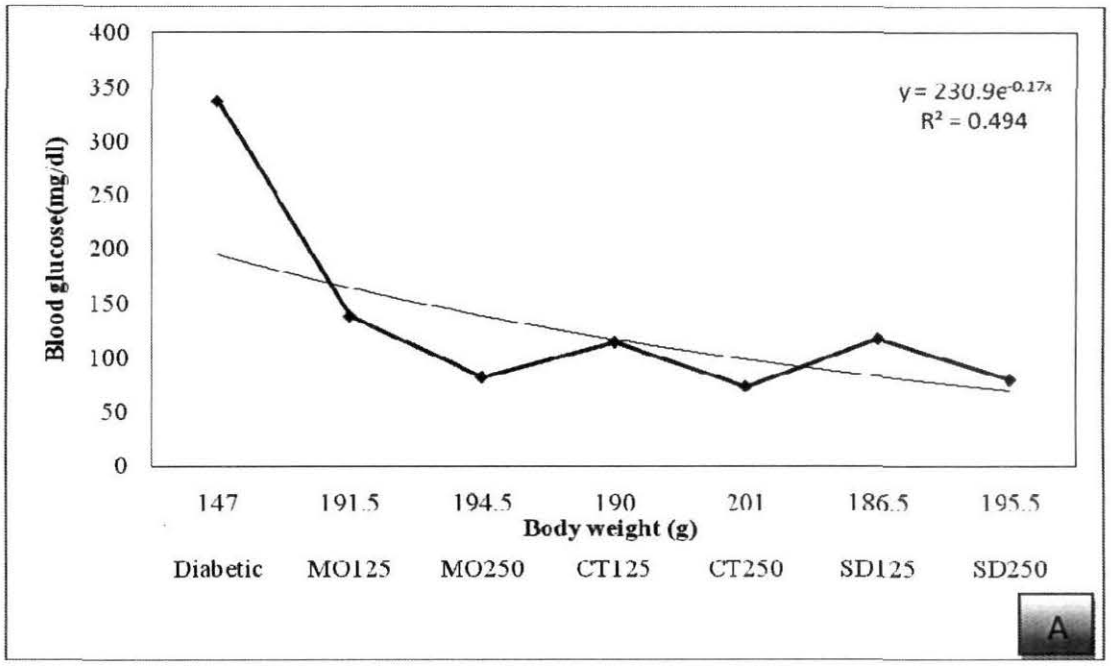


Fig-XVI : Effects of Different extracts on GSH levels
MO= *Moringa oleifera*, CT= *Cinnamomum tamala*, SD= *Scoparia dulcis*)



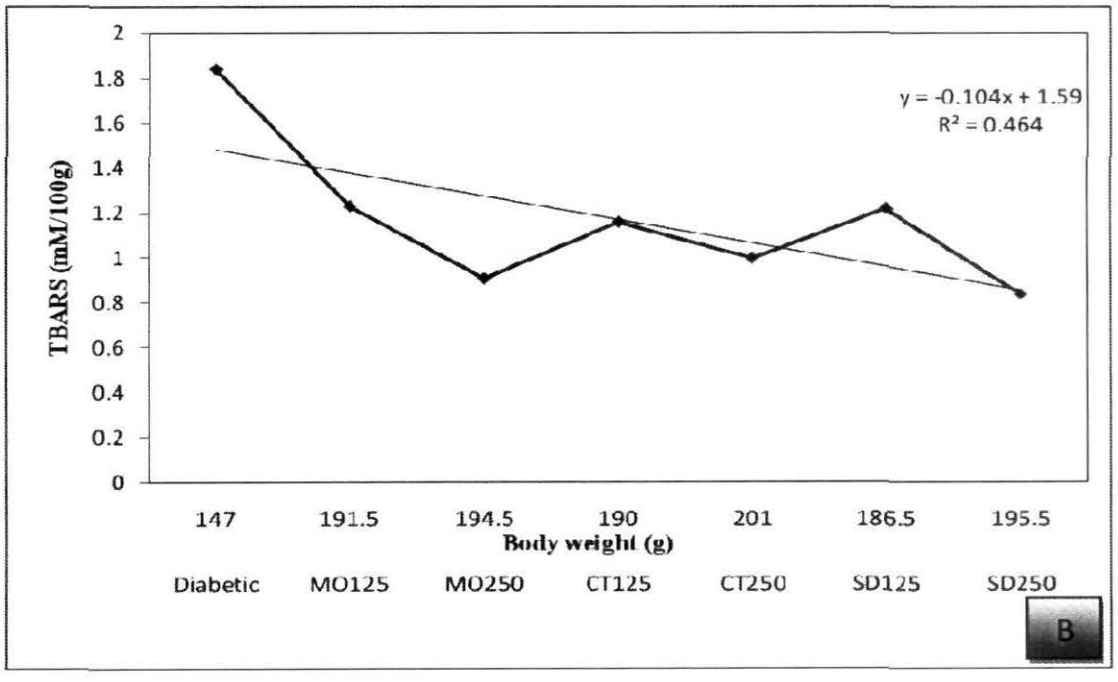
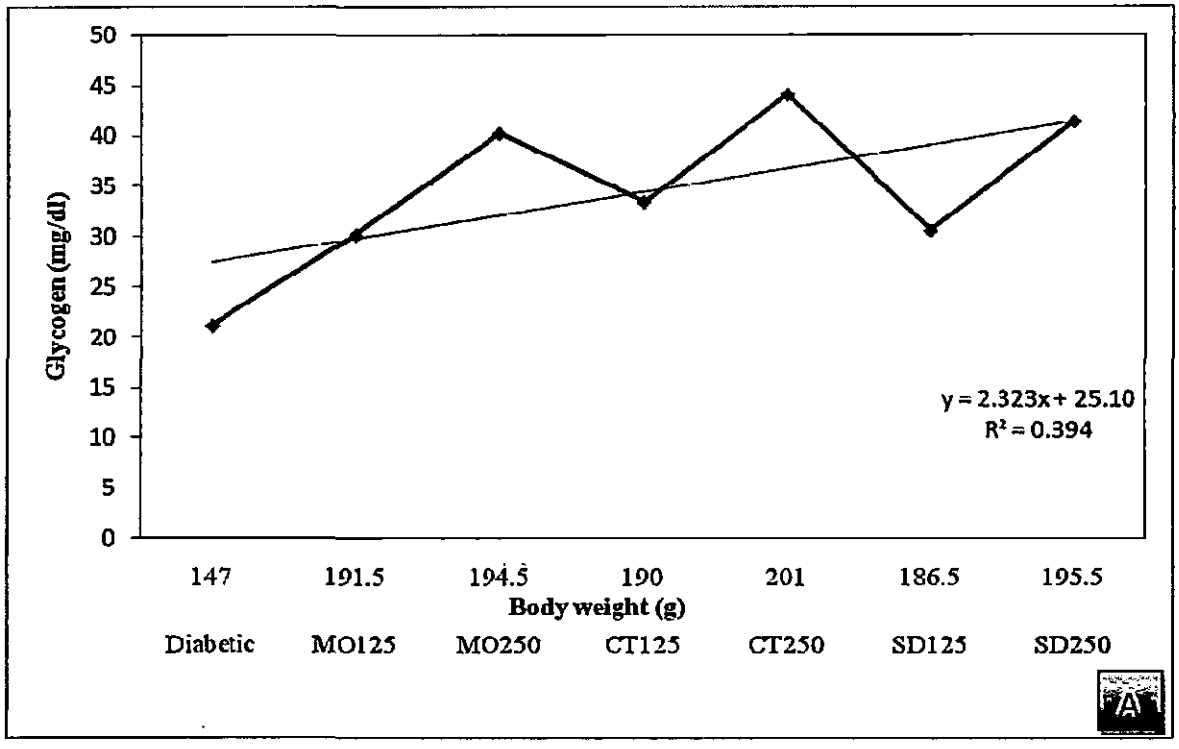


Fig.XVII: Correlation and regression between body weight of diabetic and treated rats and blood glucose content (A) and TBARS (B).



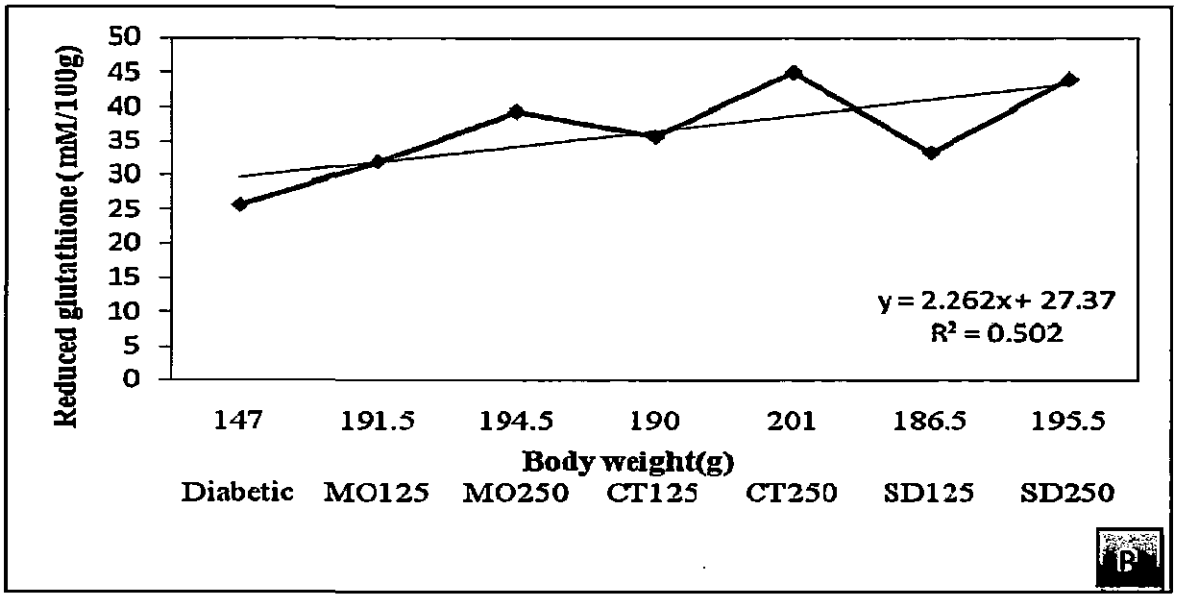


Fig.XVIII: Correlation and regression between body weight of diabetic and treated rats and glycogen (A) and GSH (B).

body weight and blood glucose, TBARS, glycogen and GSH were calculated. Body weight and blood glucose, as well as body weight and TBARS showed high negative correlation (r= -0.985 an -0.939, respectively). On the other hand, correlation between body weight and glycogen, as well as body weight and GSH, was also high, but positive (r= 0.862 and 0.826, respectively). Thus, it is clear that with increase in body weight of diabetic rats due to treatment of plant extracts, there was a decrease in blood glucose and TBARS. On the other hand, glycogen and GSH increased along with increase in body weight.