

Phytomedicinal Evaluation of *Musanga cecropioides* R. Br. ex Tedlie

By

Goddidit Esiro ENOYOZE

PG/LSC1313772

UNIVERSITY OF BENIN,

BENIN CITY

APRIL, 2021

Phytomedicinal Evaluation of *Musanga cecropioides* R. Br. ex Tedlie

By

Goddidit Esiro ENOYOZE

PG/LSC1313772

BSc. (BENIN)

MSc. (BENIN)

A THESIS WRITTEN IN THE DEPARTMENT OF PLANT BIOLOGY AND BIOTECHNOLOGY AND SUBMITTED TO THE SCHOOL OF POSTGRADUATE STUDIES IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY IN PHYTOMEDICINE OF THE UNIVERSITY OF BENIN, BENIN CITY.

APRIL, 2021

Certification

We certify that this work was carried out by Goddidit Esiro ENOYOZE in the Department of Plant Biology and Biotechnology, University of Benin, Benin City.

Prof. MacDonald Idu
Supervisor

Prof. (Mrs.) F. I. Okungbowa
Head of Department

Certification of Thesis

We the undersigned attest and declare that the thesis of Goddidit Esiro ENOYOZE, titled **Phytomedicinal Evaluation of *Musanga cecropioides* R. Br. ex Tedlie** has successfully passed the anti-plagiarism test and does not violate any Copyright regulations.

Prof. MacDonald IDU
Supervisor

Sign

Date

Prof. (Mrs.) F. I. OKUNGBOWA
Head of Department

Sign

Date

Dedication

I dedicate this work to the Almighty God and to my beloved parents Dr. and Mrs. IGBAPE. I love you beyond words.

Acknowledgements

My deepest gratitude goes to the Almighty God who gave me the grace, strength and favour to successfully go through every stage of this program successfully. To my ever-loving Supervisor and father, Prof. MacDonald Idu who never stopped believing in me even when I gave him reasons to see me short of my potentials, I say thank you. Thank you for all the lifelong lessons you have taught me since my undergraduate days till date and thank you for the patience and encouragement. God bless you sir.

My amiable Head of Department, Prof. Mrs. Okungbowa and my Post graduate coordinator Dr. Shittu, I say a big thank you for assisting in making my academic pursuit a smooth journey. I must not fail to appreciate the guidance and efforts of my past Head of Department, Prof. Osawaru and the past Post graduate coordinator, Dr. Timothy who also assisted me in diverse ways to make the journey pleasant.

I say thank you to all my lecturers who always encouraged me and were willing to render their assistance at different times, Prof. Okhuoya, Prof. (Mrs.) Kadiri, Prof. Akpaja, Prof. Aigbokhan, Prof. Anoliefo, Prof. (Mrs.) Ejale, Dr. Akinnibosun, Dr. Edegba, Dr. Berkeley and the non-teaching Staff of the Department who helped in one way or the other, God bless you all.

The efforts of Dr. Dickson, Mr. Benjamin and other members of the Phytomedicine Research Group who assisted in aspects of the work cannot be forgotten, God bless you all.

I appreciate every support rendered by the Management and Staff of Edo University Iyamho amongst who are, Prof. Aluyor, Prof. Omodia, Dr. (Mrs.) Ogboru, Dr. (Mrs.) Maliki, Dr. (Mrs.) Agbugui, Dr. Balogun, Dr. Adetunji, Dr. Ohanmu, Dr. Odoligie, Mrs. Phebean, Mr. Olori, Mrs. Augustine, Miss Ikhimalo, Fidelis and Anthony, who

provided laboratory space, equipment and both technical and manual support in carrying out most of the experiments.

To my strongest support system my spiritual parents, Apostle and Rev. Dr. Lizzy Johnson-Suleman, my family and friends, especially my dearest loving husband, Esosa Enoyoze who made countless sacrifices despite his commitments, my parents, Dr. and Mrs. Igbape, Mr. and Mrs. Osayagbon, my siblings, Maro and Mary Igbape, Roland Igbape, Mr. and Mrs. Bello, Mr. and Mrs. Novo Egbegbedia, Osaro, Faith, Eghe and Elogho, my friends – Mrs. Cynthia Umeh, Mrs. Helen Damilola, Mrs. Sandra Esere-Ozigbo and Mr. and Mrs. Alex Imas who gave their time, energy and finances to see that this quest is a success, God bless you all beyond measure. And to all my children, nieces and nephew, who always believe in me, Alenosi, Eguakhide, Naga, Eniola, Osasogie, Osawuoname, Bella and Miracle, I love you all and thanks for cheering me on always.

Table of Content

Title Page	i
Certification	iii
Certification of Thesis	iv
Dedication	v
Acknowledgements	vi
Table of Content	viii
List of Tables	xiv
List of Figures	xxiii
List of Plates	xxviii
Abstract	xxxii
CHAPTER ONE: INTRODUCTION	1
1.1 Background of the Study	1
1.2 Statement of the Problem	3
1.3 Justification for the Study	3
1.4 Aim and Objectives	3
CHAPTER TWO: LITERATURE REVIEW	5
2.1 Literature Review on <i>Musanga cecropioides</i>	5
2.1.1 Taxonomic Classification	5
2.1.2 Origin and Geographical Distribution	5
2.1.3 Botanical Description	7
2.1.4 Ethno Botany	7
2.1.5 Ethno Medicinal Uses	9
2.1.6 Literature Review on Scientific Works Done on <i>Musanga cecropioides</i>	10
2.2 Literature Review on Phyto-constituents	12
2.3 Literature Review on Antioxidants	19
2.4 Literature Review on Diarrhoea	21
2.5 Literature Review on Toxicity	22
2.6 Literature Review on Cough and Asthma	23
2.6 Literature Review on Diabetes	24
CHAPTER THREE: MATERIALS AND METHODS	25
3.1 Plant Sample Collection and Preparation	25
3.1.1 Plant Sample Collection	25
3.1.2 Plant Extract Preparation	25

3.2	Screening of Phytoconstituents	26
3.2.1	Qualitative Phytochemical Screening	26
3.2.1.1	Screening for Alkaloid	26
3.2.1.2	Screening for Tannin	26
3.2.1.3	Screening for Saponin	26
3.2.1.4	Screening for Flavonoid	26
3.2.1.5	Screening for Phenol	27
3.2.1.6	Screening for Terpenoid (Salkowski's test)	27
3.2.1.7	Screening for Cyanogenic Glycoside	27
3.2.1.8	Screening for Anthraquinone	27
3.2.1.9	Screening for Sterol/Steroids (Liebermann-Burchard Test)	27
3.2.1.10	Screening for Oxalate	28
3.2.2	Quantitative Phytochemical Screening	28
3.2.2.1	Determination of Total Alkaloid Content	28
3.2.2.2	Determination of Total Tannin Content	28
3.2.2.3	Determination of Total Saponin Content	29
3.2.2.4	Determination of Total Flavonoid Content	29
3.2.2.5	Determination of Total Phenolic Content	30
3.2.2.6	Determination of Total Terpenoid Content	30
3.2.2.7	Determination of Total Glycoside Content	31
3.2.3	Proximate Analysis	31
3.2.3.1	Determination of Percentage Moisture Content	31
3.2.3.2	Determination of Percentage Ash Content	32
3.2.3.3	Determination of Percentage Crude Protein	32
3.2.3.4	Determination of Percentage Crude Fat (Ether Extract)	34
3.2.3.5	Determination of Percentage Crude Fibre Content	35
3.2.3.6	Determination of Nitrogen-Free Extract Content (Total Carbohydrate)	35
3.2.4	Vitamins Analysis	36
3.2.5	Amino Acids Analysis	36
3.2.6	Mineral Analysis	37
3.3	Toxicity Assessment	38
3.3.1	Acute Toxicity Assessment	38
3.3.1.1	Experimental Animals	38
3.3.1.2	Experimental Design	39

3.3.2	Sub-Acute Toxicity Assessment	40
3.3.2.1	Experimental Animals	40
3.3.2.2	Experimental Design	40
3.3.2.3	Haematology Analysis	41
3.3.2.4	Biochemical Analysis	41
3.3.2.4.1	Liver Function	41
3.3.2.4.2	Renal Function	42
3.3.2.4.3	Lipid Profile	42
3.3.2.4.4	Plasma Antioxidant	42
3.3.2.5	Histology of Vital Organs	43
3.4	Antioxidant Assessment	43
3.4.1	DPPH Radical Scavenging Activity	43
3.4.2	ABTS Radical Scavenging Activity	44
3.4.3	DNA Protective Assay (DNA Nicking Experiment)	44
3.5	Antidiarrheal Study	45
3.5.1	Experimental Animals	45
3.5.2	Experimental Design	45
3.5.3	Castor Oil – Induced Diarrhoea	46
3.5.4	Castor Oil – Induced Enteropooling	46
3.6	Antitussive Study	47
3.6.1	Experimental Animals	47
3.6.2	Mucus Expectoration (Phenol Red) Experiment	47
3.6.3	Antitussive Screening Protocol	49
3.7	Antiasthma Study	50
3.7.1	Experimental Animals	50
3.7.2	Treatment Schedule	50
3.7.3	Anti-Asthma Screening Protocols	51
3.7.4	Evaluation of Trachea Fluid Viscosity (Flow Rate)	51
3.7.5	Haematology Analysis	52
3.7.6	Histology of the Lung and Trachea	52
3.8	Anti-Diabetic Study	52
3.8.1	Experimental Animals	52
3.8.2	Induction of Diabetes	53
3.8.3	Experimental Design and Treatment Schedule	53
3.8.4	Haematological Analysis	54

3.8.5	Biochemical Analysis	54
3.8.5.1	Liver Function	55
3.8.5.2	Renal Function	55
3.8.5.3	Lipid Profile	55
3.8.5.4	Total Antioxidant Capacity	55
3.8.6	In-vivo Antioxidant of the Brain, Liver and Pancreas	55
3.8.7	Histopathology	56
3.9	Data Analysis	56
CHAPTER FOUR: RESULTS		57
4.1	Screening of Phytoconstituents	57
4.1.1	Qualitative Phytochemical Screening	57
4.1.2	Quantitative Phytochemical Screening	59
4.1.3	Proximate Analysis	61
4.1.4	Vitamin Content	63
4.1.5	Carotene Content	68
4.1.6	Amino Acids	73
4.1.7	Elemental Analysis	78
4.2	Toxicity Assessment	80
4.2.1	Acute Toxicity Assessment	80
4.2.2	Sub-Acute Toxicity Assessment	84
4.2.2.1	Changes in whole body weight	84
4.2.2.2	Organ-to-body weight ratio	90
4.2.2.3	Haematology	96
4.2.2.4	Liver Function	102
4.2.2.5	Renal Function	110
4.2.2.6	Lipid Profile	118
4.2.2.7	Plasma Antioxidant	125
4.2.2.8	Histology of Vital Organs	132
4.2.2.8.1	Histology of the Heart	132
4.2.2.8.2	Histology of the Kidney	136
4.2.2.8.3	Histology of the Liver	140
4.2.2.8.4	Histology of the Lungs	144
4.3	Antioxidant Assessment	148
4.3.1	DPPH Radical Scavenging Activity	148
4.3.2	ABTS Radical Scavenging Activity	152

4.3.3	DNA Nicking Assay	156
4.4	Antidiarrheal Study	158
4.4.1	Castor oil – induced Diarrhoea	158
4.4.2	Castor oil – induced Enteropooling	162
4.5	Antitussive Study	166
4.5.1	Mucus Expectoration (Phenol Red) Experiment	166
4.5.2	Antitussive Experiment (Citric acid-induced cough)	172
4.6	Antiasthma Study	176
4.6.1	Latency to Pre-convulsive Dyspnoea	176
4.6.2	Flow Rate	180
4.6.3	Haematology	184
4.6.4	Histology of the Lungs	189
4.6.5	Trachea Wall Thickness	193
4.7	Anti Diabetic Study	197
4.7.1	Blood Glucose Levels	197
4.7.2	Changes in Body Weight	205
4.7.3	Organ to Body Weight Ratio	211
4.7.4	Haematology	217
4.7.5	Biochemical Analysis	224
4.7.5.1	Liver Function	224
4.7.5.2	Renal Function	231
4.7.5.3	Lipid Profile	238
4.7.5.4	Total Antioxidant Capacity	245
4.7.6	In-vivo Antioxidant of the Brain, Liver and Pancreas	251
4.7.6.1	Brain	251
4.7.6.2	Liver	259
4.7.6.3	Pancreas	267
4.7.7	Histopathology	275
4.7.7.1	Histology of the Heart	275
4.7.7.2	Histology of the Liver	281
4.7.7.3	Histology of the Lungs	287
4.7.7.4	Histology of the Pancreas	293
4.7.7.5	Histology of the Spleen	299
4.7.7.6	Histology of the Kidney	305
CHAPTER FIVE: DISCUSSION AND CONCLUSION		311

5.1	Phytoconstituents	311
5.2	Toxicity Studies	314
5.3	<i>In vitro</i> Antioxidant Activities	318
5.4	Anti-Diarrhoea Studies	319
5.5	Antitussive and Antiasthmatic Studies	321
5.6	Anti-Diabetic Study	323
5.7	Conclusion and Recommendation	331
5.8	Contribution to Knowledge	331
References		332

List of Tables

Table 2.1	Scientific studies on <i>Musanga cecropioides</i>	11
Table 4.1	Qualitative phytochemical screening of <i>Musanga cecropioides</i> aqueous and methanol leaf extracts, root extracts and crude root sap	58
Table 4.2	Quantitative phytochemical screening of <i>Musanga cecropioides</i> leaves, root and root sap	60
Table 4.3	Proximate analysis of <i>Musanga cecropioides</i> leaves, root and root sap	62
Table 4.4	Vitamin composition of <i>Musanga cecropioides</i> leaves, root and root sap	64
Table 4.5	Amino acid composition of <i>Musanga cecropioides</i> leaves, root and root sap	74
Table 4.6	Concentration of elements in <i>Musanga cecropioides</i> leaves, root and root sap	79
Table 4.7	Result of acute toxicity assessment on <i>Musanga cecropioides</i> leaf extracts in mice	81
Table 4.8	Result of acute toxicity assessment on <i>Musanga cecropioides</i> root extracts in mice	82
Table 4.9	Result of acute toxicity assessment on <i>Musanga cecropioides</i> crude root sap in mice	83
Table 4.10	Changes in whole body weight of rats treated daily with aqueous extracts of <i>Musanga cecropioides</i> leaves for 28 days	85
Table 4.11	Changes in whole body weight of rats treated daily with methanol extracts of <i>Musanga cecropioides</i> leaves for 28 days	86

Table 4.12	Changes in whole body weight of rats treated daily with aqueous extracts of <i>Musanga cecropioides</i> roots for 28 days	87
Table 4.13	Changes in whole body weight of rats treated daily with methanol extracts of <i>Musanga cecropioides</i> root for 28 days	88
Table 4.14	Changes in whole body weight of rats treated daily with <i>Musanga cecropioides</i> crude root sap for 28 days	89
Table 4.15	Organ-to-body weight ratios of rats treated daily with <i>Musanga cecropioides</i> aqueous leaves extract for 28 days	91
Table 4.16	Organ-to-body weight ratios of rats treated daily with <i>Musanga cecropioides</i> methanol leaves extract for 28 days	92
Table 4.17	Organ-to-body weight ratios of rats treated daily with <i>Musanga cecropioides</i> aqueous root extract for 28 days	93
Table 4.18	Organ-to-body weight ratios of rats treated daily with <i>Musanga cecropioides</i> methanol root extract for 28 days	94
Table 4.19	Organ-to-body weight ratios of rats treated daily with <i>Musanga cecropioides</i> crude root sap for 28 days	95
Table 4.20	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the haematological parameters of rats in 28 days sub-acute toxicity study	97
Table 4.21	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the haematological parameters of rats in 28 days sub-acute toxicity study	98
Table 4.22	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the haematological parameters of rats in 28 days sub-acute toxicity study	99

Table 4.23	Effect of methanol extract of <i>Musanga cecropioides</i> root on the haematological parameters of rats in 28 days sub-acute toxicity study	100
Table 4.24	Effect of <i>Musanga cecropioides</i> crude root sap on the haematological parameters of rats in 28 days sub-acute toxicity study	101
Table 4.25	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the liver function parameters of rats in 28 days sub-acute toxicity study	104
Table 4.26	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the liver function parameters of rats in 28 days sub-acute toxicity study	105
Table 4.27	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the liver function parameters of rats in 28 days sub-acute toxicity study	106
Table 4.28	Effect of methanol extract of <i>Musanga cecropioides</i> root on the liver function parameters of rats in 28 days sub-acute toxicity study	107
Table 4.29	Effect of <i>Musanga cecropioides</i> crude root sap on the liver function parameters of rats in 28 days sub-acute toxicity study	108
Table 4.30	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the renal function parameters of rats in 28 days sub-acute toxicity study	111
Table 4.31	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the renal function parameters of rats in 28 days sub-acute	112

	toxicity study	
Table 4.32	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the renal function parameters of rats in 28 days sub-acute toxicity study	113
Table 4.33	Effect of methanol extract of <i>Musanga cecropioides</i> root on the renal function parameters of rats in 28 days sub-acute toxicity study	114
Table 4.34	Effect of <i>Musanga cecropioides</i> crude root sap on the renal function parameters of rats in 28 days sub-acute toxicity study	115
Table 4.35	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the lipid profile parameters of rats in 28 days sub-acute toxicity study	118
Table 4.36	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the lipid profile parameters of rats in 28 days sub-acute toxicity study	119
Table 4.37	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the lipid profile parameters of rats in 28 days sub-acute toxicity study	120
Table 4.38	Effect of methanol extract of <i>Musanga cecropioides</i> root on the lipid profile parameters of rats in 28 days sub-acute toxicity study	121
Table 4.39	Effect of <i>Musanga cecropioides</i> crude root sap on the lipid profile parameters of rats in 28 days sub-acute toxicity study	122
Table 4.40	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the plasma antioxidant parameters of rats in 28 days sub-acute	125

	toxicity study	
Table 4.41	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study	126
Table 4.42	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study	127
Table 4.43	Effect of methanol extract of <i>Musanga cecropioides</i> root on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study	128
Table 4.44	Effect of <i>Musanga cecropioides</i> crude root sap on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study	129
Table 4.45	Effect of <i>Musanga cecropioides</i> leave extracts on castor oil – induced diarrhoea in mice	157
Table 4.46	Effect of <i>Musanga cecropioides</i> root extracts on castor oil – induced diarrhoea in mice	158
Table 4.47	Effect of <i>Musanga cecropioides</i> crude root sap on castor oil – induced diarrhoea in mice	159
Table 4.48	Effect of <i>Musanga cecropioides</i> leave extracts on castor oil – induced enteropooling in mice	161
Table 4.49	Effect of <i>Musanga cecropioides</i> root extracts on castor oil – induced enteropooling in mice	162
Table 4.50	Effect of <i>Musanga cecropioides</i> crude root sap on castor oil – induced enteropooling in mice	163

Table 4.51	Effect of <i>Musanga cecropioides</i> leaves on the haematological parameters of guinea pigs in 21 days anti-asthmatic study	184
Table 4.52	Effect of <i>Musanga cecropioides</i> root on the haematological parameters of guinea pigs in 21 days anti-asthmatic study	185
Table 4.53	Effect of <i>Musanga cecropioides</i> crude root sap on the haematological parameters of guinea pigs in 21 days anti-asthmatic study	186
Table 4.54	Effect of aqueous extracts of <i>Musanga cecropioides</i> leaves on blood sugar levels in STZ-induced diabetic rats	197
Table 4.55	Effect of methanol extracts of <i>Musanga cecropioides</i> leaves on blood sugar levels in STZ-induced diabetic rats	198
Table 4.56	Effect of aqueous extracts of <i>Musanga cecropioides</i> root on blood sugar levels in STZ-induced diabetic rats	199
Table 4.57	Effect of methanol extract of <i>Musanga cecropioides</i> root on blood sugar levels in STZ-induced diabetic rats	200
Table 4.58	Effect of <i>Musanga cecropioides</i> crude root sap on blood sugar levels in STZ-induced diabetic rats	201
Table 4.59	Effect of aqueous extracts of <i>Musanga cecropioides</i> leaves on the body weights of STZ-induced diabetic rats	203
Table 4.60	Effect of methanol extracts of <i>Musanga cecropioides</i> leaves on the body weights of STZ-induced diabetic rats	204
Table 4.61	Effect of aqueous extracts of <i>Musanga cecropioides</i> root on the weight of STZ-induced diabetic rats	205
Table 4.62	Effect of methanol extracts of <i>Musanga cecropioides</i> root on the weight of STZ-induced diabetic rats	206

Table 4.63	Effect of <i>Musanga cecropioides</i> crude root sap on the weight of STZ-induced diabetic rats	207
Table 4.64	Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with aqueous extracts of <i>Musanga cecropioides</i> leaves	209
Table 4.65	Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with methanol extracts of <i>Musanga cecropioides</i> Leaves	210
Table 4.66	Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with aqueous extracts of <i>Musanga cecropioides</i> root	211
Table 4.67	Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with methanol extracts of <i>Musanga cecropioides</i> root	212
Table 4.68	Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with <i>Musanga cecropioides</i> crude root sap	213
Table 4.69	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the haematological parameters of STZ-induced diabetic rats	216
Table 4.70	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the haematological parameters of STZ-induced diabetic rats	217
Table 4.71	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the haematological parameters of STZ-induced diabetic rats	218
Table 4.72	Effect of methanol extract of <i>Musanga cecropioides</i> root on the haematological parameters of STZ-induced diabetic rats	219

Table 4.73	Effect of <i>Musanga cecropioides</i> crude root sap on the haematological parameters of STZ-induced diabetic rats	220
Table 4.74	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the liver function parameters of STZ-induced diabetic rats	223
Table 4.75	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the liver function parameters of STZ-induced diabetic rats	224
Table 4.76	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the liver function parameters of STZ-induced diabetic rats	225
Table 4.77	Effect of methanol extract of <i>Musanga cecropioides</i> root on the liver function parameters of STZ-induced diabetic rats	226
Table 4.78	Effect of <i>Musanga cecropioides</i> crude root sap on the liver function parameters of STZ-induced diabetic rats	227
Table 4.79	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the renal function parameters of STZ-induced diabetic rats	230
Table 4.80	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the renal function parameters of STZ-induced diabetic rats	231
Table 4.81	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the renal function parameters of STZ-induced diabetic rats	232
Table 4.82	Effect of methanol extract of <i>Musanga cecropioides</i> root on the renal function parameters of STZ-induced diabetic rats	233
Table 4.83	Effect of <i>Musanga cecropioides</i> crude root sap on the renal function parameters of STZ-induced diabetic rats	234
Table 4.84	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the lipid profile parameters of STZ-induced diabetic rats	237
Table 4.85	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on	238

	the lipid profile parameters of STZ-induced diabetic rats	
Table 4.86	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the lipid profile parameters of STZ-induced diabetic rats	239
Table 4.87	Effect of methanol extract of <i>Musanga cecropioides</i> root on the lipid profile parameters of STZ-induced diabetic rats	240
Table 4.88	Effect of <i>Musanga cecropioides</i> crude root sap on the lipid profile parameters of STZ-induced diabetic rats	241
Table 4.89	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the brain antioxidant parameters of STZ-induced diabetic rats	250
Table 4.90	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the brain antioxidant parameters of STZ-induced diabetic rats	251
Table 4.91	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the brain antioxidant parameters of STZ-induced diabetic rats	252
Table 4.92	Effect of methanol extract of <i>Musanga cecropioides</i> root on the brain antioxidant parameters of STZ-induced diabetic rats	253
Table 4.93	Effect of <i>Musanga cecropioides</i> crude root sap on the brain antioxidant parameters of STZ-induced diabetic rats	254
Table 4.94	Effect of aqueous extracts of <i>Musanga cecropioides</i> leaves on the liver antioxidant parameters of STZ-induced diabetic rats	257
Table 4.95	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the liver antioxidant parameters of STZ-induced diabetic rats	258
Table 4.96	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the liver antioxidant parameters of STZ-induced diabetic rats	259
Table 4.97	Effect of methanol extract of <i>Musanga cecropioides</i> root on the liver antioxidant parameters of STZ-induced diabetic rats	260

Table 4.98	Effect of <i>Musanga cecropioides</i> crude root sap on the liver antioxidant parameters of STZ-induced diabetic rats	261
Table 4.99	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the pancreas antioxidant parameters of STZ-induced diabetic rats	264
Table 4.100	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the pancreas antioxidant parameters of STZ-induced diabetic rats	265
Table 4.101	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the pancreas antioxidant parameters of STZ-induced diabetic rats	266
Table 4.102	Effect of methanol extract of <i>Musanga cecropioides</i> root on the pancreas antioxidant parameters of STZ-induced diabetic rats	267
Table 4.103	Effect of <i>Musanga cecropioides</i> crude root sap on the pancreas antioxidant parameters of STZ-induced diabetic rats	268

List of Figures

Figure 2.1	Map of Africa showing the distribution of <i>Musanga</i>	6

cecropioides

Figure 4.1	Chromatogram of vitamin content of <i>Musanga cecropioides</i> leaves	65
Figure 4.2	Chromatogram of vitamin content of <i>Musanga cecropioides</i> root	66
Figure 4.3	Chromatogram of vitamin content of <i>Musanga cecropioides</i> root sap	67
Figure 4.4	Carotene content in <i>Musanga cecropioides</i> leaves, root and root sap	69
Figure 4.5	Chromatogram of carotene content of <i>Musanga cecropioides</i> leaves	70
Figure 4.6	Chromatogram of carotene content of <i>Musanga cecropioides</i> root	71
Figure 4.7	Chromatogram of carotene content of <i>Musanga cecropioides</i> root sap	72
Figure 4.8	Chromatogram of amino acid content of <i>Musanga cecropioides</i> leaves	75
Figure 4.9	Chromatogram of amino acid content of <i>Musanga cecropioides</i> root	76
Figure 4.10	Chromatogram of amino acid content of <i>Musanga cecropioides</i> root sap	77
Figure 4.11	DPPH radical scavenging activity of <i>Musanga cecropioides</i> leaf extracts	147
Figure 4.12	DPPH radical scavenging activity of <i>Musanga cecropioides</i> root extracts	148

Figure 4.13	DPPH radical scavenging activity of <i>Musanga cecropioides</i> crude root sap	149
Figure 4.14	ABTS radical scavenging activity of <i>Musanga cecropioides</i> leaf extracts	151
Figure 4.15	ABTS radical scavenging activity of <i>Musanga cecropioides</i> root extracts	152
Figure 4.16	ABTS radical scavenging activity of <i>Musanga cecropioides</i> crude root sap	153
Figure 4.17	DNA protective effect of <i>Musanga cecropioides</i> leaf and root extracts on Fenton's induced DNA damage of pCAMBIA 1301 DNA	155
Figure 4.18	Effect of <i>Musanga cecropioides</i> aqueous leaf extract on phenol red dye secretion in mice trachea	165
Figure 4.19	Effect of <i>Musanga cecropioides</i> methanol leaf extract on phenol red secretion in mice trachea	166
Figure 4.20	Effect of <i>Musanga cecropioides</i> aqueous root extract on phenol red secretion in mice trachea	167
Figure 4.21	Effect of <i>Musanga cecropioides</i> methanol root extract on phenol red secretion in mice trachea	168
Figure 4.22	Effect of <i>Musanga cecropioides</i> crude root sap on phenol red secretion in mice trachea	169
Figure 4.23	Antitussive effect of <i>Musanga cecropioides</i> leaf aqueous and methanol extracts on citric acid-induced cough in guinea pigs	171
Figure 4.24	Antitussive effect of <i>Musanga cecropioides</i> root aqueous	172

	and methanol extracts on citric acid-induced cough in guinea pigs	
Figure 4.25	Antitussive effect of <i>Musanga cecropioides</i> crude root sap on citric acid-induced cough in guinea pigs	173
Figure 4.26	Effect of <i>Musanga cecropioides</i> leaf extracts on latency to pre-convulsive dyspnea in ovalbumin sensitized guinea pigs	175
Figure 4.27	Effect of <i>Musanga cecropioides</i> root extracts on latency to pre-convulsive dyspnea in ovalbumin sensitized guinea pigs	176
Figure 4.28	Effect of <i>Musanga cecropioides</i> crude root sap on latency to pre-convulsive dyspnea in ovalbumin sensitized guinea pigs	177
Figure 4.29	Effect of <i>Musanga cecropioides</i> leaf extracts on tracheal fluid viscosity in ovalbumin sensitized guinea pigs	179
Figure 4.30	Effect of <i>Musanga cecropioides</i> root extracts on tracheal fluid viscosity in ovalbumin sensitized guinea pigs	180
Figure 4.31	Effect of <i>Musanga cecropioides</i> crude root sap on tracheal fluid viscosity in ovalbumin sensitized guinea pigs	181
Figure 4.32	Effect of <i>Musanga cecropioides</i> leaf extracts on tracheal wall thickness in ovalbumin sensitized guinea pigs	192
Figure 4.33	Effect of <i>Musanga cecropioides</i> root extracts on tracheal wall thickness in ovalbumin sensitized guinea pigs	193
Figure 4.34	Effect of <i>Musanga cecropioides</i> crude root sap on tracheal wall thickness in ovalbumin sensitized guinea pigs	194
Figure 4.35	Total antioxidant capacity of STZ – induced diabetic rats plasma treated with aqueous extracts of <i>Musanga cecropioides</i> leaves after 28 days	243

Figure 4.36	Total antioxidant capacity of STZ – induced diabetic rats plasma treated with methanol extracts of <i>Musanga cecropioides</i> leaves after 28 days	244
Figure 4.37	Total antioxidant capacity of STZ – induced diabetic rats plasma treated with aqueous extracts of <i>Musanga cecropioides</i> root after 28 days	245
Figure 4.38	Total antioxidant capacity of STZ – induced diabetic rats plasma treated with methanol extracts of <i>Musanga cecropioides</i> root after 28 days	246
Figure 4.39	Total antioxidant capacity of STZ – induced diabetic rats plasma treated with of <i>Musanga cecropioides</i> crude root sap after 28 days	247

List of Plates

Plate 2.1	<i>Musanga cecropioides</i> leaf and stipule	8
Plate 4.1	Effect of <i>Musanga cecropioides</i> leaf extracts on the histology of the heart in of rats in 28 days sub-acute toxicity study	131
Plate 4.2	Effect of <i>Musanga cecropioides</i> root extracts on the histology of the heart in of rats in 28 days sub-acute toxicity study	132
Plate 4.3	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the heart in of rats in 28 days sub-acute toxicity study	133
Plate 4.4	Effect of <i>Musanga cecropioides</i> leaf extracts on the histology of the kidney in of rats in 28 days sub-acute toxicity study	135
Plate 4.5	Effect of <i>Musanga cecropioides</i> root extracts on the histology of the kidney in of rats in 28 days sub-acute toxicity study	136
Plate 4.6	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the kidney in of rats in 28 days sub-acute toxicity study	137
Plate 4.7	Effect of <i>Musanga cecropioides</i> leaf extracts on the histology of the liver in of rats in 28 days sub-acute toxicity study	139
Plate 4.8	Effect of <i>Musanga cecropioides</i> root extracts on the histology of the liver in of rats in 28 days sub-acute toxicity	140

	study	
Plate 4.9	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the liver in of rats in 28 days sub-acute toxicity study	141
Plate 4.10	Effect of <i>Musanga cecropioides</i> leaf extracts on the histology of the lungs in of rats in 28 days sub-acute toxicity study	143
Plate 4.11	Effect of <i>Musanga cecropioides</i> root extracts on the histology of the lungs in of rats in 28 days sub-acute toxicity study	144
Plate 4.12	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the lungs in of rats in 28 days sub-acute toxicity study	145
Plate 4.13	Effect of <i>Musanga cecropioides</i> leaf extracts on the histology of the lungs in of guinea pigs in anti-asthmatic study	188
Plate 4.14	Effect of <i>Musanga cecropioides</i> root extracts on the histology of the lungs in of guinea pigs in anti-asthmatic study	189
Plate 4.15	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the lungs in of guinea pigs in anti-asthmatic study	190
Plate 4.16	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the histology of the heart in STZ-induced diabetic rats	270
Plate 4.17	Effect of methanol extract of <i>Musanga cecropioides</i> leaves	271

	on the histology of the heart in STZ-induced diabetic rats	
Plate 4.18	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the histology of the heart in STZ-induced diabetic rats	272
Plate 4.19	Effect of methanol extract of <i>Musanga cecropioides</i> root on the histology of the heart in STZ-induced diabetic rats	273
Plate 4.20	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the heart in STZ-induced diabetic rats	274
Plate 4.21	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the histology of the liver in STZ-induced diabetic rats	276
Plate 4.22	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the histology of the liver in STZ-induced diabetic rats	277
Plate 4.23	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the histology of the liver in STZ-induced diabetic rats	278
Plate 4.24	Effect of methanol extract of <i>Musanga cecropioides</i> root on the histology of the liver in STZ-induced diabetic rats	279
Plate 4.25	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the liver in STZ-induced diabetic rats	280
Plate 4.26	Effect of aqueous extract of <i>Musanga cecropioides</i> leave on the histology of the lung in STZ-induced diabetic rats	282
Plate 4.27	Effect of methanol extract of <i>Musanga cecropioides</i> leave on the histology of the lung in STZ-induced diabetic rats	283
Plate 4.28	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the histology of the lung in STZ-induced diabetic rats	284
Plate 4.29	Effect of methanol extract of <i>Musanga cecropioides</i> root on the histology of the lung in STZ-induced diabetic rats	285

Plate 4.30	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the lung in STZ-induced diabetic rats	286
Plate 4.31	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the histology of the pancreas in STZ-induced diabetic rats	288
Plate 4.32	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the histology of the pancreas in STZ-induced diabetic rats	289
Plate 4.33	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the histology of the pancreas in STZ-induced diabetic rats	290
Plate 4.34	Effect of methanol extract of <i>Musanga cecropioides</i> root on the histology of the pancreas in STZ-induced diabetic rats	291
Plate 4.35	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the pancreas in STZ-induced diabetic rats	292
Plate 4.36	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the histology of the spleen in STZ-induced diabetic rats	294
Plate 4.37	Effect of methanol extract of <i>Musanga cecropioides</i> leaves on the histology of the spleen in STZ-induced diabetic rats	295
Plate 4.38	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the histology of the spleen in STZ-induced diabetic rats	296
Plate 4.39	Effect of methanol extract of <i>Musanga cecropioides</i> root on the histology of the spleen in STZ-induced diabetic rats	297
Plate 4.40	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the spleen in STZ-induced diabetic rats	298
Plate 4.41	Effect of aqueous extract of <i>Musanga cecropioides</i> leaves on the histology of the kidney in STZ-induced diabetic rats	300
Plate 4.42	Effect of methanol extract of <i>Musanga cecropioides</i> leaves	301

	on the histology of the kidney in STZ-induced diabetic rats	
Plate 4.43	Effect of aqueous extract of <i>Musanga cecropioides</i> root on the histology of the kidney in STZ-induced diabetic rats	302
Plate 4.44	Effect of methanol extract of <i>Musanga cecropioides</i> root on the histology of the kidney in STZ-induced diabetic rats	303
Plate 4.45	Effect of <i>Musanga cecropioides</i> crude root sap on the histology of the kidney in STZ-induced diabetic rats	304

Abstract

Musanga cecropioides R. Br. ex Tedlie (Family Urticaceae) is a tree distributed across some parts of Africa including Nigeria. Ethno-medicinal surveys shows that its leaves, root and root sap are used in the management of several health conditions, but there is a dearth of information on the biological activities of these parts of the plant to substantiate the ethno-medicinal claims. This study was aimed at evaluating the phyto-constituents and phytomedicinal properties of *Musanga cecropioides* leaf extracts, root extracts and root sap.

The elucidation of phyto-constituents was done by carrying out qualitative and quantitative phytochemical screening, proximate analysis, and screenings for vitamins, carotene, amino acids and mineral elements using standard protocols. Acute and sub-acute toxicity assessments of the samples were carried out in experimental animals using established protocols. *Musanga cecropioides* leaf extracts, root extracts and root sap were screened for antioxidant activities using 1,1-diphenyl-2-picryl hydrozyl (DPPH) and 2,2'-azinobis-3-ethylbenzothiozoline-6-sulfonic acid (ABTS) radical scavenging models, while the DNA protective effect was investigated on DNA damage caused by Fenton's reagent. The antitussive activity was analyzed using the citric acid-induced cough model and mucus expectoration experiment, while anti-asthmatic properties were elucidated using the ovalbumin-induced asthma model.

Antidiarrheal and anti-diabetic properties were elucidated using the castor oil-induced diarrhoea and Streptozotocin (STZ)-induced diabetes models respectively.

The screening of *Musanga cecropioides* leaf extracts, root extracts and root sap for the phyto-constituents revealed the presence of alkaloids, tannins, saponins, flavonoids, moisture, fat, proteins, vitamins, carotene, essential and non-essential amino acids and micro and macro mineral elements in considerable quantities. The median lethal dose (LD₅₀) for the aqueous and methanol leaf extracts, methanol root extract and crude root sap were indeterminable as no adverse effect was observed at the highest dose of 10000 mg/kg body weight, while the aqueous root extract caused absolute mortality at 5000, 7500 and 10000 mg/kg body weight leaving the LD₅₀ at 2236 mg/kg body weight. The sub-acute toxicity study revealed that the extracts did not significantly alter the body weight and haematology parameters at 500, 1000, 2500 mg/kg. 1,1-diphenyl-2-picryl hydrozyl and 2,2'-azinobis-3-ethylbenzothiozoline-6-sulfonic acid scavenging assays revealed the presence of antioxidants in all samples with the leaf extracts showing the best activity. The leaf and root extracts protected pCAMBIA 1301 DNA from damage by Fenton's reagent. *Musanga cecropioides* leaf extracts, root extracts and root sap showed significant anti-diarrhoeal activities, significantly increased mucus expectoration and suppressed cough bouts in guinea pigs at all doses in the antitussive study. In the anti-asthmatic study, the leaf extracts significantly increased the latency to pre-convulsive dyspnoea. The anti-diabetic study revealed significant reduction in glucose level by the aqueous leaf extract (50 mg/kg), methanol leaf extract (200 mg/kg), aqueous root extract (200 mg/kg) and the root sap (2 ml/kg). *Musanga cecropioides* leaf, root and root sap possess antitussive, anti-asthmatic, anti-diarrheal and anti-diabetic activities. In conclusion, the therapeutic properties elicited by these plants extracts on selected diseases validated its ethnomedicinal reports.

CHAPTER ONE: INTRODUCTION

1.1 Background of the Study

Phytomedicines are plant based drugs, medicines obtained from herbal sources or naturally occurring substances of plant origin, useful in the prevention and treatment of diseases (Idu, 2011; Pandey *et al.*, 2011; Srivastava *et al.*, 2019). Phytomedicine as a discipline is the science that deals with studies on clinical efficacy and safety of herbal medicines in order to integrate the plant medicinal preparations into generally acceptable medicines.

Traditionally, the use of plants to treat and manage illnesses, diseases, wounds and general wellness dates as far as man begun to dominate the earth as over 90% of traditional medicine recipes and remedies have been known to contain medicinal plants (Sofowora *et al.*, 2013). In Africa, over 80% of the population depends on the use of medicinal plants in meeting their health care needs. This practice has evolved over the years with knowledge acquired from the use of plants, passed on from generation to generation, with some of this knowledge being lost. Man's reliance on plants for health care needs has transcended from being an age-long tradition in Africa, into being a major influencer of modern medicine globally. The emergence of modern drug development and discovery depends greatly on indigenous knowledge of the use of medicinal plants. The retrieval of these indigenous knowledge has been made possible by collective efforts of ethnobotanists, anthropologists, botanists and other individuals or professionals.

The study of medicinal plants has given rise to several indispensable discoveries with applications that cuts across several disciplines including microbiology, cosmetology, biochemistry and more recently, biotechnology. Medicinal plants have been defined

as plants that have in one or more of its organs, active substances that possess therapeutic properties or can be used in whole, parts or isolates as precursors for synthetic drugs (WHO, 1977; Sofowora *et al.*, 2013). The therapeutic activities of plants have been linked to the presence of certain phytochemicals which are products of metabolic processes in plants.

About 50,000 species of higher plants have been used medicinally, representing the biggest use of the natural world in terms of number of species (Idu, 2010). However, despite the vast applications of plants in health care delivery worldwide, less than 10% of these plants have been investigated from a phytochemical or pharmacological point of view in order to validate their safety and efficacy. Hence the need for evaluation of the safety and standardization of the quality of medicinal plant materials and herbal products abounds (WHO, 2007). In assuring the quality, efficacy and safety of herbal products, the plant materials must be identified and the chemical constituents determined using standard procedures. Subsequently, the biological activities of the preparation is tested using *in vitro* and *in vivo* models to establish the therapeutic potentials before further studies are carried out (Idu and Timothy, 2012).

Musanga cecropioides is a forest tree known to provide food and shelter to animals. The use of the different parts of *Musanga cecropioides* has been reported in ethnobotanical reviews as one of such medicinal plants used in the management of diverse diseases including respiratory related complaints, infectious diseases, and metabolic disorders by indigenes in Nigeria and some other parts of African.

1.2 Statement of the Problem

Musanga cecropioides leaves, root and root sap are used by indigenes and traditional healers in Nigeria to treat and manage several illnesses and diseases. Several ethno-medicinal claims are associated with this plant, however there is a dearth of scientifically validated information on the biological activities, phyto-constituents, efficacy and safety of the different parts of this plant.

1.3 Justification for the Study

This study will come up with scientific validation on the ethno-medicinal claims of *Musanga cecropioides* leaves, root and root sap. Based on the findings, the plant materials can be used in development of various herbal products.

1.4 Aim and Objectives

The aim of the study was to evaluate some of the phytomedicinal properties of *Musanga cecropioides* leaf extracts, root extracts and crude root sap.

The specific objectives of this study were to:

- i. elucidate the phyto-constituents in *Musanga cecropioides* aqueous and methanol leaves extracts, aqueous and methanol root extracts and crude root sap by carrying out qualitative phytochemical screening, quantitative phytochemical screening, proximate analysis including screening of amino acid and vitamin constituent, and elemental analysis of the samples.
- ii. assess the toxicity profile of *Musanga cecropioides* aqueous and methanol leaf and root extracts and crude root sap by carrying out acute and sub-acute toxicity studies.

- iii. evaluate the potential of *Musanga cecropioides* aqueous and methanol leaf and root extracts and root sap to scavenge for free radicals using *in vitro* antioxidant assessment models.
- iv. determine the anti-diarrhoea properties of *Musanga cecropioides* leaf extracts, root extracts and root sap.
- v. assess the antitussive potentials of *Musanga cecropioides* leaf extracts, root extracts and root sap.
- vi. carry out anti-asthmatic study on *Musanga cecropioides* leaf extracts, root extracts and root sap.
- vii. determine the anti-diabetic potentials of *Musanga cecropioides* leaf extracts, root extracts and root sap.

CHAPTER TWO: LITERATURE REVIEW

2.1 Literature Review on *Musanga cecropioides*

2.1.1 Taxonomic Classification

Musanga cecropioides R.Br. ex Tedlie is commonly known as Umbrella tree or African corkwood in English, Parasolier or bois bouchon in French, Oghohen in Bini. According to the Global Biodiversity Information Facility (GBIF, 2017) *Musanga cecropioides* may be taxonomically classified as follows:

Kingdom: Plantae

Phylum: Tracheophyta

Class: Magnoliopsida

Order: Rosales

Family: Urticaceae

Genus: *Musanga*

Species: *cecropioides*

2.1.2 Origin and Geographical Distribution

Musanga cecropioides is reported to have originated from the Democratic Republic of Congo and is also native to Angola, Cameroon, Cote d' Voire, Ethiopia, Ghana, Liberia, Sierra Leon, Sudan, Togo, Uganda and Nigeria (Burkill, 1985). It has been introduced in Madagascar (Todou and Meikeu-Kamdem, 2011). Figure 2.1 shows the distribution of *Musanga cecropioides* in Africa.

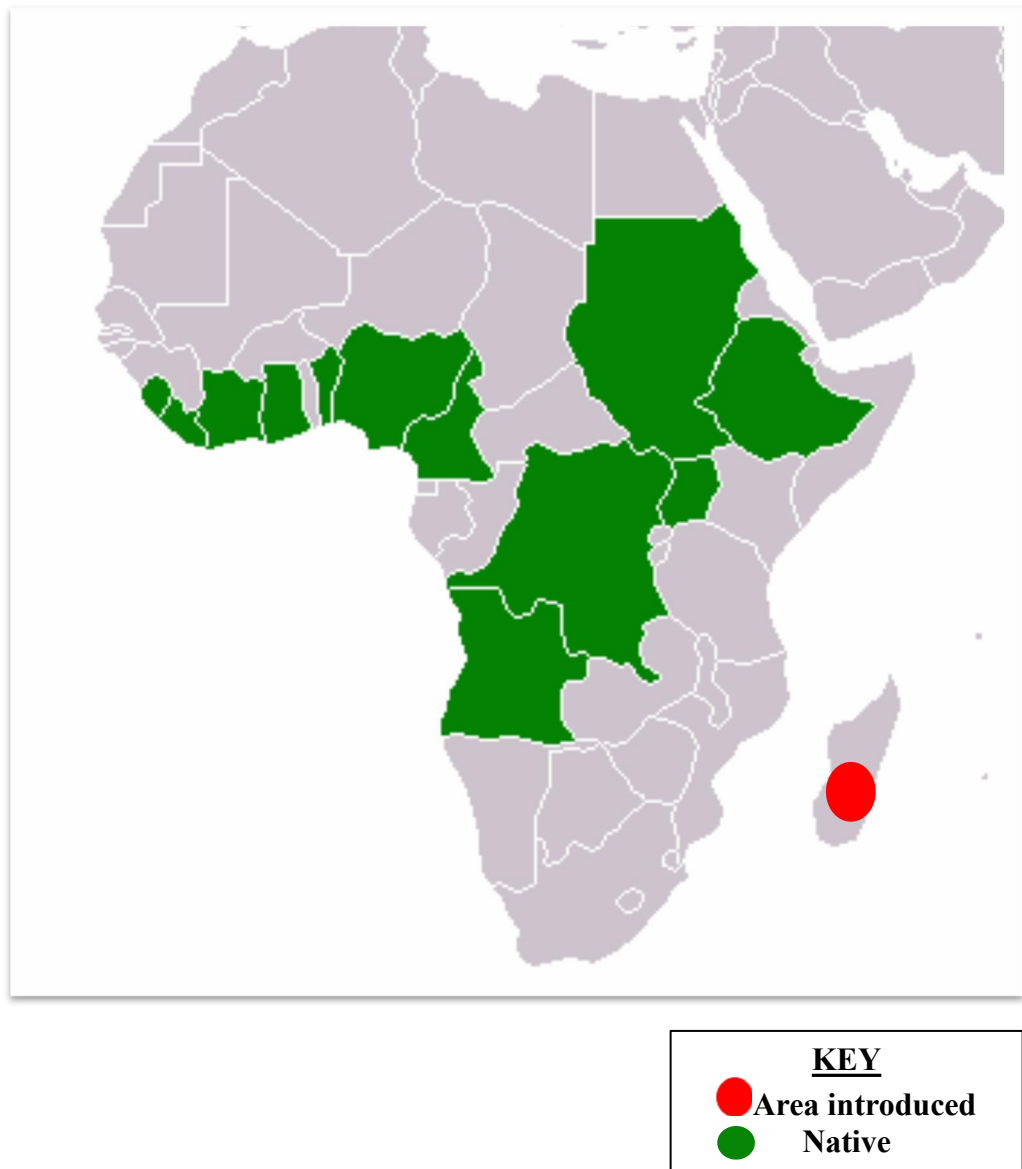


Figure 2.1: Map of Africa showing the distribution of *Musanga cecropioides*

Source: Plantspedia (2017)

2.1.3 Botanical Description

Musanga cecropioides is a deciduous, dioecious tree which grows up to the height of 30 m. The trunk is often branchless for up to 15 m of its height with a diameter of about 120 cm, usually with well-developed stilt roots. The leaf is digitately divided into 12-18 spreading segments which are entire, narrow and shortly acuminate and cuneate at the apex and base respectively with petiole of about 110 cm in length (Plate 2.1). The stipules are hairy and large (7–30 cm long), fused and completely embracing the stem. Flowers unisexual, sessile or with short pedicel. Fruit is yellowish green and succulent (Kadiri and Ajayi, 2009).

2.1.4 Ethno Botany

Musanga cecropioides is a pioneer specie and with good forest regeneration properties. It is used as a shade or ornamental tree. The wood and bark are used in construction of some house hold furniture and furniture materials like particle boards and plywood, utensils, sporting goods, rope, paper, crates, musical instruments, toys, fishing equipment and industrial insulation while the boles are used out to make containers for palm wine and to produce thin split boards. The wood ash is used in soap making and as vegetable salt. The bark can also be in palm wine preparation as an intoxicant and the stem sap has been used to prepare ink. Edible caterpillars are also collected from the leaves. The flowers also play an important role in pollination while the fruit may be edible and serves as food for some animals. (Astaras *et al.*, 2008; Orwa *et al.*, 2009; Todou and Meikeu Kamdem, 2011; Essien *et al.*, 2012).



Plate 2.1: *Musanga cecropioides* leaf and stipule

Source: Todou and Meikeu-Kamdem (2011)

2.1.5 Ethno Medicinal Uses

Musanga cecropioides is an important medicinal plant as most of its parts are used in traditional medicine in Nigeria, Cameroun and other countries in Africa. The stipules are applied as emmenagogue, used to ease childbirth, to treat stomach complaints, hiccough and wounds. The leaves are used to manage hypertension, gonorrhoea, cough and in the preparation of vaginal wash to manage painful menstruation (Bouquet, 1969; Burkill, 1985; Ayinde *et al.*, 2003; Orwa *et al.*, 2009; Todou and Meikeu-Kamdem, 2011).

A decoction of inflorescence is administered to ease childbirth (Todou and Meikeu Kamdem, 2011). The stem bark decoctions are also useful in the treatment of cough, arterial hypertension, constipation, pain during childbirth, schizophrenia, diabetes, anthelmintic, tuberculosis (in polyherbal formulations), skin diseases and gargled to treat toothache. The bark is applied externally against stiffness and lumbago. Hot infusion of the stem bark is also used for treatment of fever, jaundice, chest pains, diarrhoea, gastrointestinal disorders and liver diseases (Ayitey-Smith, 1989; Orwa *et al.*, 2009; Adeneye, 2009; Todou and Meikeu-Kamdem, 2011; Mabeku *et al.*, 2011).

Stem sap is used to stimulate breast milk production and to ease menstrual cramps (Orwa *et al.*, 2009; Todou and Meikeu-Kamdem, 2011). The root bark and kolanut are eaten together to cure cough. Root decoction or infusion is used as anthelmintic (Gill, 1992; Adeneye, 2009; Orwa *et al.*, 2009). Root sap is used to manage and cure diarrhoea, gonorrhoea, vaginal candidiasis, pulmonary complaints, treatment of upper respiratory tract infection (cough), trypanosomiasis, treatment of dirty wounds and skin diseases, otitis, rheumatism, epilepsy, oedema, and in childbirth. It is also used to cure conjunctivitis, headache and as a laxative (Idu *et al.*, 2009; Todou and Meikeu-Kamdem, 2011; Isaac, 2012; Uwah *et al.*, 2013). Dike *et al.*, 2012 reported that

Musanga cecropioides is used to treat malaria, leprosy, as anticonvulsant and anthelmintic, but the various parts used were not specified.

2.1.6 Literature Review on Scientific Works Done on *Musanga cecropioides*

Table 2.1 shows a summary of some of the scientific works done on *Musanga cecropioides*.

Table 2.1: Scientific studies on *Musanga cecropioides*

Parts used	Activities investigated	References
Root sap	Microbial studies	Isaac, 2012; Uwah <i>et al.</i> , 2013
Stem bark	Oxytocic, hypotensive, anti-hyperglycaemic, antioxidant, toxicity, hepato-protective	Ayinde <i>et al.</i> , 2006; Adeneye <i>et al.</i> , 2006a, 2006b; Adeneye <i>et al.</i> , 2007; Adeneye, 2009; Tchouya and Nantia, 2015; Nyunai <i>et al.</i> , 2016; Omoruyi and Enogieru, 2018; Legbosi and Ellis, 2018
Stem sap	Hypotensive, toxicity, diuretic	Ajagbonna <i>et al.</i> , 2015
Leaves	Hypotensive, anti-inflammatory, analgesic, antioxidant, vaso-dilatory	Kamanyi <i>et al.</i> , 1991; Kamanyi <i>et al.</i> , 1996; Dongmo <i>et al.</i> , 1996; Aziba and Gbile, 2000; Aziba, 2005; Senjobi <i>et al.</i> , 2012; Sowemimo <i>et al.</i> , 2015; Tchouya and Nantia, 2015

2.2 Literature Review on Phyto-constituents

Plants are made up of a vast array of complex molecules which are collectively termed phyto-constituents. These phyto-constituents may further be grouped as nutrient (macronutrients including carbohydrates, fats and proteins, and micronutrients including vitamins and minerals from foods that are used by cells in the body to complete diverse functions) and non-nutrient (molecules that are not considered essential for cellular or tissue needs, however, they may be important for other aspects of human health; for example, dietary fibers, phytochemicals).

In developing nations, numerous types of edible wild plants are exploited as sources of food and hence provide adequate levels of nutritional, pharmacological and industrial importance to man (Savithramma, *et al.*, 2011), however, many edible wild plants and local vegetables are under-exploited because of inadequate scientific knowledge of their nutritional and pharmacological potentials.

Phytochemicals are biologically active compounds present in plants. They are derived from various parts of plants such as leaves, flowers, seeds, barks, roots and pulps and play a vital role against a number of diseases such as asthma, arthritis, cancer and diabetes (Saxena *et al.*, 2013; Banu and Cathrine, 2015). The beneficial physiological and therapeutic effects of plant materials typically results from the combinations of the phytochemicals present in the plant. Phytochemicals are not associated with side effects as opposed to synthetic chemicals used in pharmaceutical industries and as such are generally referred to as man- friendly medicines. Several phytochemical compounds have been identified in different plants, some of which are broadly grouped as alkaloids, tannins, saponins, flavonoids, phenols and terpenoids.

Alkaloids have been reported to possess antibacterial and antifungal activities, analgesic activities, antihypertensive effects, antiarrhythmic effect, antimalarial

activity and anticancer actions (Rao *et al.*, 1978; Krishnan *et al.*, 1983). Tannins are used as astringents, antiseptic, antioxidant, haemostatic pharmaceuticals, as diuretics, against diarrhoea, stomach and duodenal tumours, and as anti-inflammatory agents (De Bruyne *et al.*, 1999; Dolara *et al.*, 2005). Saponins also have been studied for membrane-permeabilising, immune-stimulant, hypocholesterolaemic, hypoglycaemic, antifungal, antiviral and anticarcinogenic properties and they have also been found to kill protozoans and molluscs. It also has antioxidants properties, significantly affect growth, feed intake, reproduction, to impair the digestion of protein and the uptake of vitamins and minerals in the gut of animals (Morrissey and Osbourn, 1999; Takechi *et al.*, 1999; Traore *et al.*, 2000). Flavonoids have been stated to possess anti-inflammatory activity, enzyme inhibition, antimicrobial activity, oestrogenic activity, anti-allergic activity, antioxidant activity, vascular activity and cytotoxic antitumor activity (Tapas *et al.*, 2008; Atmani *et al.*, 2009). Phenols have been reported to increase bile secretion, reduce blood cholesterol and lipid levels and they also possess antimicrobial, antiulcer, anti-inflammatory, antioxidant, cytotoxic, antitumor, antispasmodic and antidepressant activities (Gryglewski *et al.*, 1987; Silva *et al.*, 2007; Ghasemzadeh *et al.*, 2010). Terpenoids possess anticarcinogenic, antimalarial, anti-ulcer, hepaticidal, antimicrobial and diuretic activities (Langenheim, 1994; Dudareva *et al.*, 2004).

Macronutrients basically provide the energy needed for metabolic processes, however, amino acids which are the building blocks of proteins have more specific roles to play in nutritional and health needs (Azad, 2018). Over three hundred amino acids have been identified, however, only twenty are involved in protein build up and synthesis, some of which are synthesized in the body (non-essential amino acids) and others are obtained from external sources (essential amino acids) like food (Akram *et al.*, 2011).

Some amino acids have been reported to regulate insulin secretion from pancreas (Lorraine *et al.*, 2006), play important roles in tissue protein and enzyme formation, synthesis of melanin and growth hormone formation and function, hence, deficiency in amino acid leads to decreased metabolic functions of protein which can in most cases be corrected or prevented by amino acid supplementation (Akram *et al.*, 2011).

Micronutrients represented by vitamins and minerals, play specific roles in metabolism and health. Vitamins are organic compounds which are essential for normal physiological functioning but are not synthesised endogenously by the body and therefore have to be obtained in small quantities from the diet (Kennedy, 2016). They include vitamins A, D, E, K, which are fat soluble vitamins and vitamins B1, B2, B3, B5, B6, B7, B9, B12 and C which are water soluble.

Vitamin A contributes to good eye sight, cell and tissue formation, proper development of the embryo, iron metabolism, immune function and reduces the risk of breast and lung cancers (Sinbad *et al.*, 2019).

Vitamin D (ergocalciferol), helps in the formation of healthy bone and teeth, promotes better inflammatory responses, boosts the immune system, promotes normal muscle function, cell division and aids calcium and phosphorus absorption and utilization (Aranow, 2011).

Vitamin E (tocopherol), is an antioxidant and protects the cells against damage that can lead to cancer, boosts the immune system, and prevents oxidation of low density lipoprotein which contributes to plaque build-up in atherosclerosis (Upston *et al.*, 2003; Lobo *et al.*, 2010).

Vitamin K1 (phylloquinone), promotes blood clotting, maintains bone health, keeps blood vessels functioning properly and reduces the risk of diabetes, atherosclerosis and osteoporosis (Schwalfenberg, 2017).

Vitamin B1 (thiamin), activates enzymes and coenzymes, helps in energy production, conduction of nerve impulses, prevents eye disease, brain disorders, reduces the severity of Alzheimer's disease and prevents heart failure (Fattal-Valevski, 2010; Gibson *et al.*, 2016).

Vitamin B2 (riboflavin), converts carbohydrates to glucose in energy production and neutralize free radicals which damage cells and DNA (Sinbad *et al.*, 2019). This neutralizing antioxidant effect may reduce or help prevent some of the damage contributing to the aging process as well as the development of a number of health conditions such as heart disease, cancer, cataracts and migraine headaches (Hilary, 2003; Said and Ross, 2013).

Vitamin B3 (niacin), has been reported to lower cardiovascular disease, atherosclerosis and diabetes risks by improving high density lipoprotein and lowering low density lipoprotein levels in cholesterol control (Shah *et al.*, 2013). Vitamin B3 also converts food to glucose used in energy production in DNA repair, stress responses, neurodegenerative diseases and neuropathological conditions (Abdullah *et al.*, 2018; Gasperi *et al.*, 2019).

Vitamin B5 (pantothenic acid), is incorporated in coenzyme A and is involved in metabolism, breaks down fat, protein, carbohydrate for energy, helps in blood formation and wound healing, reduces high cholesterol, fatigue, symptoms of inflammation in diabetes and arthritis (Kennedy, 2016).

Vitamin B6 (pyridoxine), helps the body to build protein through the metabolism of amino acids, and to produce antibodies which boosts the immune systems. Vitamin B6 is also required for the synthesis of serotonin (a neurotransmitter) and in blood formation (Anderson *et al.*, 1971; Parra *et al.*, 2018).

Vitamin B7 (biotin, vitamin H or B8), helps to convert food to glucose, activates fat and amino acid metabolism in the hair roots and fingernail cells. It also contributes to normal function of the nervous system, controls blood sugar, and reduces the risk of birth defects, hair and nail problems (Zempleni *et al.*, 2009).

Vitamin B9 occurs as folate (in foods) and folic acid (in supplements). It helps the body as a coenzyme to utilize amino acids, produce nucleic acids, form blood cells in the bone marrow, ensure rapid cell growth in infancy, adolescence, and pregnancy, control (together with vitamin B6 and vitamin B12) blood levels of the amino acid homocysteine, associated with certain chronic conditions such as heart disease, birth defects, miscarriage, heart attack, and stroke, protect against the development of cancer of the colon and the breast. It is also reported to be beneficial in protecting the brain against Alzheimer's and other forms of dementia and may help enhance the effect of antidepressants in some people (Crider *et al.*, 2011).

Vitamin B12 (cobalamine), plays active role in energy and DNA production, nerve cell health, and red blood cell formation and in the reduction of the risks of heart disease, breast cancer, depression, birth defects and Alzheimer's disease (Michael, 2011; Allen *et al.*, 2018).

Vitamin C (ascorbic acid), is a well-known antioxidant, which also serves to maintain collagen, protect against infection by boosting the immune system, control diabetes, improves metabolism, help in iron absorption, plays active role in allergy and asthma

relief, prevention of cancer, cataract and scurvy (Chambial *et al.*, 2013; Carr and Maggini, 2017).

Minerals elements are inorganic substances required by the body in small amounts for a variety of functions. They are components of enzyme systems and are essential for nervous system function. The body requires different amounts of each mineral and imbalance or deficiency of these elements have been linked to metabolic abnormalities and diseases.

Zinc is an essential trace element for protein and nucleic acid synthesis and normal body development, it also stimulates the activity of vitamins, and the formation of red and white blood cells (Claude and Paule, 1979; Melaku *et al.*, 2005).

Calcium is necessary for blood coagulation, maintenance of cell integrity, regulation of muscle contraction, development of healthy bones and teeth in infants and foetuses (Okaka and Okaka, 2001; Shemishere *et al.*, 2018).

Copper is found necessary in infant growth, host defense mechanisms, bone strength, red and white cell maturation, iron transport, cholesterol metabolism, myocardial contractility, glucose metabolism, prevention of Menkes syndrome (genetic syndrome in which alterations in copper absorption and transport leads to early death) and brain development (Danks, 1995).

Manganese is necessary for activation of certain metalloenzymes, energy metabolism, immunological system function, nervous system function, reproductive hormone function, and in antioxidant enzymes, bone and connective tissue growth, blood clotting and brain development (Keen and Zidenberg-Cherr, 1994). Inadequate daily supply of manganese is associated with growth impairment, birth defects, reduced fertility and impaired bone formation. Manganese deficiency also alter metabolisms

of lipids, proteins, and carbohydrates, results in dermatitis, slowed growth of hair and nails, decreased serum cholesterol levels, decreased levels of clotting proteins, increased serum calcium and phosphorus concentrations, and increased alkaline phosphatase activity (Avila *et al.*, 2013).

Potassium decreases the risk of stroke, lowers blood pressure, protects against loss of muscle mass, and preserves bone mineral density. It also reduces the formation of kidney stones, regulates fluid balance and controls the activity of the heart and other muscles, while potassium deficiency can lead to fatigue, weakness, paralysis, respiratory failure, painful gut obstructions and constipation (Weaver, 2013).

Iron is a major component of haemoglobin which assists in oxygen utilization, enzymatic systems, and especially neural development. Iron deficiency causes fatigue, motor and cognitive deficits, inability to concentrate, reduced resistance to infection, increased susceptibility to lead poisoning, loss of appetite, tachycardia, cardiomegaly, anaemia, perinatal complications, premature delivery, and low birth weight, however, in excessive amounts, it can lead to tissue damage. (Bailey *et al.*, 2011; Abbaspour *et al.*, 2014).

Magnesium is important for higher bone mineral density, which is important in reducing the risk of bone fractures and osteoporosis, for DNA and RNA synthesis, protein synthesis, and regulation of muscular contraction, blood pressure, insulin metabolism, nerve transmission and neuromuscular conduction. Low levels of magnesium have been associated with Alzheimer's disease, insulin resistance and type-2 diabetes mellitus, hypertension, cardiovascular disease, stroke, migraine headaches, and attention deficit hyperactivity disorder (Gröber *et al.*, 2015).

Sodium is important for many body processes, such as fluid balance, muscle contraction, and nervous system function, however, eating too much sodium puts people at risk of developing high blood pressure, heart disease, stroke, increased risk of cerebrovascular diseases and dementia (Farquhar *et al.*, 2015; Faraco *et al.*, 2018).

Heavy metals are elements with high atomic weight and density. These elements are considered toxic and induce multiple organ damage, even at lower levels of exposure, depending on several factors including the dose, route of exposure, age, gender, genetics and nutritional status of exposed individuals (Tchounwou *et al.*, 2012). Lead and nickel are among the metals of public health significance.

Lead is an extremely toxic heavy metal that disturbs various plant physiological processes and does not perform any biological functions (Jaishankar *et al.*, 2014). High lead concentration increases the production of reactive oxygen species, causing lipid membrane damage that ultimately leads to damage of chlorophyll and photosynthetic processes thereby suppressing the overall growth of the plant (Najeeb *et al.*, 2017).

Nickel exposure causes dermatitis, production of reactive oxygen species, respiratory, cardiovascular, and kidney diseases, apoptosis in human neutrophils and T-cells, teratogenicity and carcinogenesis (Schiffer *et al.*, 1991; Au *et al.*, 2006; Freitas *et al.*, 2013). It also impairs the normal homeostasis of essential metal ions, decreasing the levels of calcium, magnesium, manganese, and zinc in different tissues (Anke *et al.*, 2002).

2.3 Literature Review on Antioxidants.

Antioxidants are chemical compounds that have the ability to reduce free radicals, decrease their rate of production and decrease lipid peroxidation associated with

various diseases and ageing in humans or antioxidants are molecules that can inactivate or neutralize free radicals, thus preventing them from causing cellular damage (Sindhi *et al.*, 2013). Free radicals are highly reactive species having unpaired electrons capable of partaking in deleterious reactions causing cellular degeneration and death. Free radical induced damages have been linked to several health problems including diabetes, cardiovascular dysfunction, neurodegenerative diseases, asthma, arthritis, autoimmune diseases, ageing, dementia and Alzheimer's disease (Tiwari, 2001; Gupta and Sharma, 2006).

Antioxidants are obtained from synthetic sources (such as butylated hydroxytoluene and butylated hydroxyanisole), however there are concerns regarding safety hence natural sources are the targets for safe antioxidants (Shebis *et al.*, 2013). Phenolic compounds, vitamin E, vitamin C, flavonoids, volatile oils and some plant pigments are known antioxidants from plant sources and are reported to scavenge a wide range of reactive oxygen species, chelation of metal ions, such as iron and copper, and inhibition of enzymes responsible for free radical generation (Benavente-Garcia, 1997; Brewer, 2011). The antioxidant defence system of the body consists of enzymatic antioxidants including superoxide dismutases, catalases and glutathione peroxidases, and non-enzymatic antioxidants including ascorbic acid, Glutathione, vitamin E and carotenoids (Halliwell, 2007). Superoxide dismutases are enzymes that catalyse the breakdown or dismutation of the superoxide anion into oxygen and hydrogen peroxide (Zelko *et al.*, 2002). Catalase limits the accumulation of hydrogen peroxide (which serves as a substrate for reactions that generate hydroxyl radical), by converting hydrogen peroxide to water and oxygen in a fast reaction (Ho *et al.*, 2004). Glutathione peroxidase catalyzes the breakdown of hydrogen peroxide and organic hydroperoxides. Glutathione S transferases are a class of glutathione-dependent

antioxidant enzymes present in high concentration in the liver and show high activity with lipid peroxides and also help in detoxification (Sharma *et al.*, 2004; Hayes *et al.*, 2005). Glutathione reductase reduces glutathione disulfide to the sulfhydryl form and its deficiency is characterized by haemolysis due to increased sensitivity of erythrocyte membranes to hydrogen peroxide (Kabel, 2014). Malondialdehyde is a major aldehyde product of lipid peroxidation (Lone *et al.*, 2013) and an endogenous mutagen in mammalian cells. Malondialdehyde is an important biomarker of oxidative damage associated with a number of diseases including cancer, Alzheimer's disease, atherosclerosis and diabetes (Valko *et al.*, 2007).

2.4 Literature Review on Diarrhoea

Diarrhoea is defined as the passage of three or more liquid stools per day (Rahman *et al.*, 2013; WHO, 2017). Annually, there are about 1.7 billion cases of childhood diarrhoea, with about 525,000 deaths recorded worldwide (WHO, 2017). Diarrhoea may be as a result of an infection in the intestinal tract, caused by pathogenic microorganisms and spread through contaminated food, water, or an infected person due to poor state of hygiene. Infectious gastroenteritis is regarded as the most common cause of acute diarrhoea (Amiebenomo and Osaghae, 2017). It leads to dehydration, loss of mineral salts and electrolyte imbalance in the body of sufferers. Diarrhoea is usually considered a result of altered motility and fluid accumulation within the intestinal tract (Rahman *et al.*, 2013). Diarrhoea is treated with oral rehydration solution (ORS), which replenishes lost fluid and electrolytes in patients, vitamin A supplement to reduce the occurrence and zinc supplements to shorten the duration and improve the outcomes (WHO, 2010a). Other anti-diarrhoea drugs such as loperamide may also be administered. However, loperamide is only recommended for children above 12 years old and adults (Amiebenomo and Osaghae, 2017).

The World Health Organization (WHO) initiated a diarrhoea disease control program to study traditional medicine practices and prevention approaches (WHO, 2004). Several plants used traditionally in the management of diarrhoea have been investigated pharmacologically following the castor oil induced diarrhoea model in experimental animals (Shoba and Thomas, 2001).

2.5 Literature Review on Toxicity

Toxicity refers to the relative ability of a substance to cause adverse effects either in the cells or organs of living organisms (Anonymous, 2002; Denny and Stewart, 2013). A non-toxic substance can be toxic at a high dose, and a highly toxic substance can be considered safe at a low (Hill, 1997). Plants by virtue of their diverse chemical constituents are potentially toxic (Mensah *et al.*, 2019). The presence of toxic chemicals in plants has been reported even in cases where those plants are therapeutically relevant (Raman and Lau, 1996; Sharma *et al.*, 2007; Van Andel *et al.*, 2012; Nasri and Shirzad, 2013; Kuete, 2014; Komlaga *et al.*, 2015). The safety of medicinal plants used in herbal medicine practice has raised several concerns as it is difficult for the traditional practitioners to detect or monitor delayed effects and adverse effects arising from long-term administration (Sharif *et al.*, 2015). This issue of safety of herbal medicine products informs the need to investigate the acute toxicity (single large dose exposure), using lethal dose (LD₅₀) as the index, and the sub-acute toxicity (prolonged exposure, typically 28 days) with special consideration on its effect with respect to changes in haematological and biochemical parameters and also the effect on vital organs (Herxheimer, 1987; WHO, 2010b; Denny and Stewart, 2013).

2.6 Literature Review on Cough and Asthma

Cough is the most common symptom of airway and lung disease (Korpas and Tomori, 1978). Cough may be the most prominent symptom complained of by patients with chronic respiratory disease such as asthma (Osman *et al.*, 2001). The effect of persistent cough itself may be harmful and deleterious to the patient by interfering with breathing, social activities and sleep, and by causing deterioration in the quality of life, social embarrassment, urinary incontinence, muscle ache, insomnia, fatigue, chest and thorax pain (Irwin and Madison, 2000). Available drugs for the management of cough include expectorants, antitussives and glucocorticoids most of which are synthetic drugs, and are associated with side effects (Saha *et al.*, 2011).

Asthma is characterized by reversible airway obstruction, increased airway responsiveness, enhanced mucus production, airway inflammation and remodelling of the airways (James *et al.*, 2009). In the United States of America, a national medical case survey reported that in 1991 cough was the most common complaint for which patients sought medical attention, and the second most common reason for a general medical consultation (Schappert, 1993). Treatment of the causes of cough may include anti-inflammatory approaches such as the cough associated with eosinophilic inflammation in the airways as in asthma, cough-variant asthma or eosinophil bronchitis (Chung, 2002a). Partly because there is no apparent cause associated with a persistent cough in many patients, it is clear that the development of effective antitussives (i.e. drugs that specifically block cough whatever the cause) is needed. Currently, the most commonly used antitussives are the centrally acting opiates (acute relievers of cough) such as codeine, dihydrocodeine or pholcodeine. Sometimes for the intractable cough in terminal disease, morphine or diamorphine is used, with the advantage that these also possess analgesic properties. However, at their effective

doses, these antitussives are associated with side effects such as drowsiness, nausea, vomiting, constipation, and often cause physical dependence. Development of new antitussives has occurred on a number of fronts including in phytomedicine (Chung, 2002b).

2.6 Literature Review on Diabetes

Diabetes is a condition which occurs when there is defect in insulin secretion and/or insulin action, resulting in hyperglycaemia or raised blood sugar (Kumaran *et al.*, 2014; Dey *et al.*, 2002). Diabetes leads to serious damage to the nerves and blood vessels evident in complications such as cataract, retinopathy, nephropathy, neuropathy, oxidative stress as well as decreased glucose utilization in the brain (Pari and Latha, 2004; Kumaran *et al.*, 2014). Diabetes is a major cause of blindness, kidney failure, heart attacks, stroke and lower limb amputation. Diabetes is also characterized by disturbances in carbohydrate, fat and protein metabolism, high blood pressure, high levels of low density lipoproteins and triglycerides with low levels of high density lipoprotein. The global prevalence of diabetes among adults over 18 years of age has risen from 4.7% in 1980 to 8.5% in 2014 (Sarwar *et al.*, 2010; WHO, 2018a), especially in middle- and low-income countries. WHO reported diabetes as the seventh leading cause of death with an estimated 1.6 million deaths directly caused by diabetes in 2016, while 2.2 million deaths were attributable to high blood glucose in 2012 (WHO, 2018b). Close to a decade ago, the prevalence rate of type-2 diabetes, according to the International Diabetes Foundation/WHO reports, was estimated to be over 3.4% of 24 million Nigerian diabetes sufferers between the ages of 20 – 79 years and with projected estimate of 3.9% rise in 2025 (Ojiako and Chikezie, 2014; Chikezie and Ojiako, 2015).

CHAPTER THREE: MATERIALS AND METHODS

3.1 Plant Sample Collection and Preparation

3.1.1 Plant Sample Collection

Fresh leaves, root and root sap of *Musanga cecropioides* was collected from a private farmland in Ulorin village, Ovia North Local Government Area of Edo State, Nigeria in April 2017. A young branch bearing leaves, flowers and fruit was harvested for identification and authenticated by Prof. MacDonald Idu of the Department of Plant Biology and Biotechnology, University of Benin, Benin City. The voucher specimen was deposited in the same Department and voucher specimen number obtained (UBH-M500). The leaf and root samples needed for this work were washed to get rid of debris, then chopped into smaller bits and dried in an aseptic environment for a period of one and two weeks for the leaves and root respectively. The dried plant materials were then pulverized to powdered form using the British Milling Machine by Gallehamp. The powdered plant materials were then stored in air tight containers awaiting further use as explained in the different sections that follows.

The sap was however collected overnight by making an incision on the root and placing a collection bowl underneath for the fluid to flow. The sap was stored in fitly covered containers and refrigerated at 4°C prior to use.

3.1.2 Plant Extract Preparation

A total of 200 g of sample (powder) was diluted in 1200 ml of solvent (distilled water, methanol) in a glass jar (3000 ml). The mixture was allowed to settle for 72 hours. The mixtures were filtered and the resulting filtrate was concentrated using a water bath as described by Oshomoh *et al.* (2013).

3.2 Screening of Phytoconstituents

3.2.1 Qualitative Phytochemical Screening

3.2.1.1 Screening for Alkaloid

A 0.5 g of the extract was mixed with 15 ml of 1% hydrochloric acid, stirred and placed in a steam bath for 10 minutes. The mixture was filtered and the filtrate obtained was used for test with alkaloid reagents. To 1 ml of the filtrate, 2 drops of dragendoff's reagent was added and observed for appearance of precipitate (Okwu and Okwu, 2004).

3.2.1.2 Screening for Tannin

A 0.5 g of the powdered sample was boiled in 20 ml of distilled water in a test tube and was filtered. 2 drops of 0.1% ferric chloride was added to the filtrate. Formation of greenish to red precipitate was taken as evidence of condensed tannins (Ayeni and Yahaya, 2010).

3.2.1.3 Screening for Saponin

A 0.5 g of the plant extract was shaken with water in test tube. Few drops of olive oil was added to the mixture and vigorously stirred. Formation of emulsion in the extract indicated the presence of saponins (Odebiyi and Sofowora, 1978).

3.2.1.4 Screening for Flavonoid

Five (5) drops of 1% ammonia was added to 10 ml of the plant extract in a test tube. Formation of yellow coloration indicated a positive test for flavonoids (Ayeni and Yahaya, 2010).

3.2.1.5 Screening for Phenol

Five (5) ml of 95% ethanol was added to 1 ml of the extract and then a drop of 10% ferric chloride was also added. Pale coloration indicated the presence of phenol (Ayeni and Yahaya, 2010).

3.2.1.6 Screening for Terpenoid (Salkowski's test)

0.5 g of the extract was mixed with 2 ml of chloroform and 3 ml of concentrated sulphuric acid was carefully added to form a layer. An appearance of reddish brown colour in the inner face indicated the presence of terpenoids (Ugochukwu *et al.*, 2013).

3.2.1.7 Screening for Cyanogenic Glycoside

Three (3) ml of chloroform was added to the extract and shaken, chloroform layer is separated and 10% ammonia solution was added to it. Pink colour indicated presence of glycosides (Ayeni and Yahaya, 2010).

3.2.1.8 Screening for Anthraquinone

Five (5) ml of chloroform was added to the extract (0.5 g) in a test tube and shaken for 5 min. The mixture was filtered and the filtrate shaken with equal volume of 10% ammonia solution. A pink, red or violet colour in the aqueous layer after shaking indicated the presence of free anthraquinone (Trease and Evans, 2002).

3.2.1.9 Screening for Sterol/Steroids (Liebermann-Burchard Test)

One (1) ml of extract was treated with drops of chloroform, acetic anhydride and concentrated sulphuric acid was added and observed for the formation of dark pink or red colour (Ugochukwu *et al.*, 2013).

3.2.1.10 Screening for Oxalate

To 3 ml portion of extract was added a few drops of ethanoic acid glacial. A greenish black colouration indicates presence of oxalate (Ugochukwu *et al.*, 2013).

3.2.2 Quantitative Phytochemical Screening

3.2.2.1 Determination of Total Alkaloid Content

The alkaloid content was determined using the method adopted by Ifemeje *et al.* (2014). 1 g of the plant sample was placed in a 250 ml beaker and 40 ml of 10% acetic acid in ethanol was added. The mixture was covered and allowed to stand for 4 hours at room temperature. It was then filtered with filter paper No. 42 and the filtrate was concentrated on a water bath until a quarter of its original volume was obtained. Concentrated Ammonium hydroxide was added drop wise until precipitation was complete. The mixture was allowed to settle and the precipitate collected on a weighed filter paper. The precipitate, alkaloid, was dried and weighed. The percentage alkaloid was calculated using the formula below:

$$\% \text{ Alkaloids} = \frac{W2 - W1}{Wt \text{ of sample}} \times 100$$

Where, W1 = Weight of empty filter paper

W2 = Weight of filter paper + Alkaloid

3.2.2.2 Determination of Total Tannin Content

Tannins content was determined by modified Folin-Denis method (Polshettiwar *et al.*, 2007). The method is based on the measurement of a blue colour formed by the reduction of phosphotungsto-molybdic acid by tannin-like compounds in alkaline medium. 0.5 ml of extract (1 mg/ml) and standard solution of Tannic acid (10 - 150

µg/ml) was added to 0.5 ml Folin-Denis reagent and 1 ml of 7.5% Sodium carbonate solution. Thereafter, 3.4 ml of distilled water was added and absorbance was measured at 700 nm. The total tannin content was expressed as mg of Tannic acid equivalent /g of extract.

3.2.2.3 Determination of Total Saponin Content

The saponin content were determined using the method adopted by Ifemeje *et al.* (2014). 1 g of the sample was put into 20% acetic acid in ethanol and allowed to stand in a water bath at 5°C for 24 hours. This was filtered and the extract was concentrated using a water bath to one quarter of the original volume. Concentrated Ammonium hydroxide was then added drop-wise to the extract until the precipitation was complete. The whole solution was allowed to settle and the precipitate was collected by filtration and weighed. The saponin content was weighed and calculated in percentage following the formula below:

$$\% \text{ Saponins} = \frac{W_2 - W_1}{Wt \text{ of sample}} \times 100$$

Where, W_1 = Weight of filter paper

W_2 = Weight of filter paper + residue

3.2.2.4 Determination of Total Flavonoid Content

The total flavonoid content was determined using Aluminum chloride method (Chang *et al.*, 2002). The reaction mixture comprised of 0.5 ml of extract, 1.5 ml of methanol, 0.1 ml of aluminum chloride (10%) in ethanol, 0.1 ml of potassium acetate (1 M) and 2.5 ml of distilled water. Incubated at room temperature for 30 minutes and absorbance read at 415 nm. Quercetin in methanol was used as a positive control.

The flavonoid content is expressed in terms of standard equivalent (mg/g) of extracted compound.

3.2.2.5 Determination of Total Phenolic Content

Total phenolic content was determined according to the Folin and Ciocalteu's method (1927). Concentrations (10 - 120 µg/ml) of gallic acid were prepared in methanol. Then, 0.5 ml of the sample (1 mg/ml) was mixed with 2.5 ml of a ten-fold diluted Folin-Ciocalteu reagent and 2 ml of 7% sodium carbonate. The mixture was allowed to stand for 30 min at room temperature then absorbance read at 760 nm. All determinations were performed in triplicates with gallic acid utilized as the reference control. The total phenolic content was expressed as Gallic Acid Equivalent (GAE).

Standard calibration curve

µg/ml	Volume of standard (µl)	Volume of methanol (µl)
10	5	495
20	10	490
40	20	480
60	30	470
80	40	460
100	50	450
120	120	440

3.2.2.6 Determination of Total Terpenoid Content

2 g of the plant sample was soaked in 20 ml alcohol for 24 hours and filtered. The filtrate was extracted with 30 ml of petroleum ether, the ether extract was evaporated to dryness in an oven at 60°C for 2 hours and weighed to constant weight (Harborne, 1973; Sofowora, 1993).

3.2.2.7 Determination of Total Glycoside Content

For the determination of glycoside, 2 g each of each plant sample was weighed and dispersed in 200 ml of warm water. The suspension was heated over a hot water bath for 3 hours with continuous stirring at about 80°C. The filtrate and residue were re-extracted with another 100 ml of 10% acetone. The extracts were reduced to 10 ml on heating at 80°C. The concentration was transferred into a 100 ml beaker and weighed. The cyanogenic glycoside content was calculated (Harborne, 1973; Sofowora, 1993).

3.2.3 Proximate Analysis

The proximate composition (moisture, ash, fat, fibre, carbohydrate and protein content) of *Musanga cecropioides* leaves, root and root sap were carried out in accordance with the methods described by AOAC (2016).

3.2.3.1 Determination of Percentage Moisture Content

The leaf and root samples were ground to a fine form and mixed well. 2 g of the sample was accurately weighed into a moisture dish (in triplicate). The sample was dried for 24 hours at 105°C. After drying, the samples were removed from the oven (Memmert U.27) and placed in a desiccator to cool to constant weight. The percentage moisture content was then calculated as follows:

$$\% \text{ Moisture} = \frac{(Y - Z) \times 100}{X}$$

Where:

X = weight of the sample before drying

Y = weight of dish + sample before drying

Z = weight of dish + sample after drying

Y – Z = loss in weight of sample after drying.

3.2.3.2 Determination of Percentage Ash Content

5 g of the leaf and root sample (fine form) were weighed into separate porcelain dishes that had previously been weighed and then dried at 105°C for three hours in an oven. Afterwards, the dish with its content was transferred to a muffle furnace (Heraeus M 110) and ignited at 500°C until free from carbon (residue appears greyish-white). This was removed from the oven and the ash moistened with a few drops of water (to expose bits of unashed carbon). The ash was re-dried in the oven at 100°C for 3 hours and re-ashed in the furnace at 500°C for another one hour. This was removed from the muffle furnace, placed in a desiccator until it cooled, and was then weighed. The percentage ash was calculated as follows:

$$\% \text{ Ash} = \frac{(Y - Z) \times 100}{X}$$

Where:

X = sample weight prior to drying

Y = weight of dish and contents after ashing

Z = weight of empty dish.

3.2.3.3 Determination of Percentage Crude Protein

2 g of oven dried ground leaf and root samples were placed in 30 ml Kjeldahl digestion flasks (Gerhardt). Afterwards, 15 ml of concentrated sulphuric acid and 1 g of catalyst mixture were added to each flask. The flasks were gently heated on a

digestion rack in a fume cupboard until a greenish clear solution appeared. After about 30 minutes when the digest had cleared, the flask was heated for another 30 minutes and allowed to cool. 10 ml of distilled water was added to avoid caking. Each sample was then transferred to the Kjeldahl apparatus (Gerhardt) and a 50 ml receiver flask containing 5 ml boric acid-indicator solution was placed under the condenser of the distillation apparatus such that the tip was about 2 cm inside the solution. To the digested sample in the apparatus 10 ml of 40% sodium hydroxide solution was added through the funnel stopcock. Distillation commenced immediately by closing the steam by-pass and opening the inlet stopcock on the steam jet arm of the distillation apparatus. When the distillate reached the 35 ml mark on the receiver flask, distillation was stopped by closing the inlet stopcock first, then opening the steam by-pass. The condenser tip was rinsed with distilled water. The excess acid was titrated to first pink colour with 0.1N sodium hydroxide.

The percentage crude protein was calculated as follows:

$$\% \text{Crude protein} = \frac{\text{Titre} \times 14.01 \times \text{Normality of the acid} \times 100 \times 6.25}{1000 \times \text{weight of samp}}$$

Where:

6.25 = factor suitable for products where the specific protein portion is not well defined

14.01/1000 = constants

Titre = volume after titration.

3.2.3.4 Determination of Percentage Crude Fat (Ether Extract)

5 g of the ground leaf and root samples were each placed in a thimble lined with a circle of filter paper. The thimble with its content was placed in a 50 ml beaker and dried in an oven for 6 hours at 105°C. The thimble with its contents was transferred to a Soxhlet extractor. The beaker was rinsed three times with ethyl ether and emptied into the Soxhlet extraction flask. The sample contained in the thimble was extracted with ethyl ether for 6 to 8 hours at a condensation rate of 3 - 6 drops per second. At the completion of the extraction, the fat extract was transferred from the extraction flask into a pre-weighed evaporating dish with several rinsing of ethyl ether. The evaporating dish was placed in the fumehood with the fan on, to evaporate the ethyl ether until no odour was detectable. The dish with its contents was dried in an oven for 30 minutes at 105°C, removed from the oven, cooled in a desiccator to constant weight and weighed.

The percentage crude fat was calculated as follows:

$$\% \text{Crude fat (ether extract)} = \frac{W2 - W1 \times 100}{S}$$

Where:

W1 = weight of empty evaporating dish

W2 = weight of evaporating dish + content after drying

S = weight of sample before drying

3.2.3.5 Determination of Percentage Crude Fibre Content

5 g of ground sample was weighed and placed in a 1 litre conical flask. A 150 ml preheated 0.128 M sulphuric acid was added and the content boiled for 30 minutes. The content was filtered through a fluted funnel and the residue washed three times with hot water. To the digest was added 150 ml preheated 0.15 M potassium hydroxide and heated to boiling. Some drops of antifoaming agent (n-octanol) was added and the content boiled slowly for 30 minutes, filtered and the residue washed three times with hot water, followed by washing three times with acetone in Cold Extraction Unit (Tecator1615). The resulting residue was dried in the oven at 130°C for 1 hour, cooled in a desiccator and weighed, and then ashed at 500°C for 30 minutes, cooled in a desiccator and weighed.

The percentage crude fibre was calculated as follows:

$$\% \text{crude fibre} = \frac{W2 - W1 \times 100}{W1}$$

Where:

W1 = Sample weight before drying

W2 = Weight of residue after drying

W3 = Weight of residue after ashing

3.2.3.6 Determination of Nitrogen-Free Extract Content (Total Carbohydrate)

The percentage carbohydrate content of the leaf and root sample was determined by summing up the percentages of moisture, ash, crude protein, fat (ether extract) and

subtracting from 100. The difference in value was taken as the percentage total carbohydrate content of the leaf sample. The total carbohydrate of the leaf and root sample is contained in two fractions, the crude fibre and the nitrogen-free extract.

3.2.4 Vitamins Analysis

Fat soluble vitamins were determined using High Performance Liquid Chromatography (HPLC) following methods described by AOAC (2016) and Idu *et al.* (2018). For the extraction of water soluble vitamins, the sample was grinded with the aid of laboratory mortar and pestle. Accurately weighed 0.1 g of ground powder was put into 100 ml volumetric flask and 80 ml of water was added. After 15 minutes of ultrasonic extraction, the water was added to the volumetric flask mark. For fat soluble vitamins, accurately weighed 0.125 g of ground sample was added into 10 ml volumetric flask and 8 ml of CH₃OH-CH₂Cl₂ (dichloromethane methanol 1:1, v/v) was added to the volumetric flask mark. The prepared sample solution was stored in the dark and diluted. Prior to injection, the solutions were filtered through a 0.2 µm filter (Millex-GN).

For fat soluble vitamins, the mobile phase used was CH₃OH:CH₃CN (methanol: methyl cyanide, 8:2, v/v) and methyl tert-butyl ether. Column used was acclaim PA, 3 µm, 120 Å, 3.0 × 150 mm. For water soluble vitamins, the mobile phase used was 25 mM phosphate buffer, pH 3.6 and CH₃CN- mobile phase A (7:3, v/v). Column used was acclaim C18, 3 µm, 120 Å, 3.0 × 150 mm. Column temperature and injection volume for both vitamins were 25°C and 10 µl respectively.

3.2.5 Amino Acids Analysis

Analysis of amino acids in *Musanga cecropioides* leaves, root and root sap were carried out in accordance with the methods described by AOAC (2016). The samples

were dried, pulverized and made free of water by ensuring constant weight for a period of time in the laboratory. Dried leaf and root samples of 0.5 g were weighed into the 250 ml conical flask capacity. The samples were defatted by extracting the fat content of the sample with 30 ml of petroleum spirit three times with soxhlet extractor that was equipped with thimble. The samples were hydrolysed three times for complete hydrolysis to be achieved for the totality of amino acids recovery. The pulverized and defatted samples were soaked with 30 ml of 1 M potassium hydroxide solution and was incubated for 48 hours at 110°C in hermetically closed borosilicate glass container. After the alkaline hydrolysis, the hydrolysate was neutralized to get pH in the range of 2.5 - 5.0. The solution was purified by cation-exchanger solid phase extraction. The amino acids in purified solution were derivatized with ethylchloroformate by the established mechanism. The derivatising reagent removed by scavenging with nitrogen gas for proper mop up of the excess reagent. The derivatised amino acid that is free of derivatising reagent was made up to 1 ml in a vial for gas chromatography analysis.

Analysis of amino acids was conducted by Gas Chromatography (HP 6890) equipped with capillary column EZ (10 m × 0.2 mm × 0.25 µm) and pulsed flame photometric detector (PFPD). The inlet temperature was 250°C with the split ratio of 20:1 and detector temperature was 320°C. The flow rate was 1.0 ml/min and hydrogen was used as a carrier gas. Initial temperature at 110°C, first ramping at 27°C/min to 320°C and second ramping constant for 5 minutes at 320°C. Hydrogen pressure was 20 psi while compressed air was 35 psi.

3.2.6 Mineral Analysis

Musanga cecropioides leaves, root and root sap were analysed for mineral elements following methods described by AOAC (2016). 0.1 g of ashed sample was weighed

into a pre-cleaned borosilicate 250 ml capacity beaker for digestion. 20 ml of nitric acid was added to the weighed sample in the beaker. The sample with the digesting solvent was placed on the hot plate for digestion in the fume cupboard. The beaker and its contents after the digestion were allowed to cool. Another 20 ml of the digesting solvent was added and digested further in the fume cupboard and the mixture was allowed to cool to the room temperature. The mixture was filtered into the 250 ml volumetric capacity borosilicate container. The filtrate was made up to the mark with deionised water. The digested samples were sub-sampled into pre-cleaned borosilicate glass containers and then analysed for its elemental composition using UNICAM 929 London Atomic Absorption Spectrophotometer powered by the SOLAAR software.

3.3 Toxicity Assessment

Toxicity assessments were carried out as described below:

3.3.1 Acute Toxicity Assessment

The acute oral toxicity test of the aqueous and methanol extracts of *Musanga cecropioides* leaves and root, and *Musanga cecropioides* crude root sap was evaluated in albino mice using the method described by Lorke (1983), with slight modifications as described by Usman *et al.* (2016).

3.3.1.1 Experimental Animals

Acute toxicity assessment was performed using 75 albino mice of either sex weighing 20 – 35 g. The animals were obtained from a private animal farm in Ibadan, Oyo State, Nigeria and allowed to acclimatize for two weeks in the Department of Animal and Environmental Biology animal house, University of Benin, Benin City. They were housed in standard plastic cages and allowed free access to animal pellets (Vital Feeds,

Nigeria) and free access to water. The animals were exposed to 12 hours light/dark cycle with room temperature at $28.0 \pm 1.0^{\circ}\text{C}$ and were handled according to standard protocols for the use of laboratory animals (National Institute of Health, 2002). The study was overseen by institutional ethical committee. The extracts were administered by using orogastric gavage.

3.3.1.2 Experimental Design

The experiment was conducted in two phases as follows:

Phase one: animals were shared in three groups of three mice ($n = 3$) for each treatment. The doses administered at this stage were 10, 100 and 1000 mg/kg for the aqueous and methanol extracts of *Musanga cecropioides* leaves and root, while 10, 20 and 40 ml/kg body weight was administered for *Musanga cecropioides* crude root sap. The animals were observed hourly for 12 hours and once daily for the next 2 weeks for signs of toxicity namely salivation, stretching of the body, weakness, brushing of nose on the floor, sleep, coma and death.

Phase two: animals were also shared in three groups of two mice ($n = 2$) for each treatment dose. The doses administered at this stage were 5000, 7500 and 10000 mg/kg for the aqueous and methanol extracts of *Musanga cecropioides* leaves and root, while 60, 80 and 100 ml/kg body weight was administered for *Musanga cecropioides* crude root sap. The animals were observed every hour for 12 hours and up to two weeks for any signs of toxicity or mortality.

The LD_{50} was determined using the following formula:

$$\text{LD}_{50} = \sqrt{(D_o \times D_{100})}$$

Where D_o = highest dose that gave no mortality

And D_{100} = lowest dose that produced mortality

3.3.2 Sub-Acute Toxicity Assessment

The sub-acute toxicity study of *Musanga cecropioides* leaf and root extracts and root sap was done following the methods described by Oshomoh *et al.* (2013) and Olaniyan *et al.* (2016). The animals were administered *Musanga cecropioides* leaf and root extracts (500, 1000 and 2500 mg/kg body weight) and root sap (5, 10, 25 ml/kg body weight) for 28 days. On the 28th day, the rats were fasted overnight and anaesthetized with chloroform in a chamber. The animals were then sacrificed and 5 ml of blood was collected by cardiac puncture for haematology and biochemical analysis. Organ weight was measured and vital organs harvested for histology.

3.3.2.1 Experimental Animals

Sub-acute toxicity assessment was performed using 64 albino rats of either sex weighing 100 – 200 g. The animals were obtained from the animal house in Ambrose Alli University, Ekpoma, and allowed to acclimatize for 2 weeks, with unrestricted access to pelletized vital growers feed and clean water before the experiment. The animals were exposed to 12 hours light/dark cycle with room temperature at $28.0 \pm 1.0^{\circ}\text{C}$ and were handled according to standard protocols for the use of laboratory animals (National Institute of Health, 2002). The study was overseen by institutional ethical committee. The extracts were administered by using orogastric tubes.

3.3.2.2 Experimental Design

The treatment groups are as follows: (1) Control administered 1 ml/kg distilled water; (2) *Musanga cecropioides* aqueous leaf extract 500 mg/kg; (3) *Musanga cecropioides* aqueous leaf extract 1000 mg/kg; (4) *Musanga cecropioides* aqueous leaf extract 2500

mg/kg; (5) *Musanga cecropioides* methanol leaf extract 500 mg/kg; (6) *Musanga cecropioides* methanol leaf extract 1000 mg/kg; (7) *Musanga cecropioides* methanol leaf extract 2500 mg/kg; (8) *Musanga cecropioides* aqueous root extract 500 mg/kg; (9) *Musanga cecropioides* aqueous root extract 1000 mg/kg; (10) *Musanga cecropioides* aqueous root extract 2500 mg/kg; (11) *Musanga cecropioides* methanol root extract 500 mg/kg; (12) *Musanga cecropioides* methanol root extract 1000 mg/kg; (13) *Musanga cecropioides* methanol root extract 2500 mg/kg; (14) *Musanga cecropioides* crude root sap 5 ml/kg; (15) *Musanga cecropioides* crude root sap 10 ml/kg; (16) *Musanga cecropioides* crude root sap 25 ml/kg. (n = 4)

3.3.2.3 Haematology Analysis

Two millilitres of blood was collected in 5 ml EDTA (ethylenediaminetetra acetic acid) bottles and estimated for concentration of various haematological parameters. The parameters considered were white blood cell count, lymphocytes, monocytes, granulocytes, red blood cell count, haemoglobin concentration, packed cell volume and platelet count. The haematological parameters were analysed using automatic haematology analyser (Model BC-2800) within 24 hours of blood collection.

3.3.2.4 Biochemical Analysis

Three to five (3 – 5) ml of blood was collected in 5 ml Lithium heparin bottles and centrifuged at 2500 rpm for 10 minutes and the plasma was collected into sterile plain bottles for biochemical analysis.

3.3.2.4.1 Liver Function

Alanine aminotransferase and Aspartate aminotransferase activities were estimated following the method of Reitman and Frankel (1957) while Alkaline phosphatase was

estimated following the method described by Plummer (1978) using commercially available test kit (BioVision Inc, USA). Gamma glutamyl transferase activity was estimated using the kinetic colorimetric method as described by Persijn and Van der Slik (1976). Total bilirubin, conjugated bilirubin and unconjugated bilirubin were determined following the colorimetric method described by Jendrassik and Grof (1938). Total protein was assayed by the Biuret method Dumas *et al.* (1981).

3.3.2.4.2 Renal Function

Creatinine and urea were assayed using commercial kits and in accordance with principles previously reported by Larsen (1972) and Taylor and Vadgama (1992). Sodium, chloride bicarbonate and potassium were measured using standard Flame Atomic Absorption Photometry procedure as described by Howe *et al.* (2005).

3.3.2.4.3 Lipid Profile

Total cholesterol was determined enzymatically by hydrolysis and oxidation as described by Trinder (1969). Triacylglycerol was estimated after enzymatic hydrolysis by lipases following the Trinder (1969) and Tietz (1990) methods. High density lipoprotein was estimated using Randox kit. Low density lipoprotein and very low density lipoprotein were calculated using the Friedewald formula (Friedewald *et al.*, 1972).

3.3.2.4.4 Plasma Antioxidant

Malondialdehyde concentration was determined following the method described by Varshney and Kale (1990). The assay is based on the reaction of malondialdehyde with thiobarbituric acid, forming a red colour complex that absorbs light at 535 nm. Superoxide dismutase was determined following the method described by Misra and

Fridovich (1972). Catalase concentration was determined according to the method described by Cohen *et al.* (1970). Glutathione peroxidase activity was determined following the method described by Flohe and Gunzler (1984). Glutathione reductase activity was determined following the method described by Teitze (1969).

3.3.2.5 Histology of Vital Organs

The vital organs were isolated from the sacrificed rats and weighed in a digital weighing balance and then fixed in 10% formal saline for 24 hours, dehydrated in an alcohol-xylene series and embedded in paraffin. Sections were stained with haematoxylin and eosin for histological examination and photomicrographs were taken. The organs considered include heart, liver, lungs, and kidney.

3.4 Antioxidant Assessment

3.4.1 DPPH Radical Scavenging Activity

DPPH radical-scavenging activity of *Musanga cecropioides* leave extracts, root extracts and crude root sap was determined according to the method described by Adebisi *et al.* (2017). DPPH was dissolved in methanol to a 0.025 g/l. Ascorbic acid (standard) and the plant extracts were diluted with distilled water to get stock solution while the crude root sap was used as its stock solution. The various concentrations (10, 20, 40, 60, 80 and 100 µg/ml) of the stock solution was added to each test tube containing 1 ml of DPPH working solution. After a 20 minutes reaction at room temperature, the absorbance of the solution was measured at 515 nm. The free radical scavenging activity of each sample was determined by comparing its absorbance with that of a blank solution (DPPH solution). The ability to scavenge the DPPH radical was expressed as percentage inhibition and calculated using the following equation:

$$\% \text{ Inhibition} = \frac{A_0 - A_1}{A_0} \times 100$$

Where A0 is the absorbance of the blank solution and A1 is the absorbance of the sample.

3.4.2 ABTS Radical Scavenging Activity

ABTS radical-scavenging activity of *Musanga cecropioides* leaves extracts, root extracts and crude root sap was determined according to the method described by Re *et al.* (1999). The ABTS radical cation (ABTS⁺) was produced by the reaction between 5 ml of ABTS stock solution and 5 ml of 2.45 mM (ammonium) potassium persulfate solution, stored in the dark at room temperature for 16 hours. Before use, this solution was diluted with water to get an absorbance of 0.70 ± 0.02 at 734 nm and equilibrated at 30°C. The plant samples at various concentrations were diluted with distilled water to get sample solution. 5 IL of sample solution was homogenized with 195 IL ABTS_ + solution, the mixture was incubated at room temperature for 6 minutes and its absorbance was recorded at 734 nm. Blanks were run in each assay. ABTS scavenging ability was expressed as IC₅₀ (lg/ml) and the inhibition percentage calculated using the following formula:

$$\% \text{ Inhibition} = \frac{A_0 - A_1}{A_0} \times 100$$

Where A0 is the absorbance of the control and A1 is the absorbance of the sample.

3.4.3 DNA Protective Assay (DNA Nicking Experiment)

This assay was performed according to the method of Lee *et al.* (2002) to evaluate the potential of *Musanga cecropioides* leaf and root extracts to protect pCAMBIA 1301 DNA from destroying effects of hydroxyl radicals produced by Fenton's reagent. The reaction mixture constituted of 1 µl plasmid DNA (50 µg/100 µl), 10 µl Fenton's reagent (30 mM H₂O₂, 50 µM ascorbic acid, and 80 µM FeCl₃) and aqueous and methanol extracts of *Musanga cecropioides* leaf and root (100 µg/ml) and distilled

water to make the final volume up to 20 μ l. DMSO (50 μ g/ml) was used in place of Fenton's reagent in the negative control. It was followed by incubation at 37°C for 30 min. The analysis of DNA was done on 1% agarose gel electrophoresis. The positive control used was quercetin (50 μ M).

3.5 Antidiarrheal Study

3.5.1 Experimental Animals

One hundred and thirty-six (136) albino mice of either sex, weighing 16 – 33 g were used for both experiments (68 animals for each experiment). The animals were obtained from the animal house in Ambrose Alli University, Ekpoma, and allowed to acclimatize for 2 weeks in standard mice cages in Edo University Animal House, Edo University Iyamho, Nigeria. The animals were allowed unrestricted access to pelletized vital growers feed and clean water before the experiment. The animals were exposed to 12 hours light/dark cycle with room temperature at $28.0 \pm 1.0^\circ\text{C}$ and were handled according to standard protocols for the use of laboratory animals (National Institute of Health, 2002). The study was overseen by institutional ethical committee.

3.5.2 Experimental Design

Just before each experiment, the animals were allowed to fast for 18 hours and were grouped as follows: (1) Negative control group given 2 ml/kg Normal saline; (2) Positive control group received 5 mg/kg Loperamide; (3) 50 mg/kg *Musanga cecropioides* aqueous leaf extract; (4) 100 mg/kg *Musanga cecropioides* aqueous leaf extract; (5) 200 mg/kg *Musanga cecropioides* aqueous leaf extract; (6) 50 mg/kg *Musanga cecropioides* methanol leaf extract; (7) 100 mg/kg *Musanga cecropioides* methanol leaf extract; (8) 200 mg/kg *Musanga cecropioides* methanol leaf extract; (9) 50 mg/kg *Musanga cecropioides* aqueous root extract; (10) 100 mg/kg *Musanga*

cecropioides aqueous root extract; (11) 200 mg/kg *Musanga cecropioides* aqueous root extract; (12) 50 mg/kg *Musanga cecropioides* methanol root extract; (13) 100 mg/kg *Musanga cecropioides* methanol root extract; (14) 200 mg/kg *Musanga cecropioides* methanol root extract; (15) 0.5 ml/kg *Musanga cecropioides* crude root sap; (16) 1 ml/kg *Musanga cecropioides* crude root sap; (17) 2 ml/kg *Musanga cecropioides* crude root sap. (n = 4)

3.5.3 Castor Oil – Induced Diarrhoea

The effect of *Musanga cecropioides* on castor oil – induced diarrhoea was determined following previously described methods (Uddin *et al.*, 2005; Nwosu *et al.* 2012). All animals were administered the respective treatments and after 1 hour they were all administered 12 ml/kg body weight Castor oil orally using an orogastric gavage. The animals were each placed in individual cages lined with absorbent paper and observed for 4 hours. The number of formed and unformed stool was recorded at the end of the experiment. The percentage inhibition of diarrhoea was expressed as follows:

$$\% \text{ Inhibition of diarrhoea} = [(A-B)/A] 100$$

Where A indicated mean number of diarrheal faeces in group treated with normal saline;

B indicated mean number of diarrheal faeces in groups treated with drug.

3.5.4 Castor Oil – Induced Enteropooling

The effect of *Musanga cecropioides* on castor oil-induced enteropooling was carried out according to the method described by Rahman *et al.* (2013). One hour after all the animals were administered various treatments, they were challenged with 12 ml/kg body weight Castor oil orally using an orogastric gavage. After 1 hour of castor oil administration, the mice were sacrificed and the small intestine from the pylorus to

the caecum was isolated. Then the intestinal contents were weighed and volume measured by graduated tube. Percentage inhibition in volume of intestinal content was determined as follows:

$$\% \text{ Inhibition in volume of intestinal content} = [(A-B)/A] 100$$

Where A indicated mean volume of intestinal content of group treated with normal saline;

B indicated mean volume of intestinal content of group treated with drugs.

3.6 Antitussive Study

3.6.1 Experimental Animals

Antitussive experiment was performed using 48 adult guinea pigs of either sex weighing 260 – 460 g. Mucus expectorant activity was evaluated using 90 mice of either sex weighing 17 – 33 g. The guinea pigs were obtained from the animal facility of the Department of Physiology, Ambrose Alli University, Ekpoma, Nigeria. The mice were obtained from a private animal farm in Ibadan, Oyo State, Nigeria. All animals were allowed two weeks acclimatization in the animal facility of the Faculty of Science, Edo University Iyamho, Iyamho, Edo State. They were all allowed free access to pellets and tap water and were exposed to natural light-dark cycle and room temperature. All animals were handled according to standard protocols for the use of laboratory animals (National Institute of Health, 2002) and the experiments were overseen by members of Ethics Committee of the Faculty of Science, University of Benin, Nigeria.

3.6.2 Mucus Expectorant (Phenol Red) Experiment

This was based on the method first described by Engler and Szelenyi (1984) with slight modifications by Ozolua *et al.* (2016).

The animals for this experiment were grouped (n=5) as follows: (1) Control group given 1 ml/kg distilled water; (2) 15 mg/kg Bromohexine; (3) 50 mg/kg Sodium cromoglycate; (4) 50 mg/kg *Musanga cecropioides* aqueous leaf extract; (5) 100 mg/kg *Musanga cecropioides* aqueous leaf extract; (6) 200 mg/kg *Musanga cecropioides* aqueous leaf extract; (7) 50 mg/kg *Musanga cecropioides* methanol leaf extract; (8) 100 mg/kg *Musanga cecropioides* methanol leaf extract; (9) 200 mg/kg *Musanga cecropioides* methanol leaf extract; (10) 50 mg/kg *Musanga cecropioides* aqueous root extract; (11) 100 mg/kg *Musanga cecropioides* aqueous root extract; (12) 200 mg/kg *Musanga cecropioides* aqueous root extract; (13) 50 mg/kg *Musanga cecropioides* methanol root extract; (14) 100 mg/kg *Musanga cecropioides* methanol root extract; (15) 200 mg/kg *Musanga cecropioides* methanol root extract; (16) 0.5 ml/kg *Musanga cecropioides* crude root sap; (17) 1 ml/kg *Musanga cecropioides* crude root sap; (18) 2 ml/kg *Musanga cecropioides* crude root sap.

All treatments were administered orally except for sodium cromoglycate that was administered intraperitoneally (i.p.).

On the 8th day, after an overnight fast, treatment was done as usual and the animals in the third group were administered 50 mg/kg sodium cromoglycate. About 30 minutes later the secretagogue, ammonium chloride was administered to all groups (5 mg/kg orally). Thirty minutes after the administration of ammonium chloride, each mouse was injected with phenol red (500 mg/kg i.p.). All the mice were sacrificed by cervical dislocation 30 min after phenol red injection. The 2 cm of trachea was removed from the thyroid cartilage to the main stem bronchi. Each trachea was kept for 30 min in 2 ml normal saline. Sodium hydroxide (0.1 ml, 1 M) was added to the fluid to stabilize the pH. The absorbance of phenol red released from the trachea was read at 460 nm using a T80+UV/VIS spectrophotometer (PG Instruments Ltd, Beijing,

China). A standard curve (graph of absorbance against concentration, $R^2 = 0.947$) was plotted from which the concentrations of phenol red were extrapolated.

3.6.3 Antitussive Screening Protocol

This was based on the guinea pig cough model described by Nadig and Laxmi (2005). A day before the experiment, guinea pigs were placed individually in a glass chamber ($60 \times 36 \times 60$ cm) for 5 min before cough was induced by exposure to citric acid aerosol (7.5% w/v) using an Omron® (Omron Health Care Ltd, Japan) compressor nebulizer (rate of 0.4 ml/min and particle size 5 μ m) for 5 min. The animals exhibiting at least 10 bouts of cough were selected for the study and fasted overnight but with access to water. The selected animals were randomly allotted to experimental groups (n=4 per group). The animals were treated orally as outlined below:

(1) Control group given 1 ml/ kg distilled; (2) 25 mg/kg dihydrocodeine; (3) 50 mg/kg *Musanga cecropioides* aqueous leaf extract; (4) 100 mg/kg *Musanga cecropioides* aqueous leaf extract; (5) 50 mg/kg *Musanga cecropioides* methanol leaf extract; (6) 100 mg/kg methanol leaf extract; (7) 50 mg/kg *Musanga cecropioides* aqueous root extract; (8) 100 mg/kg *Musanga cecropioides* aqueous root extract; (9) 50 mg/kg *Musanga cecropioides* methanol root extract; (10) 100 mg/kg *Musanga cecropioides* methanol root extract; (11) 0.5 ml/kg *Musanga cecropioides* crude root sap; (12) 1 ml/kg *Musanga cecropioides* crude root sap.

An hour after administration, they were re-exposed to citric acid aerosol (as earlier described) and the numbers of cough bouts were recorded.

Percentage suppression of cough was calculated using the formula:

$$\frac{\text{Number of Pre Treatment Cough Bouts} - \text{Number of Post Treatment Cough Bouts}}{\text{Number of Pre Treatment Cough Bouts}} \times 100$$

3.7 Antiasthma Study

3.7.1 Experimental Animals

Anti-asthmatic experiments were performed using 90 adult guinea pigs of either sex weighing 300 – 460 g. The guinea pigs were obtained from the animal facility of the Department of Physiology, Ambrose Alli University, Ekpoma, Nigeria and allowed two weeks acclimatization in the Department of Animal and Environmental Biology animal house, University of Benin. They were all allowed free access to vital growers pellets and tap water and were exposed to natural light-dark cycle and room temperature. All animals were handled according to standard protocols for the use of laboratory animals (National Institute of Health, 2002) and the experiments were overseen by members of Ethics Committee of the Faculty of Science, University of Benin, Nigeria.

3.7.2 Treatment Schedule

Guinea pigs were randomly allotted into groups (n=6 per group) as outlined below:

(1) non-sensitized control (given 2 ml/kg of distilled water); (2) ovalbumin (OV) sensitized+2 ml/kg of distilled water; (3) OV sensitized+0.5 mg/kg salbutamol; (4) OV sensitized+50 mg/kg *Musanga cecropioides* aqueous leaf extract; (5) OV sensitized+100 mg/kg *Musanga cecropioides* aqueous leaf extract; (6) OV sensitized+50 mg/kg *Musanga cecropioides* methanol leaf extract; (7) OV sensitized+100 mg/kg *Musanga cecropioides* methanol leaf extract; (8) OV sensitized+50 mg/kg *Musanga cecropioides* aqueous root extract; (9) OV sensitized+100 mg/kg *Musanga cecropioides* aqueous root extract; (10) OV sensitized+50 mg/kg *Musanga cecropioides* methanol root extract; (11) OV

sensitized+100 mg/kg *Musanga cecropioides* methanol root extract; (12) OV sensitized+0.5 ml/kg *Musanga cecropioides* crude root sap; (13) OV sensitized+1 ml/kg *Musanga cecropioides* crude root sap.

3.7.3 Anti-Asthma Screening Protocols

The animals were sensitized following the method described by Bramley *et al.* (1995) and Ozolua *et al.* (2016). They were given intraperitoneal injections of 100 mg Ovalbumin, a booster dose of 50 mg Ovalbumin 24 hours later and a final dose of 50 mg 24 hours before exposure to histamine aerosol. The administration of extract and distilled water was done daily using an orogastric gavage for 14 days.

On the 14th day, all treatments were administered as appropriate. One hour later, the animals were exposed to 0.2% histamine dihydrochloride (dissolved in normal saline) aerosol in glass chamber (60 × 56 × 60 cm) using Omron® (Omron Healthcare Ltd, Japan) compressor nebulizer (rate of 0.4 ml/min and particle size of 5 µm) until pre-convulsive dyspnoea was observed. The animals were then removed from the chamber and placed in fresh air to recover.

3.7.4 Evaluation of Trachea Fluid Viscosity (Flow Rate)

Guinea pigs used in the experiments above were euthanized under chloroform anaesthesia and 2 cm lengths of tracheae up to the point of thoracic bifurcation were isolated. Tracheal fluid viscosity was estimated by an indirect method described by Reid and Ugwu (1987) and Ovuakporie-Uvo and Idu (2016). The animals were sacrificed and using a 1 ml graduated syringe fitted with a hypodermic needle (21G, 0.8 × 40 mm, Nr2), 1 ml of tracheal fluid was withdrawn and the plunger of the syringe was carefully removed after turning the needle point-down and holding it in place with a retort stand so that the fluid could drop under the influence of gravity. Using stop watch, the time taken for the content of the syringe to be emptied was

recorded. The flow rate was calculated as volume/second and was used as an index of viscosity.

3.7.5 Haematology Analysis

This was done as described in 3.3.2.3 above.

3.7.6 Histology of the Lung and Trachea

The lungs and trachea were isolated from the sacrificed guinea pigs and fixed in 10% formal saline for 24 hours, dehydrated in an alcohol-xylene series and embedded in paraffin. Sections were stained with haematoxylin and eosin for histological examination and photomicrographs were taken. The lungs were observed for pathological changes while the trachea thickness of all animals were measured under the microscope.

3.8 Anti-Diabetic Study

The anti-diabetic activity of *Musanga cecropioides* aqueous and methanol leaf extracts, aqueous and methanol root extracts and crude root sap was studied using Streptozotocin-induced diabetic rats following methods described by Pari and Latha (2004), Balekari and Veeresham (2015) and Ezenwa *et al.* (2015).

3.8.1 Experimental Animals

One hundred and thirty-eight (138) healthy male and female Wistar albino rats weighing between 100 to 205 g were used for the experiment. The animals were purchased from the Department of Biochemistry Animal House, University of Benin, Benin City and were kept in standard animal cages (which were regularly cleaned)

housed in the Edo University Animal House, Edo University Iyamho, Nigeria and maintained under standard laboratory conditions (temperature: 28 - 31°C; humidity: 50 - 55%; and 12:12 hours day: night cycle). The animals were allowed unrestricted access to water and standard laboratory diet, and allowed to acclimatize to the new environment for a period of two weeks. They were handled according to standard protocols for the use of laboratory animals (National Institute of Health, 2002).

3.8.2 Induction of Diabetes

Diabetes was induced in overnight fasted rats by a single intraperitoneal injection of 50 mg/kg body weight of streptozotocin (STZ) (Sigma). STZ was dissolved in 0.1 M cold sodium citrate buffer, pH 4.5 and the control rats were injected with vehicle (sodium citrate buffer) alone. To prevent STZ-induced hypoglycaemia, rats received 5% dextrose solution after STZ administration and for the next 24 hours. Diabetes was verified after 72 hours by measuring blood glucose level with strips using glucometer (Accu-Chek® Active, Roche Diagnostic Corporation, Germany) and the diabetic rats confirmed as those having blood glucose level greater than 200 mg/dl (Ezenwa *et al.*, 2015) and were grouped for the experiment.

3.8.3 Experimental Design and Treatment Schedule

The effect of the extracts was studied in STZ-induced diabetic rats for 4 weeks. The rats were divided into the following treatment groups (n = 6):

- (1) Normal control + 1 ml/kg distilled water; (2) STZ control + 1 ml/kg distilled water;
- (3) STZ + 10 mg/kg Glibenclamide-standard drug; (4) STZ + aqueous extract of *Musanga cecropioides* leaves 30 mg/kg; (5) STZ + aqueous extract of *Musanga cecropioides* leaves 50 mg/kg; (6) STZ + aqueous extract of *Musanga cecropioides* leaves 100 mg/kg; (7) STZ + aqueous extract of *Musanga cecropioides* leaves 200

mg/kg; (8) STZ + methanol extract of *Musanga cecropioides* leaves 30 mg/kg; (9) STZ + methanol extract of *Musanga cecropioides* leaves 50 mg/kg; (10) STZ + methanol extract of *Musanga cecropioides* leaves 100 mg/kg; (11) STZ + methanol extract of *Musanga cecropioides* leaves 200 mg/kg; (12) STZ + aqueous extract of *Musanga cecropioides* root 30 mg/kg; (13) STZ + aqueous extract of *Musanga cecropioides* root 50 mg/kg; (14) STZ + aqueous extract of *Musanga cecropioides* root 100 mg/kg; (15) STZ + aqueous extract of *Musanga cecropioides* root 200 mg/kg; (16) STZ + methanol extract of *Musanga cecropioides* root 30 mg/kg; (17) STZ + methanol extract of *Musanga cecropioides* root 50 mg/kg; (18) STZ + methanol extract of *Musanga cecropioides* root 100 mg/kg; (19) STZ + methanol extract of *Musanga cecropioides* root 200 mg/kg; (20) STZ + crude sap of *Musanga cecropioides* root 0.5 ml/kg; (21) STZ + crude sap of *Musanga cecropioides* root 1 ml/kg; (22) STZ + crude sap of *Musanga cecropioides* root 2 ml/kg; (23) STZ + crude sap of *Musanga cecropioides* root 3 ml/kg.

The various treatments were administered orally using a gavage for 28 days. The glibenclamide, aqueous and methanol extracts of *Musanga cecropioides* leaves and root were triturated with distilled water just before oral administration. The fasting body weight and fasting blood glucose level was estimated on days 1, 7, 14, 21 and 28 of the experiment.

3.8.4 Haematological Analysis

Haematological analysis was done following the same procedures described in 3.3.2.3.

3.8.5 Biochemical Analysis

Blood sample was collected in lithium heparin bottles and the plasma was separated into plain bottles and used for liver function, renal function, lipid profile tests and total antioxidant capacity estimation.

3.8.5.1 Liver Function

Same procedures described in 3.3.2.4.1.

3.8.5.2 Renal Function

Same procedures described in 3.3.2.4.2.

3.8.5.3 Lipid Profile

Same procedures described in 3.3.2.4.3.

3.8.5.4 Total Antioxidant Capacity

The total antioxidant capacity was determined using the improved spectrophotometric version described by Re *et al.* (1999). ABTS radical cation was prepared as described in 3.4.2. The blood plasma separated for each experimental animal (10 μ l) was added to 1 ml of ABTS stock solution. For the control, 10 μ l of ethanol was added to 1 ml of ABTS solution. The absorbance of all samples were read at 734 nm after 6 minutes and the percentage inhibition were calculated as described also in section 3.4.2.

3.8.6 In-vivo Antioxidant of the Brain, Liver and Pancreas

The complete brain and parts of the liver and pancreas were collected for *in-vivo* antioxidant estimation. The different tissue samples were weighed and homogenized in 2 ml normal saline and then separated using a centrifuge at 4000 rpm for 10 minutes. The supernatant was used for antioxidant assessments following the same procedures in 3.3.2.4.4.

3.8.7 Histopathology

The vital organs were isolated from the sacrificed rats and weighed in a digital weighing balance and then fixed in 10% formal saline for 24 hours, dehydrated in an alcohol-xylene series and embedded in paraffin. Sections were stained with haematoxylin and eosin for histological examination and photomicrographs were taken. The organs considered include heart, liver, lungs, pancreas, spleen and kidney.

3.9 Data Analysis

Data were subjected to one way analysis of variance (ANOVA), followed by Dunnett's test for multiple comparisons using Graphpad prism software (version 6.01). Results are expressed as mean $\pm$ SEM and values of $P < 0.05$ were considered as statistically significant.

CHAPTER FOUR: RESULTS

4.1 Screening of Phytoconstituents

4.1.1 Qualitative Phytochemical Screening

Table 4.1 show the results on the qualitative phytochemical screening of *Musanga cecropioides* aqueous and methanol leaf extracts, root extracts and crude root sap. Alkaloid, tannin, saponin, flavonoid and phenol was found present in all extracts. Terpenoid was present in all extracts apart from the crude root sap. Cyanogenic glycoside was present in only the aqueous and methanol leaf extracts, while anthraquinone was present in aqueous leaf extract and methanol root extract. Sterol was found only in the aqueous root extract and oxalate was found present in the methanol extracts of both the leaf and root.

Table 4.1: Qualitative Phytochemical Screening of *Musanga cecropioides* aqueous and methanol leaf extracts, root extracts and crude root sap

Phytochemicals	MCL Aq	MCL Meth	MCR Aq	MCR Meth	MCCRS
Alkaloid	+	+	+	+	+
Tannin	+	+	+	+	+
Saponin	+	++	+	++	+
Flavonoid	+	+	+	+	+
Phenol	++	++	++	++	+
Terpenoid	++	++	++	++	-
Cyanogenic Glycoside	+	+	-	-	-
Anthraquinone	+	-	-	+	-
Sterol/Steroid	-	-	+	-	-
Oxalate	-	+	-	+	-

-Negative; + positive; ++ strongly positive

MCL: *Musanga cecropioides* leaves; MCR: *Musanga cecropioides* root; MCCRS: *Musanga cecropioides* root sap; Aq: Aqueous extract; Meth: Methanol extract

4.1.2 Quantitative Phytochemical Screening

Table 4.2 show the results on the quantitative phytochemical screening of *Musanga cecropioides* leaves, root and root sap. *Musanga cecropioides* leaves showed the highest concentration of alkaloid (7.00 ± 1.00 %), tannin ($84.60 \mu\text{g/ml}$), saponin (3.75 ± 1.75 %), flavonoid ($21.03 \mu\text{g/ml}$), phenol ($67.64 \mu\text{g/ml}$), terpenoid (0.24 ± 0.11 g) and glycoside (0.22 ± 0.10 g).

Table 4.2: Quantitative phytochemical screening of *Musanga cecropioides* leaves, root and root sap

Phytochemicals	Leaves	Root	Root sap
Alkaloid (%)	7.00 ± 1.00	1.00 ± 0.00	1.75 ± 1.25
Tannin ($\mu\text{g/ml}$)	84.60 ± 0.00	37.92 ± 0.00	5.14 ± 0.00
Saponin (%)	3.75 ± 1.75	2.25 ± 0.75	0.30 ± 0.10
Flavonoid ($\mu\text{g/ml}$)	21.03 ± 0.00	18.32 ± 0.00	11.29 ± 0.00
Phenol ($\mu\text{g/ml}$)	67.64 ± 0.00	34.69 ± 0.00	5.97 ± 0.00
Terpenoid (g)	0.24 ± 0.11	0.11 ± 0.06	0.00 ± 0.00
Glycoside (g)	0.22 ± 0.10	0.00 ± 0.00	0.00 ± 0.00

4.1.3 Proximate Analysis

Table 4.3 show the results on the proximate analysis of *Musanga cecropioides* leaves, root and root sap. *Musanga cecropioides* leaves had the highest percentage ash (7.48%), fibre (7.60%), soluble carbohydrate (11.53%) and protein (0.63%) content, while *Musanga cecropioides* root sap had the highest percentage moisture (84.59%) and fat (15.00%) content, with no ash, fibre and carbohydrate content.

Table 4.3: Proximate analysis of *Musanga cecropioides* leaves, root and root sap

Parameters	Leaves	Root	Root sap
Moisture %	62.21	80.19	84.59
Ash %	7.48	2.47	-
Fat %	10.55	10.40	15.00
Fibre %	7.60	3.73	-
Soluble Carbohydrate %	11.53	3.07	-
Protein %	0.63	0.14	0.41

4.1.4 Vitamin Content

Table 4.4 show the results on the vitamin content of *Musanga cecropioides* leaves, root and root sap. Vitamins A, B1, B2, B3, B5, B6, B7, B9, B12, C, D, E and K1 were present in *Musanga cecropioides* leaves, root and root sap, with the leaves having the highest concentration of all except vitamins B2, B5 and B6 which were highest in *Musanga cecropioides* root sap.

Table 4.4: Vitamin Composition of *Musanga cecropioides* Leaves, Root and Root Sap

Vitamins	Leaves (mg/100g)	Root (mg/100g)	Root Sap (mg/100g)
A	0.939	0.758	0.426
B1 (thiamin)	0.088	0.058	0.075
B2 (riboflavin)	0.037	0.029	0.065
B3 (niacin)	1.374	0.688	0.649
B5 (pantothenic acid)	0.179	0.259	0.281
B6 (pyridoxine)	0.174	0.108	0.194
B7 (biotin)	0.157	0.080	0.001
B9 (folate)	0.075	0.057	0.001
B12 (cobalamine)	0.193	0.132	0.028
C (ascorbic acid)	25.395	16.121	17.200
D (ergocalciferol)	0.018	0.014	0.002
E (tocopherol)	0.944	0.646	0.367
K1 (phylloquinone)	0.106	0.076	0.005

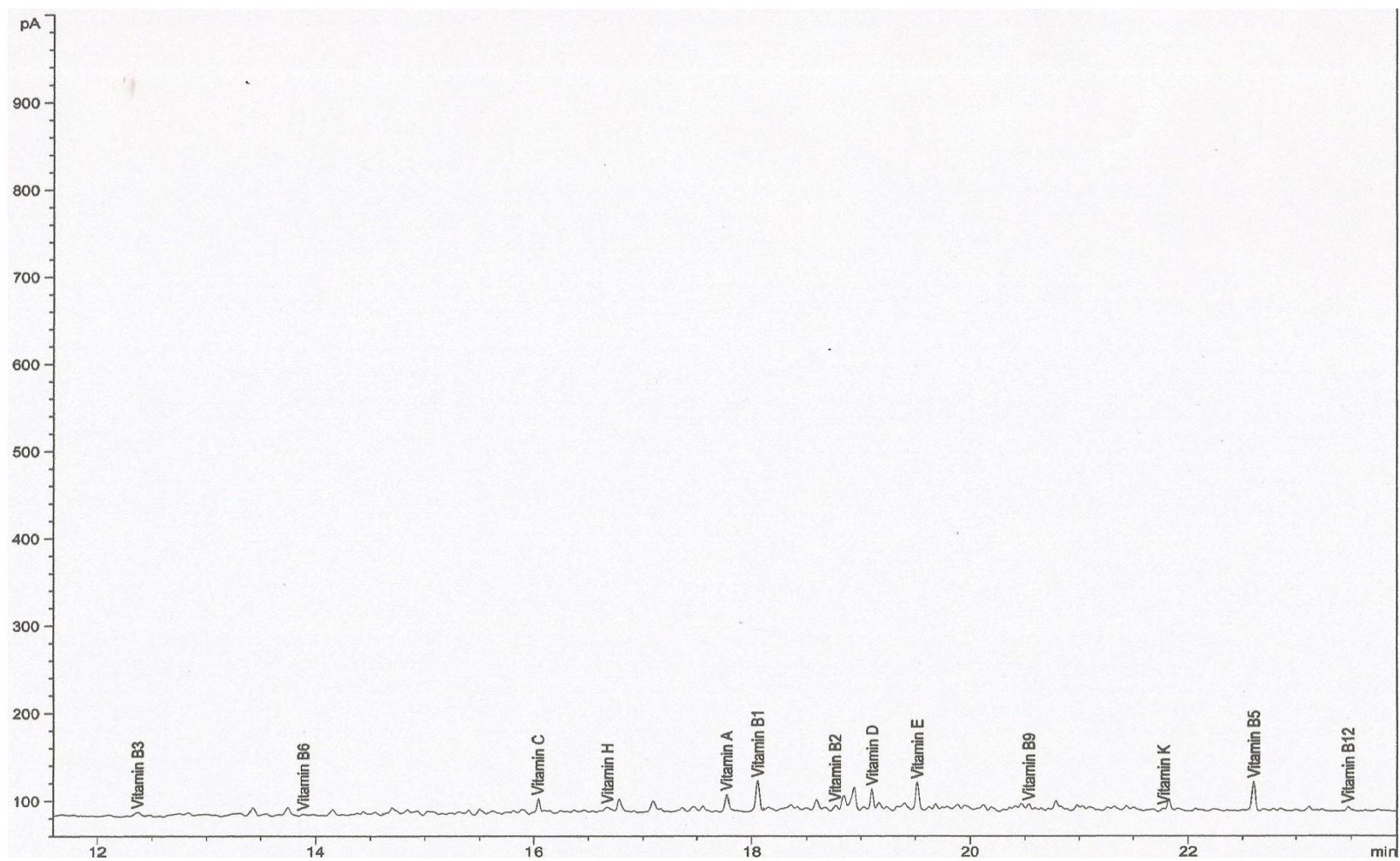


Figure 4.1: Chromatogram of vitamin content of *Musanga cecropioides* leaves

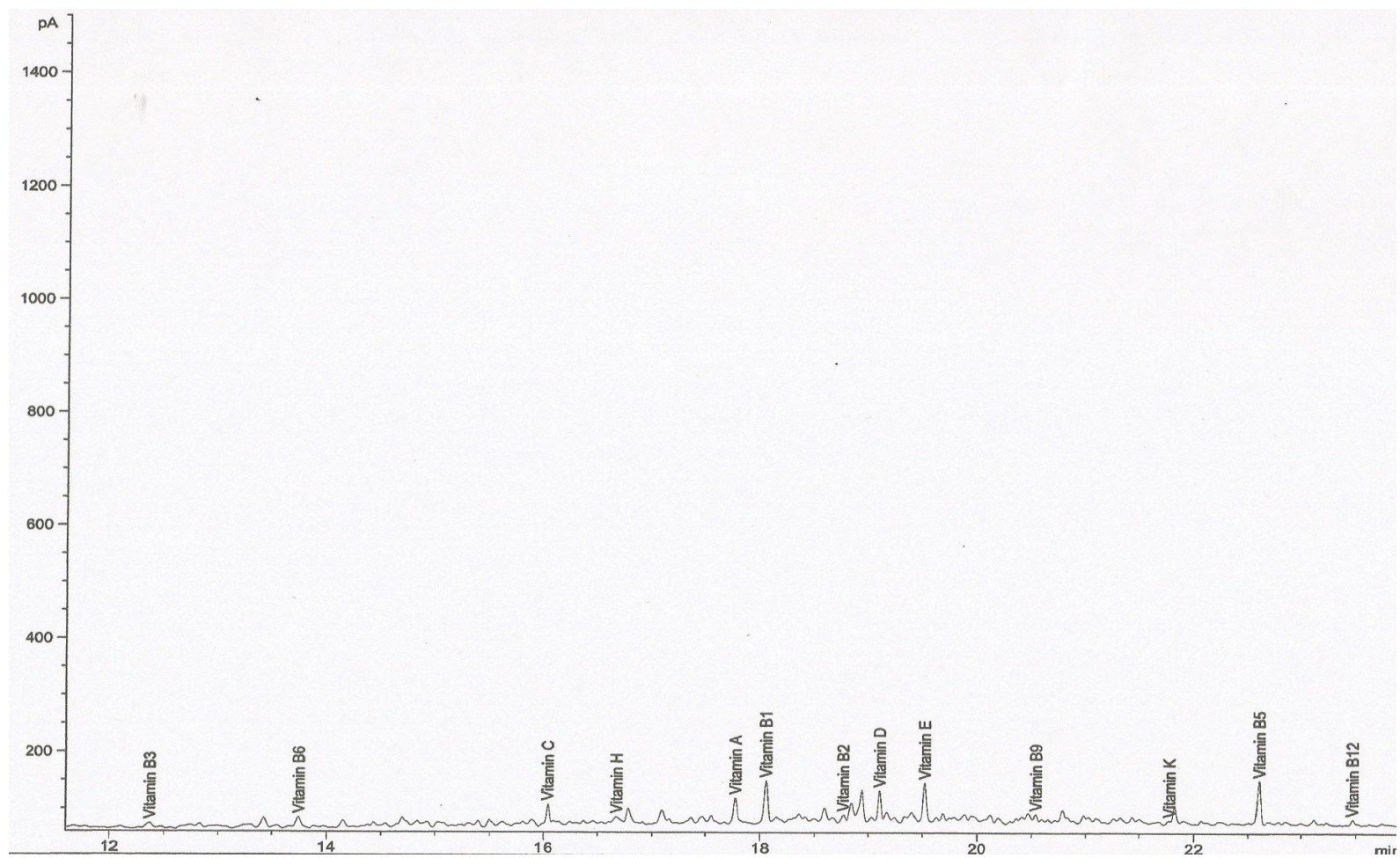


Figure 4.2: Chromatogram of vitamin content of *Musanga cecropioides* root

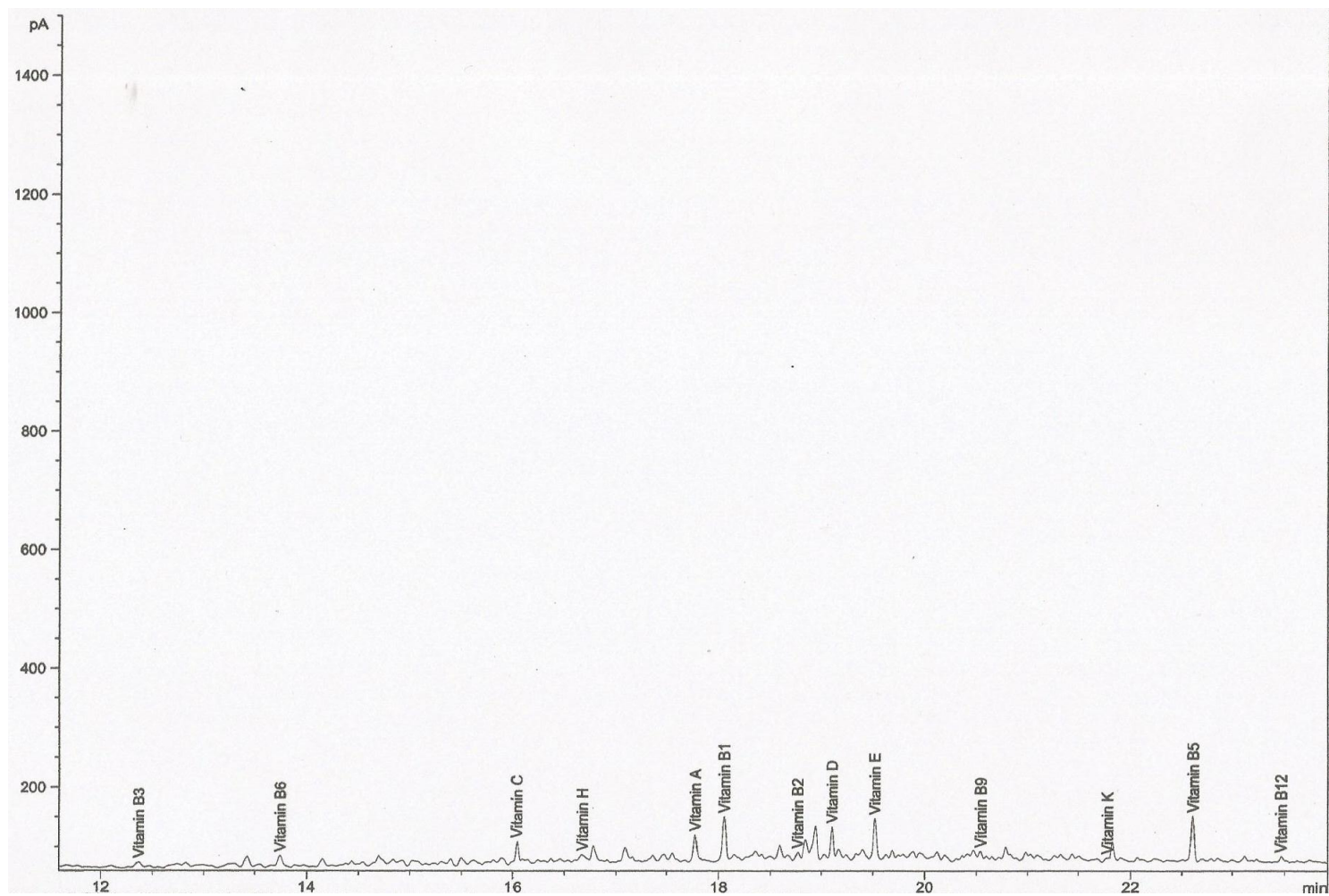


Figure 4.3: Chromatogram of vitamin content of *Musanga cecropioides* root sap

4.1.5 Carotene Content

Figure 4.1 show the results on the carotene content of *Musanga cecropioides* leaves, root and root sap. *Musanga cecropioides* leaves showed the highest concentration at 21.29 ± 1.36 ($\mu\text{g}/100\text{ g}$).

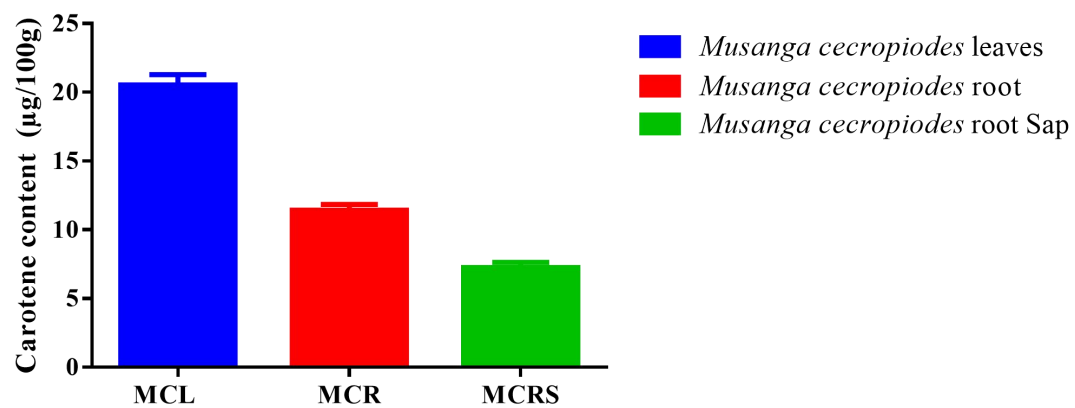


Figure 4.4: Carotene content in *Musanga cecropioides* leaves, root and root sap

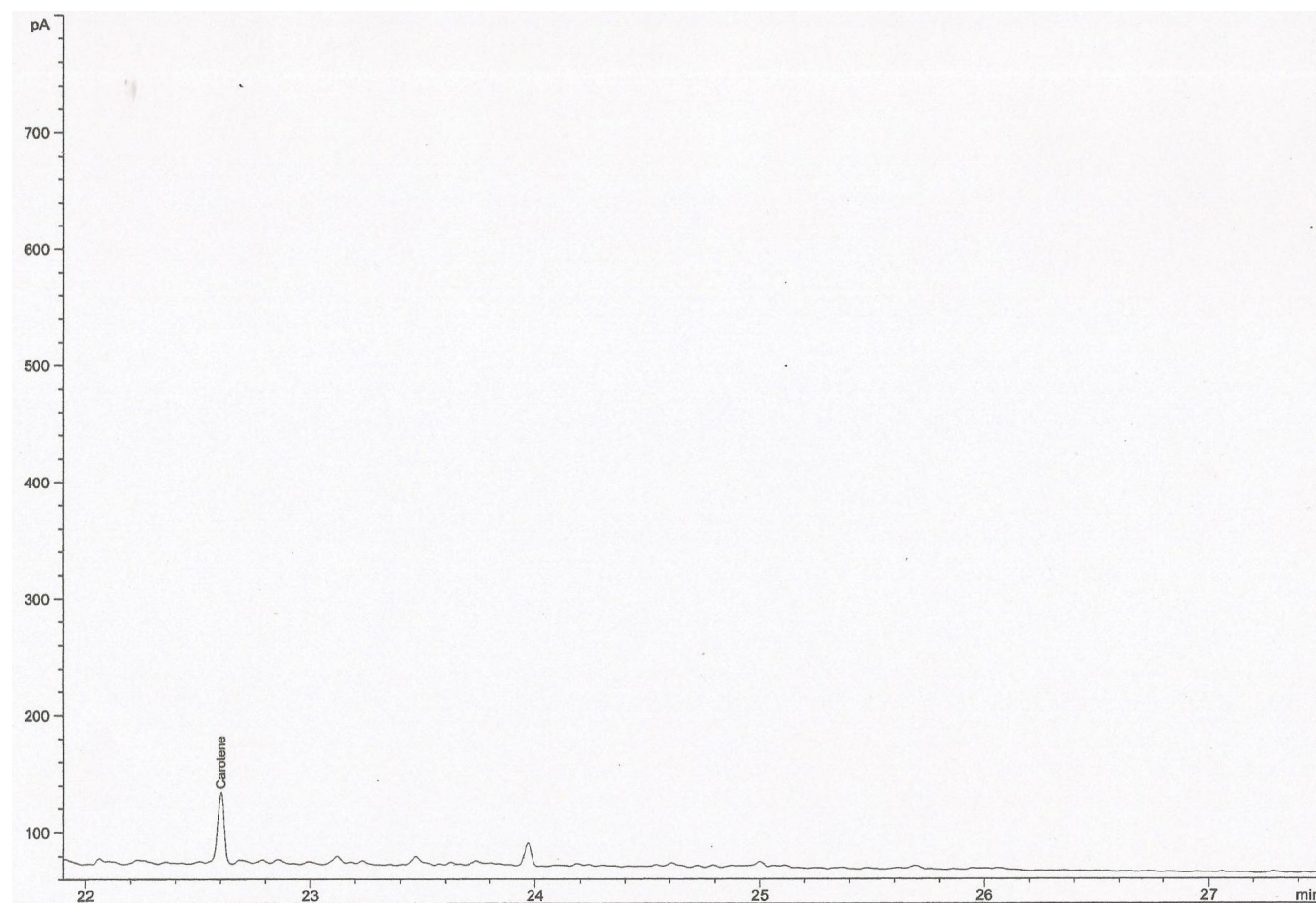


Figure 4.5: Chromatogram of carotene content of *Musanga cecropioides* leaves



Figure 4.6: Chromatogram of carotene content of *Musanga cecropioides* root

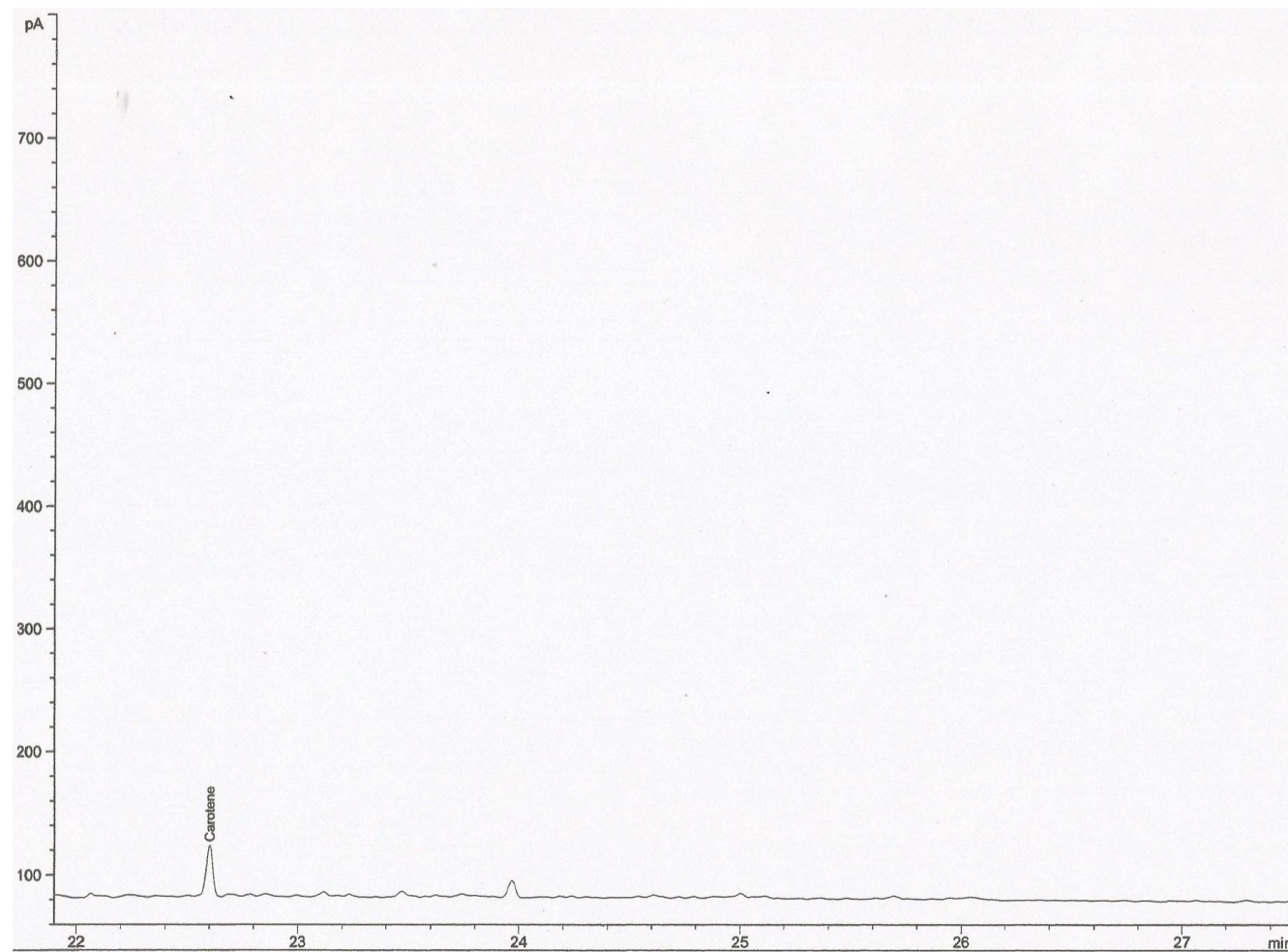


Figure 4.7: Chromatogram of carotene content of *Musanga cecropioides* root sap

4.1.6 Amino Acids

Table 4.5 shows the results on the amino acid contents of *Musanga cecropioides* leaves, root and root sap. *Musanga cecropioides* leaves, root and root sap showed the presence of essential and non-essential amino acids. *Musanga cecropioides* leaves showed the highest concentrations of glycine, alanine, serine tyrosine, cysteine, valine, methionine, phenylalanine, isoleucine, leucine and tryptophan at 7.18, 7.39, 5.13, 4.34, 1.62, 6.10, 2.16, 5.72, 4.72, 7.85 and 1.38 g/100 g protein respectively. *Musanga cecropioides* root showed the highest concentration of proline, arginine, threonine and lysine at 6.05, 6.32, 4.07, 5.87 g/100 g protein respectively. *Musanga cecropioides* root sap showed the highest concentrations of aspartate, glutamate and histidine at 9.13, 13.09, 4.37 g/100 g protein respectively.

Table 4.5: Amino Acid Composition of *Musanga cecropioides* Leaves, Root and Root Sap

Amino Acids		Leaves	Root	Root Sap
		g/100 g protein		
Non-essential amino acids	Glycine	7.18	5.81	2.53
	Alanine	7.39	6.16	2.39
	Serine	5.13	4.13	2.49
	Aspartate	7.28	8.12	9.13
	Glutamate	12.74	11.77	13.09
	Tyrosine	4.34	3.13	1.74
	Cysteine	1.62	0.54	0.79
	Proline	4.97	6.05	3.50
Essential amino acids	Valine	6.10	5.83	2.92
	Methionine	2.16	1.40	0.80
	Phenylalanine	5.72	4.49	2.80
	Histidine	2.17	1.29	4.37
	Arginine	5.87	6.32	4.33
	Threonine	4.03	4.07	3.65
	Isoleucine	4.72	4.03	2.67
	Leucine	7.85	5.82	4.80
	Tryptophan	1.38	0.81	0.29
	Lysine	3.00	5.87	4.02

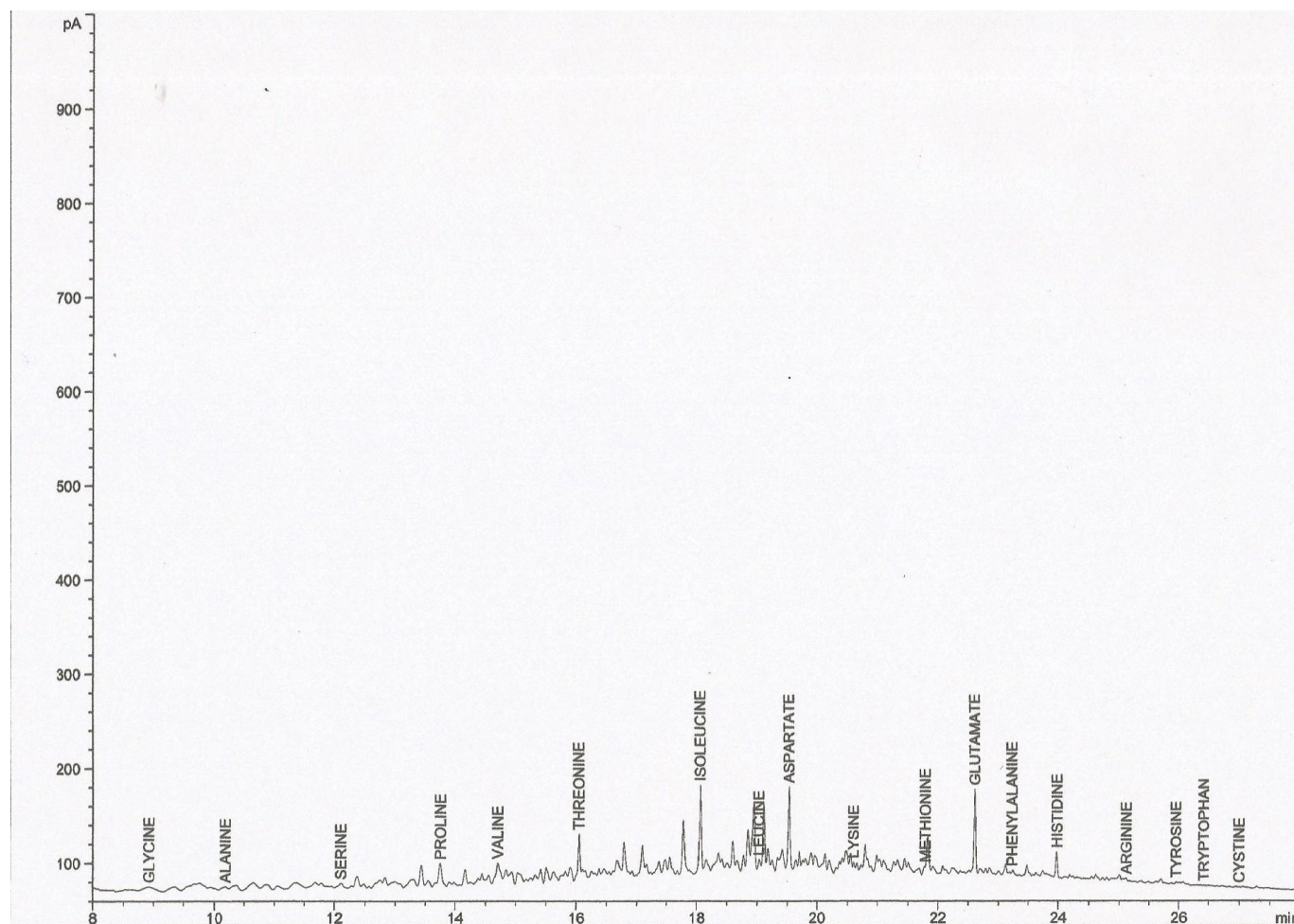


Figure 4.8: Chromatogram of amino acid content of *Musanga cecropioides* leaves

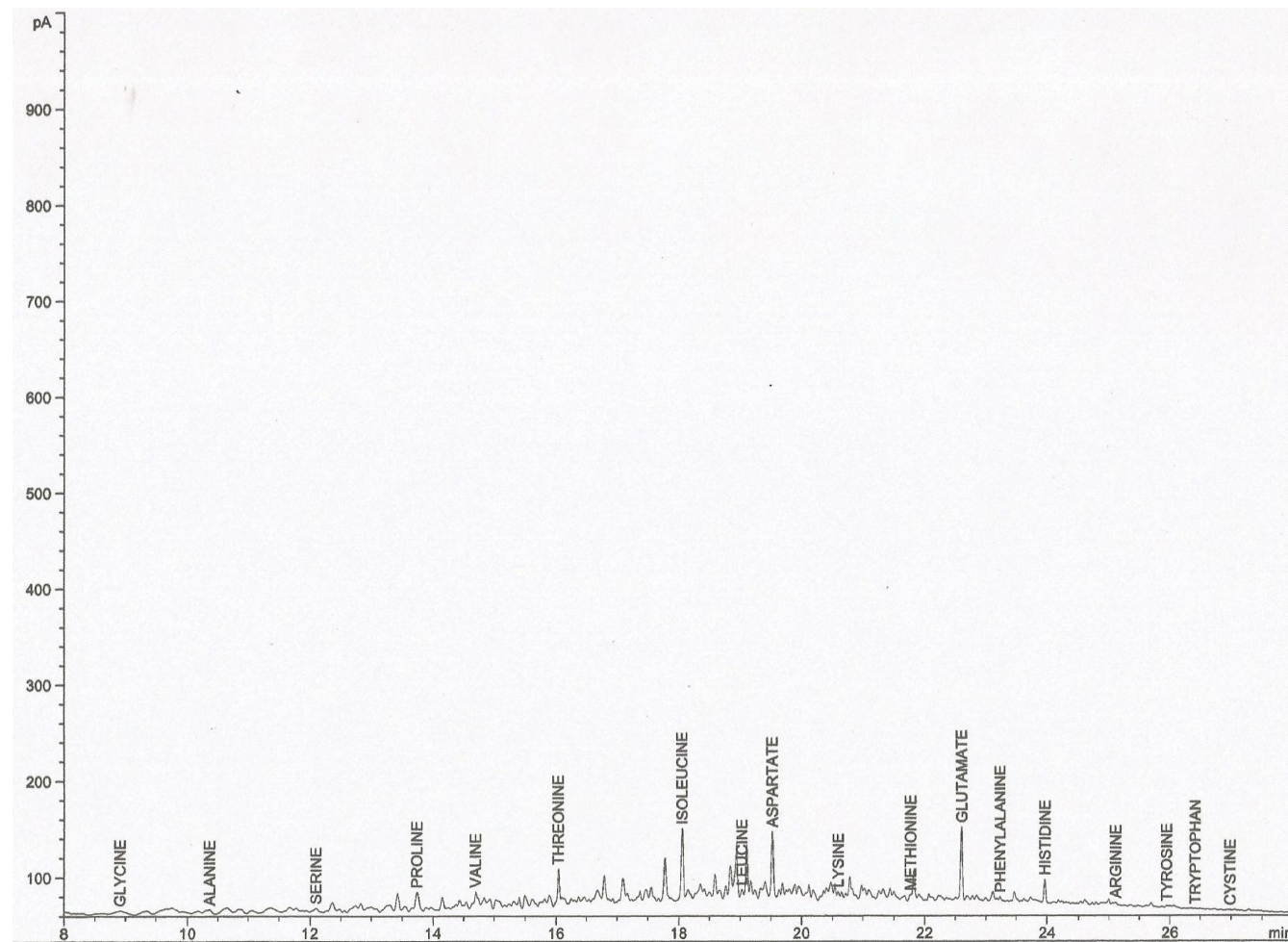


Figure 4.9: Chromatogram of amino acid content of *Musanga cecropioides* root

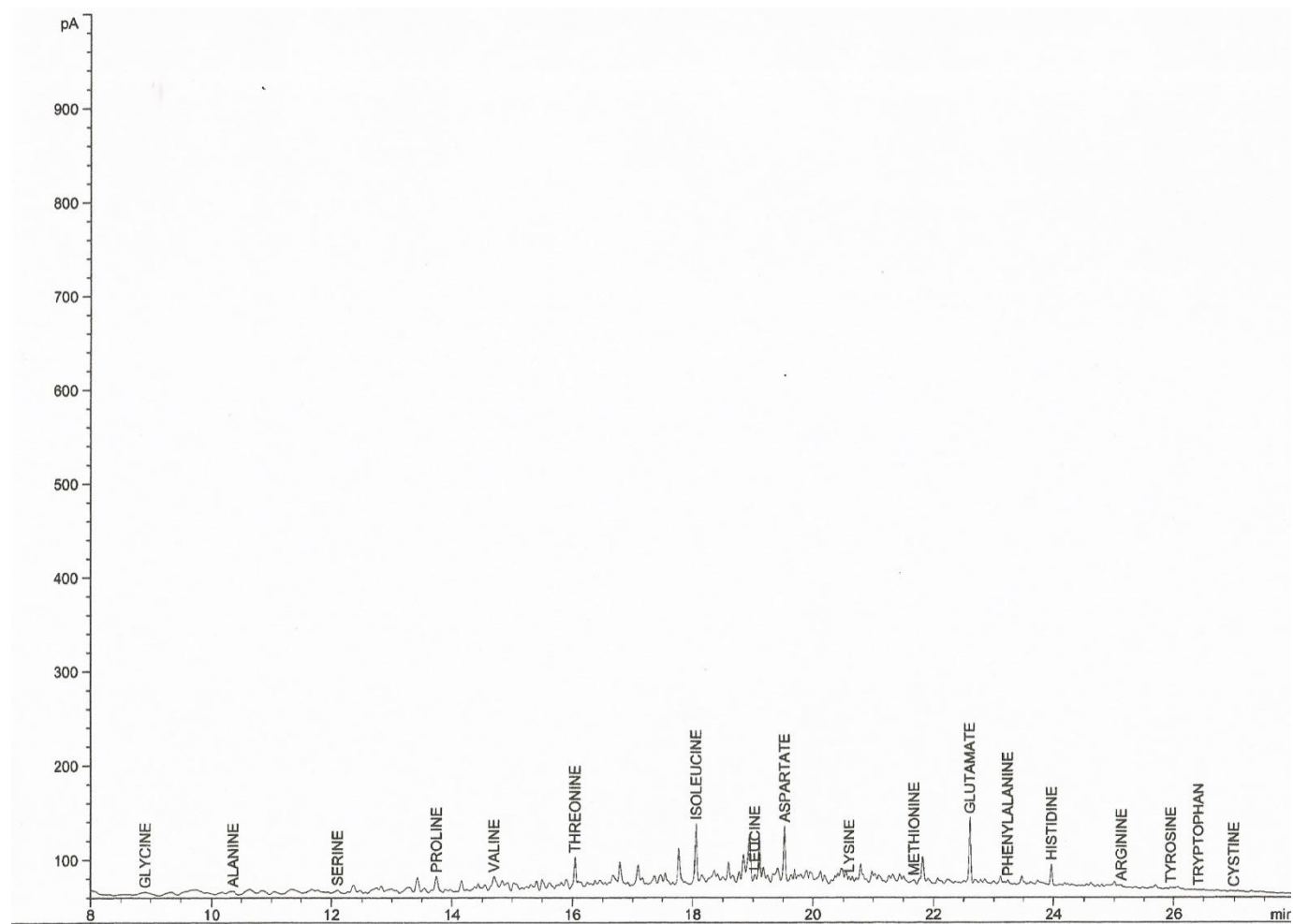


Figure 4.10: Chromatogram of amino acid content of *Musanga cecropioides* root sap

4.1.7 Elemental Analysis

Table 4.6 shows the results on the elemental analysis of *Musanga cecropioides* leaves, root and root sap. *Musanga cecropioides* leaves showed the highest concentration of zinc (0.28 mg/kg), copper (0.12 mg/kg), manganese (0.41 mg/kg), potassium (84.60 mg/kg), calcium (48.25 mg/kg), magnesium (19.00 mg/kg), sodium (10.90 mg/kg) and lead while *Musanga cecropioides* root showed the highest concentrations of iron (5.96 mg/kg) and nickel (0.01 mg/kg).

Table 4.6: Concentration of Elements in *Musanga cecropioides* Leaves, Root and Root Sap

Elements	Recommended Daily Intake/ Permissible Limits (mg)	Leaves (mg/kg)	Root (mg/kg)	Root Sap (mg/L)
Zinc	15	0.28	0.22	0.05
Copper	2	0.12	0.10	0.09
Iron	3.9	3.10	5.96	0.30
Manganese	5	0.41	0.24	0.10
Potassium	3500	84.60	52.80	6.90
Calcium	300	48.25	21.60	5.65
Magnesium	350	19.00	12.00	2.25
Sodium	2400	10.90	6.32	4.12
Lead	< 1	0.20	0.00	0.00
Nickel	< 1	0.01	0.02	0.00

4.2 Toxicity Assessment

4.2.1 Acute Toxicity Assessment

Table 4.7, 4.8 and 4.9 show the results on the acute toxicity assessment of *Musanga cecropioides* leaf extracts, root extracts and crude root sap respectively. No mortality was observed in groups treated with 10, 100, 1000, 5000, 7500 and 10000 mg/kg body weight of *Musanga cecropioides* aqueous and methanol leaf extracts and methanol root extract. The groups treated with aqueous root extracts at 10, 100 and 1000 mg/kg showed no mortality as well, however at higher doses (5000, 7500 and 10000 mg/kg) there was 100% mortality (Table 4.8). The groups treated with *Musanga cecropioides* crude root sap (Table 4.9) showed no mortality at all doses administered (10, 20, 40, 60, 80, 100 ml/kg). The LD₅₀ of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, methanol root extract and crude root sap were indeterminable as they were above 10000 mg/kg and 100 ml/kg for the extracts and sap respectively. The LD₅₀ for *Musanga cecropioides* aqueous root extract was calculated as 2236 mg/kg body weight.

Table 4.7: Result of Acute Toxicity Assessment on *Musanga cecropioides* Leaf Extracts in Mice

STAGE 1				
Extract	Dose (mg/kg)	Number of death	Mortality (%)	Symptoms
Aqueous extract	10	0/3	0	None
	100	0/3	0	None
	1000	0/3	0	None
Methanol extract	10	0/3	0	None
	100	0/3	0	None
	1000	0/3	0	None
STAGE 2				
Extract	Dose (mg/kg)	Number of death	Mortality (%)	Symptoms
Aqueous extract	5000	0/2	0	None
	7500	0/2	0	None
	10000	0/2	0	None
Methanol extract	5000	0/2	0	None
	7500	0/2	0	None
	10000	0/2	0	None

(0/3)= 0= Number of death, 3= Number of rats used for the test

Table 4.8: Result of Acute Toxicity Assessment on *Musanga cecropioides* Root Extracts in Mice

STAGE 1				
Extract	Dose (mg/kg)	Number of death	Mortality (%)	Symptoms
Aqueous extract	10	0/3	0	None
	100	0/3	0	None
	1000	0/3	0	None
Methanol extract	10	0/3	0	None
	100	0/3	0	None
	1000	0/3	0	None
STAGE 2				
Extract	Dose (mg/kg)	Number of death	Mortality (%)	Symptoms
Aqueous extract	5000	2/2	100	Death within 1 hour
	7500	2/2	100	Death within 1 hour
	10000	2/2	100	Death within 1 hour
Methanol extract	5000	0/2	0	None
	7500	0/2	0	None
	10000	0/2	0	None

(0/3)= 0= Number of death, 3= Number of rats used for the test

Table 4.9: Result of Acute Toxicity Assessment on *Musanga cecropioides* Crude Root Sap in Mice

STAGE 1			
Dose (ml/kg)	Number of death	Mortality (%)	Symptoms
10	0/3	0	None
20	0/3	0	None
40	0/3	0	None
STAGE 2			
Dose (ml/kg)	Number of death	Mortality (%)	Symptoms
60	0/2	0	None
80	0/2	0	None
100	0/2	0	None

0/3: 0= Number of death, 3= Number of rats used for the test

4.2.2 Sub-Acute Toxicity Assessment

4.2.2.1 Changes in whole body weight

Tables 4.10, 4.11, 4.12, 4.13 and 4.14 shows results on the changes in whole body weight of animals treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap in the 28 days sub-acute toxicity assessment respectively. No significant difference was observed at $P < 0.05$ throughout the 28 days of the study in groups treated with *Musanga cecropioides* leaf and root extracts (aqueous and methanol) at 500, 1000 and 2500 mg/kg body weight. The groups treated with *Musanga cecropioides* crude root sap (Table 4.14) at 10 and 25 ml/kg body weight showed significantly lower values at $P < 0.05$ when compared to the control group, however an increase in the weight of the animals was observed at the end of the experiment.

Table 4.10: Changes in whole body weight of rats treated daily with aqueous extracts of *Musanga cecropioides* leaves for 28 days

Treatment groups/Dose	Mean weight of animals (g) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Control 1 ml/kg DW	133.2 ± 33.67	141.8 ± 28.88	163.2 ± 23.52	167.3 ± 26.40	182.9 ± 29.69
MCL Aq 500 mg/kg	155.4 ± 8.00	161.0 ± 10.40	161.7 ± 11.24	162.3 ± 12.00	160.0 ± 12.39
MCL Aq 1000 mg/kg	138.3 ± 8.71	145.1 ± 9.99	148.8 ± 4.02	147.6 ± 4.52	147.2 ± 7.61
MCL Aq 2500 mg/kg	153.2 ± 16.48	164.8 ± 14.20	164.6 ± 9.76	161.2 ± 6.38	159.4 ± 6.28

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; DW: distilled water; No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.11: Changes in whole body weight of rats treated daily with methanol extracts of *Musanga cecropioides* leaves for 28 days

Treatment groups/Dose	Mean weight of animals (g) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Control 1 ml/kg DW	133.2 ± 33.67	141.8 ± 28.88	163.2 ± 23.52	167.3 ± 26.40	182.9 ± 29.69
MCL Meth 500 mg/kg	172.5 ± 7.37	169.0 ± 12.20	160.9 ± 13.20	162.8 ± 8.22	161.1 ± 7.02
MCL Meth 1000 mg/kg	177.5 ± 11.93	178.9 ± 5.65	164.5 ± 2.37	165.7 ± 7.10	163.9 ± 14.59
MCL Meth 2500 mg/kg	128.9 ± 7.00	143.3 ± 12.96	137.8 ± 17.88	140.9 ± 12.49	142.1 ± 11.67

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* Leaves; Meth: methanol extract; DW: distilled water; No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.12: Changes in whole body weight of rats treated daily with aqueous extracts of *Musanga cecropioides* roots for 28 days

Treatment groups/Dose	Mean weight of animals (g) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Control 1 ml/kg DW	133.2 ± 33.67	141.8 ± 28.88	163.2 ± 23.52	167.3 ± 26.40	182.9 ± 29.69
MCR Aq 500 mg/kg	180.4 ± 11.05	182.9 ± 11.49	174.8 ± 13.04	179.4 ± 11.22	191.8 ± 9.03
MCR Aq 1000 mg/kg	173.9 ± 17.83	181.6 ± 19.87	179.6 ± 19.77	169.3 ± 17.17	175.5 ± 22.27
MCR Aq 2500 mg/kg	170.0 ± 20.36	178.1 ± 21.10	159.2 ± 7.49	168.6 ± 13.66	172.3 ± 13.86

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; DW: distilled water; No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.13: Changes in whole body weight of rats treated daily with methanol extracts of *Musanga cecropioides* root for 28 days

Treatment groups/Dose	Mean weight of animals (g) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Control 1 ml/kg DW	133.2 ± 33.67	141.8 ± 28.88	163.2 ± 23.52	167.3 ± 26.40	182.9 ± 29.69
MCR Meth 500 mg/kg	170.7 ± 21.03	157.2 ± 16.73	159.1 ± 17.86	162.7 ± 19.75	166.2 ± 21.07
MCR Meth 1000 mg/kg	158.2 ± 5.19	150.8 ± 2.25	153.9 ± 2.32	156.3 ± 2.19	160.4 ± 2.70
MCR Meth 2500 mg/kg	141.3 ± 7.68	139.6 ± 7.62	139.9 ± 8.37	140.7 ± 9.10	141.0 ± 11.27

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* Root; Meth: methanol extract; DW: distilled water; No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.14: Changes in whole body weight of rats treated daily with *Musanga cecropioides* crude root sap for 28 days

Treatment groups/Dose	Mean weight of animals (g) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Control 1 ml/kg DW	133.2 ± 33.67	141.8 ± 28.88	163.2 ± 23.52	167.3 ± 26.40	182.9 ± 29.69
MCCRS 5 ml/kg	101.3 ± 8.76	108.8 ± 7.48	116.3 ± 5.14	118.7 ± 2.54	122.1 ± 1.72
MCCRS 10 ml/kg	101.3 ± 4.87	100.2 ± 5.10	102.3 ± 7.40*	105.0 ± 5.71*	107.9 ± 5.20*
MCCRS 25 ml/kg	106.7 ± 8.20	106.3 ± 8.75	101.0 ± 9.39*	103.1 ± 10.43*	106.5 ± 12.09*

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; * Significant values at $P < 0.05$, when compared with the control group

4.2.2.2 Organ-to-body weight ratio

Tables 4.15, 4.16, 4.17, 4.18 and 4.19 shows results on the organ-to-body weight ratio of animals treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap in the 28 days sub-acute toxicity assessment respectively. On the 28th day of administration *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract (at 500, 1000 and 2500 mg/kg) and crude root sap (at 5, 10 and 25 ml/kg), no significant difference ($P < 0.05$) was observed in the liver, heart, kidney and lungs-to-body weight ratio when compared to the control group expect for the liver-to-body weight ratio of the group treated with methanol leaf extract of *Musanga cecropioides* at 500 mg/kg which was significantly lower at $P < 0.05$ (25.82 ± 2.40) when compared to the control group (35.88 ± 2.30).

Table 4.15: Organ-to-body weight ratios of rats treated daily with *Musanga cecropioides* aqueous leaves extract for 28 days

Treatment groups/Dose	Ratios ($\times 10^{-3}$)			
	LV:BW	H:BW	K:BW	L:BW
Control 1 ml/kg DW	35.88 $\pm$ 2.30	3.48 $\pm$ 0.13	6.12 $\pm$ 0.44	8.03 $\pm$ 0.97
MCL Aq 500 mg/kg	28.91 $\pm$ 2.40	3.56 $\pm$ 0.05	6.22 $\pm$ 0.13	7.40 $\pm$ 1.47
MCL Aq 1000 mg/kg	30.58 $\pm$ 3.26	4.19 $\pm$ 0.24	6.38 $\pm$ 0.20	8.14 $\pm$ 1.52
MCL Aq 2500 mg/kg	28.87 $\pm$ 1.76	3.75 $\pm$ 0.17	5.76 $\pm$ 0.15	6.55 $\pm$ 0.37

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; LV: Liver; H: Heart; K: kidney; L: Lungs;

No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.16: Organ-to-body weight ratios of rats treated daily with *Musanga cecropioides* methanol leaves extract for 28 days

Treatment groups/Dose	Ratios ($\times 10^{-3}$)			
	LV:BW	H:BW	K:BW	L:BW
Control 1 ml/kg DW	35.88 $\pm$ 2.30	3.48 $\pm$ 0.13	6.12 $\pm$ 0.44	8.03 $\pm$ 0.97
MCL Meth 500 mg/kg	25.82 $\pm$ 2.40*	3.53 $\pm$ 0.14	6.10 $\pm$ 0.19	6.82 $\pm$ 0.41
MCL Meth 1000 mg/kg	30.38 $\pm$ 2.09	3.52 $\pm$ 0.35	6.28 $\pm$ 0.34	9.93 $\pm$ 3.90
MCL Meth 2500 mg/kg	29.49 $\pm$ 1.02	3.99 $\pm$ 0.24	6.03 $\pm$ 0.13	5.83 $\pm$ 0.08

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; LV: Liver; H: Heart; K: kidney; L: Lungs; * Significant value at $P < 0.05$, when compared with the control group

Table 4.17: Organ-to-body weight ratios of rats treated daily with *Musanga cecropioides* aqueous root extract for 28 days

Treatment groups/Dose	Ratios ($\times 10^{-3}$)			
	LV:BW	H:BW	K:BW	L:BW
Control 1 ml/kg DW	35.88 $\pm$ 2.30	3.45 $\pm$ 0.13	6.12 $\pm$ 0.44	8.03 $\pm$ 0.97
MCR Aq 500 mg/kg	34.08 $\pm$ 1.33	3.00 $\pm$ 0.43	6.37 $\pm$ 0.25	7.45 $\pm$ 0.99
MCR Aq 1000 mg/kg	33.83 $\pm$ 3.01	3.98 $\pm$ 0.35	6.11 $\pm$ 0.36	6.02 $\pm$ 0.32
MCR Aq 2500 mg/kg	32.83 $\pm$ 1.66	4.05 $\pm$ 0.53	6.01 $\pm$ 0.26	6.75 $\pm$ 0.81

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; LV: Liver; H: Heart; K: kidney; L: Lungs; No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.18: Organ-to-body weight ratios of rats treated daily with *Musanga cecropioides* methanol root extract for 28 days

Treatment groups/Dose	Ratios ($\times 10^{-3}$)			
	LV:BW	H:BW	K:BW	L:BW
Control 1 ml/kg DW	35.88 $\pm$ 2.30	3.48 $\pm$ 0.13	6.12 $\pm$ 0.44	8.03 $\pm$ 0.97
MCR Meth 500 mg/kg	32.19 $\pm$ 0.80	4.04 $\pm$ 0.32	6.38 $\pm$ 0.24	7.53 $\pm$ 0.47
MCR Meth 1000 mg/kg	34.13 $\pm$ 1.12	3.46 $\pm$ 0.10	6.02 $\pm$ 0.40	6.77 $\pm$ 0.32
MCR Meth 2500 mg/kg	32.58 $\pm$ 1.31	4.00 $\pm$ 0.39	6.00 $\pm$ 0.34	7.49 $\pm$ 0.45

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* Root; Meth: Methanol extract; DW: distilled water; LV: Liver; H: Heart; K: kidney; L: Lungs; No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.19: Organ-to-body weight ratios of rats treated daily with *Musanga cecropioides* crude root sap for 28 days

Treatment groups/Dose	Ratios ($\times 10^{-3}$)			
	LV:BW	H:BW	K:BW	L:BW
Control 1 ml/kg DW	35.88 $\pm$ 2.30	3.48 $\pm$ 0.13	6.12 $\pm$ 0.44	8.03 $\pm$ 0.97
MCCRS 5 ml/kg	30.28 $\pm$ 1.71	3.18 $\pm$ 0.11	5.33 $\pm$ 0.33	6.96 $\pm$ 0.62
MCCRS 10 ml/kg	30.23 $\pm$ 0.90	3.46 $\pm$ 0.52	5.91 $\pm$ 0.30	9.62 $\pm$ 1.42
MCCRS 25 ml/kg	30.53 $\pm$ 0.73	3.47 $\pm$ 0.26	5.66 $\pm$ 0.12	7.56 $\pm$ 0.98

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; LV: Liver; H: Heart; K: kidney; L: Lungs; No Significant difference observed at $P < 0.05$, when compared with the control group

4.2.2.3 Haematology

Tables 4.20, 4.21, 4.22, 4.23 and 4.24 shows results on the haematology analysis of animals treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap in the 28 days sub-acute toxicity assessment respectively. Administration of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract (at 500, 1000 and 2500 mg/kg) and crude root sap (at 5, 10 and 25 ml/kg), did not significantly alter the white blood cell count, lymphocytes, monocytes, granulocytes, red blood cell count, haemoglobin concentration, haematocrit and platelet count when compared to the control group except for the granulocytes of the group treated with *Musanga cecropioides* crude root sap at 25 ml/kg which was significantly higher at $P < 0.05$ (2.63 ± 0.73) when compared to the control group (1.03 ± 0.60).

Table 4.20: Effect of aqueous extract of *Musanga cecropioides* leaves on the haematological parameters of rats in 28 days sub-acute toxicity study

Parameters	WBC $10^{-3}/\mu\text{L}$	LYM $10^{-3}/\mu\text{L}$	MON $10^{-3}/\text{UI}$	GRAN $10^{-3}/\mu\text{L}$	RBC $10^{-6}/\text{UL}$	HGB g/dL	HCT %	PLT $10^{-3}/\text{UI}$
Control 1 ml/kg DW	10.83 ± 3.02	9.00 ± 2.65	0.80 ± 0.30	1.03 ± 0.60	5.55 ± 0.44	12.50 ± 0.87	48.55 ± 0.59	693.8 ± 95.39
MCL Aq 500 mg/kg	6.28 ± 2.27	4.60 ± 1.61	0.43 ± 0.17	1.38 ± 0.47	5.36 ± 0.49	13.55 ± 1.04	47.08 ± 3.43	552.3 ± 147.2
MCL Aq 1000 mg/kg	5.88 ± 0.96	4.45 ± 0.95	0.40 ± 0.07	1.03 ± 0.10	5.92 ± 0.33	13.73 ± 0.66	50.88 ± 3.35	655.3 ± 134.2
MCL Aq 2500 mg/kg	4.40 ± 0.83	3.35 ± 1.00	0.33 ± 0.10	0.73 ± 0.16	6.01 ± 0.22	14.15 ± 0.32	51.75 ± 2.92	440.0 ± 56.26

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=4$

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; DW: distilled water

WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Hematocrit; PLT: Platelet count

No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.21: Effect of methanol extract of *Musanga cecropioides* leaves on the haematological parameters of rats in 28 days sub-acute toxicity study

Parameters	WBC $10^3/\mu\text{L}$	LYM $10^3/\mu\text{L}$	MON $10^3/\mu\text{L}$	GRAN $10^3/\mu\text{L}$	RBC $10^6/\mu\text{L}$	HGB g/dL	HCT %	PLT $10^3/\mu\text{L}$
Control 1 ml/kg DW	10.83 ± 3.02	9.00 ± 2.65	0.80 ± 0.30	1.03 ± 0.60	5.55 ± 0.44	12.50 ± 0.87	48.55 ± 0.59	693.8 ± 95.39
MCL Meth 500 mg/kg	6.28 ± 1.07	4.68 ± 1.18	0.43 ± 0.05	0.93 ± 0.14	6.06 ± 0.21	13.80 ± 0.30	53.05 ± 1.53	575.8 ± 106.8
MCL Meth 1000 mg/kg	6.33 ± 1.46	4.43 ± 1.12	0.28 ± 0.09	0.58 ± 0.18	4.55 ± 1.32	10.45 ± 3.10	35.80 ± 10.73	960.8 ± 325.9
MCL Meth 2500 mg/kg	6.75 ± 0.09	5.40 ± 0.21	0.48 ± 0.08	0.88 ± 0.15	5.82 ± 0.29	13.25 ± 0.33	49.90 ± 1.92	660.3 ± 33.33

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* Leaves; Meth: Methanol extract; DW: distilled water

WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Hematocrit; PLT: Platelet count

No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.22: Effect of aqueous extract of *Musanga cecropioides* root on the haematological parameters of rats in 28 days sub-acute toxicity study

Parameters	WBC 10 ³ /uL	LYM 10 ³ /uL	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ /uL	HGB g/dL	HCT %	PLT 10 ³ /uL
Control 1 ml/kg DW	10.83 ± 3.02	9.00 ± 2.65	0.80 ± 0.30	1.03 ± 0.60	5.55 ± 0.44	12.50 ± 0.87	48.55 ± 0.59	693.8 ± 95.39
MCR Aq 500 mg/kg	6.60 ± 0.30	6.18 ± 0.29	0.15 ± 0.03	0.28 ± 0.03	5.54 ± 0.25	13.33 ± 0.57	48.25 ± 2.00	653.0 ± 65.94
MCR Aq 1000 mg/kg	10.05 ± 4.17	8.78 ± 4.10	0.48 ± 0.18	0.80 ± 0.37	5.21 ± 0.19	12.48 ± 0.57	44.13 ± 1.21	676.3 ± 130.9
MCR Aq 2500 mg/kg	7.45 ± 1.19	6.10 ± 1.34	0.48 ± 0.09	0.88 ± 0.23	6.09 ± 0.41	12.43 ± 1.35	50.35 ± 2.30	863.3 ± 235.5

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; DW: distilled water

WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Hematocrit; PLT: Platelet count

No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.23: Effect of methanol extract of *Musanga cecropioides* root on the haematological parameters of rats in 28 days sub-acute toxicity study

Parameters	WBC 10 ³ /uL	LYM 10 ³ /uL	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ /uL	HGB g/dL	HCT %	PLT 10 ³ /uL
Control 1 ml/kg DW	10.83 ± 3.02	9.00 ± 2.65	0.80 ± 0.30	1.03 ± 0.60	5.55 ± 0.44	12.50 ± 0.87	48.55 ± 0.59	693.8 ± 95.39
MCR Meth 500 mg/kg	6.93 ± 0.44	6.08 ± 0.40	0.35 ± 0.13	0.50 ± 0.18	6.24 ± 0.17	14.65 ± 0.42	50.05 ± 0.94	809.3 ± 116.9
MCR Meth 1000 mg/kg	6.73 ± 1.20	5.43 ± 0.76	0.43 ± 0.11	0.88 ± 0.36	6.09 ± 0.12	14.40 ± 0.21	49.58 ± 0.38	667.8 ± 104.0
MCR Meth 2500 mg/kg	7.20 ± 1.94	4.55 ± 1.30	0.70 ± 0.27	1.95 ± 0.41	4.09 ± 0.65	11.38 ± 1.35	33.23 ± 5.93	534.5 ± 157.1

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* Root; Meth: Methanol extract; DW: distilled water

WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count

No Significant difference observed at $P < 0.05$, when compared with the control group

Table 4.24: Effect of *Musanga cecropioides* crude root sap on the haematological parameters of rats in 28 days sub-acute toxicity study

Parameters	WBC $10^3/\mu\text{L}$	LYM $10^3/\mu\text{L}$	MON $10^3/\mu\text{L}$	GRAN $10^3/\mu\text{L}$	RBC $10^6/\mu\text{L}$	HGB g/dL	HCT %	PLT $10^3/\mu\text{L}$
Control 1 ml/kg DW	10.83 ± 3.02	9.00 ± 2.65	0.80 ± 0.30	1.03 ± 0.60	5.55 ± 0.44	12.50 ± 0.87	48.55 ± 0.59	693.8 ± 95.39
MCCRS 5 ml/kg	8.43 ± 2.74	6.80 ± 2.17	0.53 ± 0.23	1.10 ± 0.35	5.76 ± 0.20	13.80 ± 0.68	48.30 ± 4.53	568.5 ± 133.5
MCCRS 10 ml/kg	11.00 ± 2.90	7.83 ± 2.30	0.80 ± 0.16	1.70 ± 0.38	5.64 ± 0.55	13.35 ± 1.11	46.53 ± 3.82	476.8 ± 26.05
MCCRS 25 ml/kg	10.15 ± 2.56	6.58 ± 1.77	0.95 ± 0.26	$2.63 \pm 0.73^*$	5.635 ± 0.44	13.48 ± 1.18	44.33 ± 3.68	375.3 ± 37.02

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* Crude Root Sap; DW: distilled water

WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count

* Significant values at $P < 0.05$, when compared to control group

4.2.2.4 Liver Function

Tables 4.25, 4.26, 4.27, 4.28 and 4.29 shows results on the liver function tests of animals treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap in the 28 days sub-acute toxicity assessment respectively.

In table 4.25, *Musanga cecropioides* aqueous leaf extract significantly reduced the Alanine aminotransferase levels of the groups administered 500 mg/kg (23.80 ± 0.63 U/L significantly lower at $P < 0.001$), 1000 mg/kg (23.79 ± 0.51 U/L significantly lower at $P < 0.001$) and 2500 mg/kg (25.06 ± 0.90 U/L significantly lower at $P < 0.01$) body weight when compared to the control group (29.59 ± 0.75 U/L). The unconjugated bilirubin level of the group treated with 2500 mg/kg body weight ($4.50 \pm 0.29 \times 10^{-2}$ mg/dl) was significantly higher at $P < 0.05$ when compared with the control group ($2.25 \pm 0.25 \times 10^{-2}$ mg/dl).

In table 4.26, *Musanga cecropioides* methanol leaf extract significantly increased the total bilirubin in the groups treated with 500 mg/kg ($9.25 \pm 0.48 \times 10^{-2}$ mg/dl significantly higher at $P < 0.05$) and 1000 mg/kg ($10.25 \pm 1.25 \times 10^{-2}$ mg/dl significantly higher at $P < 0.01$) body weight when compared to the control ($5.50 \pm 0.65 \times 10^{-2}$ mg/dl). Unconjugated bilirubin was also significantly increased at $P < 0.01$ in the groups treated with 500 mg/kg ($5.00 \pm 0.00 \times 10^{-2}$ mg/dl) and 1000 mg/kg ($5.00 \pm 0.71 \times 10^{-2}$ mg/dl) body weight when compared with the control ($2.25 \pm 0.25 \times 10^{-2}$ mg/dl). However, total protein was significantly reduced at $P < 0.05$ in the group treated with 1000 mg/kg body weight (11.44 ± 0.45 g/dl) when compared with the control group (15.28 ± 0.78 g/dl).

In table 4.27, *Musanga cecropioides* aqueous root extract significantly increased the Alkaline phosphate level at $P < 0.01$ in the group treated with 2500 mg/kg body weight (21.12 ± 2.34 U/L) when compared with the control group (15.41 ± 0.43 U/L).

In table 4.28, *Musanga cecropioides* methanol root extract significantly reduced Alanine aminotransferase level at $P < 0.05$ in the group treated with 1000 mg/kg body weight (25.87 ± 1.27 U/L) when compared with the control group (29.59 ± 0.75 U/L). Aspartate aminotransferase level was significantly reduced at $P < 0.05$ in the group treated with 500 mg/kg body weight (43.52 ± 0.21 U/L) when compared with the control group (48.21 ± 0.48 U/L). Total protein level was also significantly reduced at $P < 0.05$ in the group treated with 1000 mg/kg body weight (11.90 ± 0.68 g/dl) when compared with the control group (15.28 ± 0.78 g/dl). However alkaline phosphate level was significantly increased at $P < 0.001$, $P < 0.01$ and $P < 0.05$ in the groups treated with 500 (25.23 ± 0.55 U/L), 1000 (21.04 ± 0.99 U/L) and 2500 (20.40 ± 0.74 U/L) mg/kg body weight respectively, when compared with the control group (15.41 ± 0.43 U/L).

In table 4.29, *Musanga cecropioides* crude root sap did not significantly alter any of the liver function parameters when compared to the control group.

Table 4.25: Effect of aqueous extract of *Musanga cecropioides* leaves on the liver function parameters of rats in 28 days sub-acute toxicity study

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB $\times 10^{-2}$ (mg/dl)	CB $\times 10^{-2}$ (mg/dl)	UB $\times 10^{-2}$ (mg/dl)	TP (g/dl)
Control I ml/kg DW	29.59 $\pm$ 0.75	48.21 $\pm$ 0.48	15.41 $\pm$ 0.43	0.61 $\pm$ 0.01	5.50 $\pm$ 0.65	3.25 $\pm$ 0.48	2.25 $\pm$ 0.25	15.28 $\pm$ 0.78
MCL Aq 500 mg/kg	23.80 $\pm$ 0.63***	47.20 $\pm$ 1.00	15.63 $\pm$ 0.81	0.58 $\pm$ 0.05	7.75 $\pm$ 1.03	4.00 $\pm$ 0.41	3.75 $\pm$ 0.85	12.95 $\pm$ 1.08
MCL Aq 1000 mg/kg	23.79 $\pm$ 0.51***	46.93 $\pm$ 0.80	15.60 $\pm$ 0.80	0.57 $\pm$ 0.06	7.75 $\pm$ 1.65	3.75 $\pm$ 1.03	3.75 $\pm$ 1.03	13.55 $\pm$ 0.81
MCL Aq 2500 mg/kg	25.06 $\pm$ 0.90**	47.57 $\pm$ 0.60	17.12 $\pm$ 1.04	0.63 $\pm$ 0.06	7.75 $\pm$ 0.48	3.25 $\pm$ 0.63	4.50 $\pm$ 0.29*	12.45 $\pm$ 1.05

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group

Table 4.26: Effect of methanol extract of *Musanga cecropioides* leaves on the liver function parameters of rats in 28 days sub-acute toxicity study

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB $\times 10^{-2}$ (mg/dl)	CB $\times 10^{-2}$ (mg/dl)	UB $\times 10^{-2}$ (mg/dl)	TP (g/dl)
Control 1 ml/kg DW	29.59 $\pm$ 0.75	48.21 $\pm$ 0.48	15.41 $\pm$ 0.43	0.61 $\pm$ 0.01	5.50 $\pm$ 0.65	3.25 $\pm$ 0.48	2.25 $\pm$ 0.25	15.28 $\pm$ 0.78
MCL Meth 500 mg/kg	26.89 $\pm$ 0.19	45.19 $\pm$ 0.78	17.92 $\pm$ 0.19	0.72 $\pm$ 0.01	9.25 $\pm$ 0.48*	4.25 $\pm$ 0.48	5.00 $\pm$ 0.00**	12.95 $\pm$ 0.58
MCL Meth 1000 mg/kg	28.23 $\pm$ 0.80	48.10 $\pm$ 1.67	19.11 $\pm$ 0.47	0.72 $\pm$ 0.02	10.25 $\pm$ 1.25**	5.25 $\pm$ 0.75	5.00 $\pm$ 0.71**	11.44 $\pm$ 0.45*
MCL Meth 2500 mg/kg	29.72 $\pm$ 0.19	47.11 $\pm$ 2.12	18.56 $\pm$ 0.43	0.74 $\pm$ 0.01	8.25 $\pm$ 1.03	4.50 $\pm$ 0.96	3.75 $\pm$ 0.25	13.49 $\pm$ 0.64

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$, when compared to control group

Table 4.27: Effect of aqueous extract of *Musanga cecropioides* root on the liver function parameters of rats in 28 days sub-acute toxicity study

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB $\times 10^{-2}$ (mg/dl)	CB $\times 10^{-2}$ (mg/dl)	UB $\times 10^{-2}$ (mg/dl)	TP (g/dl)
Control 1 ml/kg DW	29.59 $\pm$ 0.75	48.21 $\pm$ 0.48	15.41 $\pm$ 0.43	0.61 $\pm$ 0.01	5.50 $\pm$ 0.65	3.25 $\pm$ 0.48	2.25 $\pm$ 0.25	15.28 $\pm$ 0.78
MCR Aq 500 mg/kg	29.56 $\pm$ 0.90	46.57 $\pm$ 0.89	17.81 $\pm$ 1.29	0.56 $\pm$ 0.04	7.25 $\pm$ 0.48	3.75 $\pm$ 0.25	3.50 $\pm$ 0.50	13.92 $\pm$ 0.23
MCR Aq 1000 mg/kg	29.01 $\pm$ 1.54	46.31 $\pm$ 1.36	18.78 $\pm$ 1.81	0.59 $\pm$ 0.05	6.50 $\pm$ 1.04	3.50 $\pm$ 0.65	3.00 $\pm$ 0.41	12.69 $\pm$ 0.75
MCR Aq 2500 mg/kg	27.41 $\pm$ 1.22	44.95 $\pm$ 1.24	21.12 $\pm$ 2.34**	0.54 $\pm$ 0.05	6.25 $\pm$ 0.63	3.25 $\pm$ 0.25	3.00 $\pm$ 0.41	12.07 $\pm$ 0.60

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=4$

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; ** significant values at $P < 0.01$, when compared to control group

Table 4.28: Effect of methanol extract of *Musanga cecropioides* root on the liver function parameters of rats in 28 days sub-acute toxicity study

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB $\times 10^{-2}$ (mg/dl)	CB $\times 10^{-2}$ (mg/dl)	UB $\times 10^{-2}$ (mg/dl)	TP (g/dl)
Control 1 ml/kg DW	29.59 $\pm$ 0.75	48.21 $\pm$ 0.48	15.41 $\pm$ 0.43	0.61 $\pm$ 0.01	5.50 $\pm$ 0.65	3.25 $\pm$ 0.48	2.25 $\pm$ 0.25	15.28 $\pm$ 0.78
MCR Meth 500 mg/kg	27.07 $\pm$ 0.64	43.52 $\pm$ 0.21*	25.23 $\pm$ 0.55***	0.59 $\pm$ 0.13	4.50 $\pm$ 0.50	2.00 $\pm$ 0.00	2.50 $\pm$ 0.50	13.17 $\pm$ 0.75
MCR Meth 1000 mg/kg	25.87 $\pm$ 1.27*	45.84 $\pm$ 1.17	21.04 $\pm$ 0.99**	0.52 $\pm$ 0.03	4.25 $\pm$ 0.63	2.00 $\pm$ 0.41	2.25 $\pm$ 0.25	11.90 $\pm$ 0.68*
MCR Meth 2500 mg/kg	27.45 $\pm$ 0.36	45.74 $\pm$ 1.22	20.40 $\pm$ 0.74*	0.52 $\pm$ 0.03	4.25 $\pm$ 0.48	2.00 $\pm$ 0.00	2.25 $\pm$ 0.48	12.59 $\pm$ 0.92

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=4$

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group

Table 4.29: Effect of *Musanga cecropioides* crude root sap on the liver function parameters of rats in 28 days sub-acute toxicity study

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB $\times 10^{-2}$ (mg/dl)	CB $\times 10^{-2}$ (mg/dl)	UB $\times 10^{-2}$ (mg/dl)	TP (g/dl)
Control 1 ml/kg DW	29.59 $\pm$ 0.75	48.21 $\pm$ 0.48	15.41 $\pm$ 0.43	0.61 $\pm$ 0.01	5.50 $\pm$ 0.65	3.25 $\pm$ 0.48	2.25 $\pm$ 0.25	15.28 $\pm$ 0.78
MCCRS 5 ml/kg	29.61 $\pm$ 0.63	48.56 $\pm$ 0.62	17.33 $\pm$ 1.07	0.68 $\pm$ 0.04	5.25 $\pm$ 0.95	2.75 $\pm$ 0.48	2.50 $\pm$ 0.50	12.67 $\pm$ 1.31
MCCRS 10 ml/kg	30.32 $\pm$ 0.41	47.42 $\pm$ 0.20	17.40 $\pm$ 0.41	0.66 $\pm$ 0.03	5.25 $\pm$ 0.48	2.75 $\pm$ 0.48	2.50 $\pm$ 0.29	13.32 $\pm$ 0.84
MCCRS 25 ml/kg	30.58 $\pm$ 0.43	47.99 $\pm$ 0.34	16.76 $\pm$ 0.80	0.65 $\pm$ 0.04	6.00 $\pm$ 0.82	3.75 $\pm$ 0.63	2.25 $\pm$ 0.25	13.25 $\pm$ 0.56

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; no significant difference when groups were compared to control group

4.2.2.5 Renal Function

Tables 4.30, 4.31, 4.32, 4.33 and 4.34 show results on the renal function tests of animals treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap in the 28 days sub-acute toxicity assessment respectively.

In Table 4.30 only the group treated with *Musanga cecropioides* aqueous leaf extract at 2500 mg/kg dose show significantly higher ($P < 0.05$) Sodium level (106.6 ± 1.39 mmol/L) when compared to the control group (99.49 ± 0.48 mmol/L).

In Table 4.31, the renal function parameters of the groups treated with *Musanga cecropioides* methanol leaf extract (at 500, 1000 and 2500 mg/kg body weight) were not significantly different from the control group.

In Table 4.32, *Musanga cecropioides* aqueous root extract significantly increased ($P < 0.05$) the urea concentration in the groups treated with 500 (31.95 ± 1.85 mg/dl), 1000 (31.39 ± 2.89 mg/dl) and 2500 (32.30 ± 2.25 mg/dl) mg/kg when compared to the control group (25.24 ± 0.75 mg/dl). Creatinine and sodium levels were also significantly increased ($P < 0.01$) in the group treated with 500 mg/kg body weight (0.46 ± 0.03 mg/dl and 108.5 ± 3.21 mmol/L respectively) when compared with the control group (0.36 ± 0.01 mg/dl and 99.49 ± 0.48 mmol/L respectively). However, potassium concentration was significantly reduced ($P < 0.05$) in the group treated with 2500 mg/kg body weight (21.60 ± 1.77 mmol/L) when compared with the control group (25.80 ± 0.24 mmol/L).

In Table 4.33, *Musanga cecropioides* methanol root extract significantly reduced potassium and bicarbonate levels in all treatment doses (500, 1000 and 2500 mg/kg body weight) at $P < 0.001$ and $P < 0.05$ respectively, when compared to the control

group. Chloride levels were also significantly reduced in the groups treated with 500 and 1000 mg/kg body weight at $P < 0.001$, and the group treated with 2500 mg/kg at $P < 0.01$ when compared to the control group.

In Table 4.34, *Musanga cecropioides* crude root sap at all administered doses (5, 10, 25 ml/kg body weight) did not significantly alter the renal function parameters at $P < 0.05$ when compared with the control group.

Table 4.30: Effect of aqueous extract of *Musanga cecropioides* leaves on the renal function parameters of rats in 28 days sub-acute toxicity study

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Control 1 ml/kg DW	25.24 ± 0.75	0.36 ± 0.01	99.49 ± 0.48	25.80 ± 0.24	65.95 ± 0.47	13.05 ± 0.67
MCL Aq 500 mg/kg	26.80 ± 1.09	0.38 ± 0.01	104.3 ± 2.93	26.80 ± 0.44	73.02 ± 1.00	12.50 ± 1.04
MCL Aq 1000 mg/kg	27.83 ± 1.22	0.36 ± 0.01	101.6 ± 1.64	25.28 ± 0.38	72.43 ± 1.30	13.31 ± 1.43
MCL Aq 2500 mg/kg	29.18 ± 0.36	0.37 ± 0.01	106.6 ± 1.39*	26.14 ± 0.63	75.54 ± 0.35	15.10 ± 0.36

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water;

* Significant values at $P < 0.05$, when compared to control group

Table 4.31: Effect of methanol extract of *Musanga cecropioides* leaves on the renal function parameters of rats in 28 days sub-acute toxicity study

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Control 1 ml/kg DW	25.24 ± 0.75	0.36 ± 0.01	99.49 ± 0.48	25.80 ± 0.24	65.95 ± 0.47	13.05 ± 0.67
MCL Meth 500 mg/kg	28.32 ± 0.58	0.39 ± 0.02	105.0 ± 0.36	26.63 ± 0.46	76.76 ± 1.13	14.66 ± 0.62
MCL Meth 1000 mg/kg	26.08 ± 0.72	0.41 ± 0.01	103.0 ± 0.62	24.87 ± 0.17	72.43 ± 1.37	15.21 ± 0.73
MCL Meth 2500 mg/kg	25.44 ± 1.34	0.40 ± 0.01	104.0 ± 0.90	25.67 ± 0.72	72.50 ± 1.66	14.21 ± 0.16

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water;

No Significant difference in various groups when compared to control group.

Table 4.32: Effect of aqueous extract of *Musanga cecropioides* root on the renal function parameters of rats in 28 days sub-acute toxicity study

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Control 1 ml/kg DW	25.24 ± 0.75	0.36 ± 0.01	99.49 ± 0.48	25.80 ± 0.24	65.95 ± 0.47	13.05 ± 0.67
MCR Aq 500 mg/kg	31.95 ± 1.85*	0.46 ± 0.03**	108.5 ± 3.21**	22.73 ± 1.24	66.85 ± 2.13	10.58 ± 0.12
MCR Aq 1000 mg/kg	31.39 ± 2.89*	0.41 ± 0.03	102.1 ± 2.08	23.64 ± 1.67	67.71 ± 3.69	10.60 ± 0.09
MCR Aq 2500 mg/kg	32.30 ± 2.25*	0.42 ± 0.02	102.5 ± 1.44	21.60 ± 1.77*	62.54 ± 3.80	10.55 ± 0.12

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water;

* Significant values at $P < 0.05$; ** Significant values at $P < 0.01$, when compared to control group

Table 4.33: Effect of methanol extract of *Musanga cecropioides* root on the renal function parameters of rats in 28 days sub-acute toxicity study

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Control 1 ml/kg DW	25.24 ± 0.75	0.36 ± 0.01	99.49 ± 0.48	25.80 ± 0.24	65.95 ± 0.47	13.05 ± 0.67
MCR Meth 500 mg/kg	26.87 ± 3.21	0.35 ± 0.02	97.70 ± 2.13	16.84 ± 0.90***	41.35 ± 5.59***	10.20 ± 0.08*
MCR Meth 1000 mg/kg	26.01 ± 0.10	0.36 ± 0.01	98.31 ± 1.33	18.81 ± 0.59***	46.85 ± 6.37***	10.31 ± 0.07*
MCR Meth 2500 mg/kg	26.48 ± 0.48	0.36 ± 0.02	99.28 ± 1.56	18.86 ± 0.95***	48.37 ± 5.85**	10.26 ± 0.07*

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water;

* Significant values at $P < 0.05$; ** Significant values at $P < 0.01$; *** Significant values at $P < 0.001$, when compared to control group

Table 4.34: Effect of *Musanga cecropioides* crude root sap on the renal function parameters of rats in 28 days sub-acute toxicity study

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Control 1 ml/kg DW	25.24 ± 0.75	0.36 ± 0.01	99.49 ± 0.48	25.80 ± 0.24	65.95 ± 0.47	13.05 ± 0.67
MCCRS 5 ml/kg	25.71 ± 0.41	0.37 ± 0.01	100.5 ± 0.51	25.50 ± 0.43	68.04 ± 0.89	13.30 ± 0.61
MCCRS 10 ml/kg	25.41 ± 0.53	0.37 ± 0.01	101.0 ± 0.87	26.27 ± 0.96	69.16 ± 0.65	12.78 ± 0.73
MCCRS 25 ml/kg	25.83 ± 0.64	0.38 ± 0.01	101.5 ± 0.40	27.11 ± 0.53	69.41 ± 0.99	13.04 ± 0.68

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water;

No Significant difference in various groups when compared to control group.

4.2.2.6 Lipid Profile

Tables 4.35, 4.36, 4.37, 4.38 and 4.39 show results on the lipid profile of animals treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap in the 28 days sub-acute toxicity assessment respectively.

In Table 4.35, *Musanga cecropioides* aqueous leaf extract significantly reduced (at $P < 0.001$) the high density lipoprotein in all treatment groups (500 mg/kg at 14.93 ± 0.67 mg/dl, 1000 mg/kg at 14.93 ± 0.67 mg/dl and 2500 mg/kg at 16.00 ± 0.75 mg/kg) when compared to the control group (23.25 ± 0.48 mg/dl). All other parameters were not significantly different from the control group.

In Table 4.36, *Musanga cecropioides* methanol leaf extract significantly reduced (at $P < 0.001$) the high density lipoprotein in all treatment groups (500 mg/kg at 17.56 ± 0.34 mg/dl, 1000 mg/kg at 18.22 ± 0.50 mg/dl and 2500 mg/kg at 18.12 ± 0.81 mg/kg) when compared to the control group (23.25 ± 0.48 mg/dl). All other parameters were not significantly different from the control group.

In Table 4.37, *Musanga cecropioides* aqueous root extract also significantly reduced (at $P < 0.001$) the high density lipoprotein in all treatment groups. Low density lipoprotein levels were also significantly reduced at $P < 0.001$ in the groups treated with 500 mg/kg (15.85 ± 0.40 mg/dl) and 2500 mg/kg (17.89 ± 5.34 mg/dl) and $P < 0.01$ in the group treated with 1000 mg/kg (23.80 ± 6.29 mg/dl) body weight when compared with the control group (38.88 ± 0.99 mg/dl). However, total cholesterol level was significantly increased at $P < 0.001$ and $P < 0.05$ in the groups treated with 1000 mg/kg (79.94 ± 7.62 mg/dl) and 2500 mg/kg (71.93 ± 7.45 mg/dl) body weight respectively, when compared to the control group (59.15 ± 0.60 mg/dl).

In Table 4.38, *Musanga cecropioides* methanol root extract significantly reduced (at $P < 0.001$) the high density lipoprotein and low density lipoprotein levels in all treatment groups. However, total cholesterol level was significantly increased at $P < 0.001$ and $P < 0.01$ in the groups treated with 1000 mg/kg (78.14 ± 2.70 mg/dl) and 2500 mg/kg (76.85 ± 3.08 mg/dl) body weight respectively, when compared to the control group (59.15 ± 0.60 mg/dl).

In Table 4.39, *Musanga cecropioides* crude root sap did not significantly alter lipid profile parameters, only the high density lipoprotein was significantly reduced at $P < 0.05$ in group treated with 5 ml/kg body weight (20.24 ± 0.62 mg/dl) when compared to the control group (23.25 ± 0.48 mg/dl).

Table 4.35: Effect of aqueous extract of *Musanga cecropioides* leaves on the lipid profile parameters of rats in 28 days sub-acute toxicity study

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Control 1 ml/kg DW	59.15 ± 0.60	217.6 ± 0.47	23.25 ± 0.48	38.88 ± 0.99	43.52 ± 0.09
MCL Aq 500 mg/kg	70.52 ± 2.34	208.7 ± 2.89	14.93 ± 0.67***	43.71 ± 2.19	41.49 ± 0.55
MCL Aq 1000 mg/kg	67.64 ± 0.98	204.5 ± 3.87	15.12 ± 0.68***	41.86 ± 1.09	40.92 ± 0.77
MCL Aq 2500 mg/kg	67.56 ± 1.38	208.3 ± 3.59	16.00 ± 0.75***	41.89 ± 1.37	41.66 ± 0.72

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; *** significant values at $P < 0.001$, when compared to control group

Table 4.36: Effect of methanol extract of *Musanga cecropioides* leaves on the lipid profile parameters of rats in 28 days sub-acute toxicity study

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Control 1 ml/kg DW	59.15 ± 0.60	217.6 ± 0.47	23.25 ± 0.48	38.88 ± 0.99	43.52 ± 0.09
MCL Meth 500 mg/kg	65.18 ± 0.20	215.6 ± 0.65	17.56 ± 0.34***	39.61 ± 0.30	43.12 ± 0.13
MCL Meth 1000 mg/kg	63.52 ± 0.83	215.7 ± 1.07	18.22 ± 0.50***	38.60 ± 0.60	43.14 ± 0.21
MCL Meth 2500 mg/kg	62.34 ± 0.79	215.5 ± 1.43	18.12 ± 0.81***	37.36 ± 1.20	43.09 ± 0.29

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; *** significant values at $P < 0.001$, when compared to control group

Table 4.37: Effect of aqueous extract of *Musanga cecropioides* root on the lipid profile parameters of rats in 28 days sub-acute toxicity study

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Control 1 ml/kg DW	59.15 ± 0.60	217.6 ± 0.47	23.25 ± 0.48	38.88 ± 0.99	43.52 ± 0.09
MCR Aq 500 mg/kg	67.92 ± 0.67	204.1 ± 4.90	11.25 ± 0.18***	15.85 ± 0.40***	40.82 ± 0.98
MCR Aq 1000 mg/kg	79.94 ± 7.62***	224.2 ± 9.15	11.30 ± 0.45***	23.80 ± 6.29**	44.85 ± 1.83
MCR Aq 2500 mg/kg	71.93 ± 7.45*	211.8 ± 13.29	11.67 ± 0.58***	17.89 ± 5.34***	42.36 ± 2.66

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group

Table 4.38: Effect of methanol extract of *Musanga cecropioides* root on the lipid profile parameters of rats in 28 days sub-acute toxicity study

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Control 1 ml/kg DW	59.15 ± 0.60	217.6 ± 0.47	23.25 ± 0.48	38.88 ± 0.99	43.52 ± 0.09
MCR Meth 500 mg/kg	65.11 ± 1.94	205.1 ± 7.23	15.56 ± 0.83***	13.54 ± 1.04***	41.01 ± 1.45
MCR Meth 1000 mg/kg	78.14 ± 2.70***	217.4 ± 4.39	14.93 ± 1.05***	19.74 ± 3.16***	43.48 ± 0.88
MCR Meth 2500 mg/kg	76.85 ± 3.08**	208.9 ± 2.01	14.50 ± 0.62***	20.59 ± 3.74***	41.76 ± 0.41

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group

Table 4.39: Effect of *Musanga cecropioides* crude root sap on the lipid profile parameters of rats in 28 days sub-acute toxicity study

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Control 1 ml/kg DW	59.15 ± 0.60	217.6 ± 0.47	23.25 ± 0.48	38.88 ± 0.99	43.52 ± 0.09
MCCRS 5 ml/kg	61.92 ± 1.63	217.4 ± 1.43	20.24 ± 0.62*	38.67 ± 1.67	43.49 ± 0.29
MCCRS 10 ml/kg	59.47 ± 1.04	214.6 ± 1.12	21.23 ± 0.46	37.77 ± 1.10	42.92 ± 0.22
MCCRS 25 ml/kg	59.83 ± 0.50	214.5 ± 1.20	20.94 ± 0.77	37.86 ± 0.58	42.90 ± 0.24

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; * Significant values at $P < 0.05$, when compared to control group

4.2.2.7 Plasma Antioxidant

Tables 4.40, 4.41, 4.42, 4.43 and 4.44 show results on the plasma antioxidant concentration of animals treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap in the 28 days sub-acute toxicity assessment respectively.

In Table 4.40, *Musanga cecropioides* aqueous leaf extract significantly reduced the Malondialdehyde and Glutathione reductase concentrations at $P < 0.05$ and $P < 0.01$ in the groups treated with 500 mg/kg (24.81 ± 0.61 mmole/ml) and 2500 mg/kg (1.63 ± 0.10 U/ml), when compared with the control group at 36.12 ± 0.83 mmole/ml and 2.92 ± 0.04 U/ml, respectively.

In Table 4.41, *Musanga cecropioides* methanol leaf extract caused a dose dependent reduction in the Superoxide dismutase and catalase levels in the groups treated with 500 (5.27 ± 0.42 and 213.3 ± 1.79 U/ml at $P < 0.05$), 1000 (5.26 ± 0.07 and 209.7 ± 5.52 U/ml at $P < 0.05$ and 0.01 respectively) and 2500 mg/kg (4.49 ± 0.15 and 202.2 ± 3.22 U/ml at $P < 0.01$ and 0.001 respectively) body weight when compared to the control group (7.66 ± 0.21 and 255.3 ± 1.04 U/ml) respectively. Glutathione peroxidase level was significantly reduced at $P < 0.01$ in the group treated with 500 mg/kg body weight (127.8 ± 6.18 U/ml) when compared to the control group (150.3 ± 0.86 U/ml). Glutathione reductase levels were also significantly reduced in the groups treated with 500 mg/kg (1.52 ± 0.03 U/ml) at $P < 0.001$ and 2500 mg/kg (1.99 ± 0.17 U/ml) body weight at $P < 0.05$ when compared to the control group (2.92 ± 0.04 U/ml).

In Table 4.42, *Musanga cecropioides* aqueous root extract significantly increased the malondialdehyde concentration at $P < 0.05$ in the group treated with 500 mg/kg body

weight (46.43 ± 1.87 mmole/ml) when compared to the control group (36.12 ± 0.83 mmole/ml). Superoxide dismutase concentration was significantly reduced in the groups treated with 500 (at $P < 0.01$), 1000 (at $P < 0.05$) and 2500 (at $P < 0.01$) mg/kg and catalase was also significantly reduced in all the treatment groups at $P < 0.001$. Glutathione peroxidase was also significantly reduced at $P < 0.001$ in the groups treated with 500 (113.3 ± 5.75 U/ml) and 1000 (115.1 ± 5.74 U/ml) mg/kg and $P < 0.01$ in the group treated with 2500 (128.1 ± 2.66 U/ml) mg/kg body weight when compared to the control group (150.3 ± 0.86 U/ml).

In Table 4.43, *Musanga cecropioides* methanol root extract at the dose of 500 mg/kg body weight significantly reduced malondialdehyde, superoxide dismutase, catalase and glutathione peroxidase levels at $P < 0.05$, 0.05, 0.001 and 0.05 respectively. At 1000 and 2500 mg/kg body weight, catalase and glutathione peroxidase levels were significantly reduced at $P < 0.001$.

In Table 4.44, *Musanga cecropioides* crude root sap significantly reduced the Superoxide dismutase concentration at $P < 0.01$ in the group treated with 10 ml/kg body weight (4.48 ± 0.46 U/ml) when compared with the control group (7.66 ± 0.21 U/ml). Glutathione peroxidase concentration was also significantly reduced at $P < 0.05$ in the group treated with 25 ml/kg body weight (131.8 ± 1.39 U/ml) when compared with the control group (150.3 ± 0.86 U/ml).

Table 4.40: Effect of aqueous extract of *Musanga cecropioides* leaves on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Control 1 ml/kg DW	36.12 ± 0.83	7.66 ± 0.21	255.3 ± 1.04	150.3 ± 0.86	2.92 ± 0.04
MCL Aq 500 mg/kg	24.81 ± 0.61*	8.31 ± 0.15	231.4 ± 0.72	134.7 ± 2.82	2.11 ± 0.16
MCL Aq 1000 mg/kg	26.11 ± 0.72	8.43 ± 0.28	237.6 ± 5.51	137.0 ± 3.98	2.12 ± 0.41
MCL Aq 2500 mg/kg	27.10 ± 0.75	8.68 ± 0.07	237.2 ± 2.18	141.3 ± 2.09	1.63 ± 0.10**

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$, when compared to control group

Table 4.41: Effect of methanol extract of *Musanga cecropioides* leaves on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Control 1 ml/kg DW	36.12 ± 0.83	7.66 ± 0.21	255.3 ± 1.04	150.3 ± 0.86	2.92 ± 0.04
MCL Meth 500 mg/kg	30.17 ± 1.14	5.27 ± 0.42*	213.3 ± 1.79*	127.8 ± 6.18**	1.52 ± 0.03***
MCL Meth 1000 mg/kg	31.05 ± 0.88	5.26 ± 0.07*	209.7 ± 5.52**	149.0 ± 2.10	1.76 ± 0.19
MCL Meth 2500 mg/kg	32.61 ± 0.85	4.49 ± 0.15**	202.2 ± 3.22***	143.0 ± 7.19	1.99 ± 0.17*

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group

Table 4.42: Effect of aqueous extract of *Musanga cecropioides* root on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Control 1 ml/kg DW	36.12 ± 0.83	7.66 ± 0.21	255.3 ± 1.04	150.3 ± 0.86	2.92 ± 0.04
MCR Aq 500 mg/kg	46.43 ± 1.87*	4.87 ± 0.86**	202.4 ± 14.56***	113.3 ± 5.75***	2.63 ± 0.19
MCR Aq 1000 mg/kg	39.58 ± 6.52	5.43 ± 1.27*	202.4 ± 14.23***	115.1 ± 5.74***	2.77 ± 0.15
MCR Aq 2500 mg/kg	37.72 ± 6.22	4.96 ± 0.35**	186.1 ± 16.61***	128.1 ± 2.66**	2.47 ± 0.18

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group

Table 4.43: Effect of methanol extract of *Musanga cecropioides* root on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Control 1 ml/kg DW	36.12 ± 0.83	7.66 ± 0.21	255.3 ± 1.04	150.3 ± 0.86	2.92 ± 0.04
MCR Meth 500 mg/kg	24.32 ± 0.38*	5.45 ± 0.08*	167.8 ± 4.21***	130.1 ± 0.88*	3.18 ± 0.33
MCR Meth 1000 mg/kg	29.22 ± 1.83	6.87 ± 0.28	156.8 ± 8.15***	118.3 ± 2.91***	2.96 ± 0.08
MCR Meth 2500 mg/kg	27.29 ± 1.35	6.36 ± 0.35	172.6 ± 10.07***	122.3 ± 0.84***	2.56 ± 0.32

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; *** significant values at $P < 0.001$, when compared to control group

Table 4.44: Effect of *Musanga cecropioides* crude root sap on the plasma antioxidant parameters of rats in 28 days sub-acute toxicity study

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Control 1 ml/kg DW	36.12 ± 0.83	7.66 ± 0.21	255.3 ± 1.04	150.3 ± 0.86	2.92 ± 0.04
MCCRS 5 ml/kg	35.78 ± 0.70	5.67 ± 0.94	232.3 ± 7.81	140.8 ± 8.23	2.78 ± 0.35
MCCRS 10 ml/kg	34.46 ± 0.36	4.48 ± 0.46**	250.9 ± 1.85	146.2 ± 5.10	2.38 ± 0.12
MCCRS 25 ml/kg	34.16 ± 1.57	6.12 ± 0.55	236.1 ± 9.68	131.8 ± 1.39*	2.91 ± 0.21

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$, when compared to control group

4.2.2.8 Histology of Vital Organs

4.2.2.8.1 Histology of the Heart

Plates 4.1, 4.2 and 4.3 show photomicrographs of sections of the heart of rats treated with *Musanga cecropioides* leaf extracts, root extracts, and crude root sap after the 28 days sub-acute toxicity assessment respectively. There were no pathological alterations observed in all treatment groups, all myocytes appeared normal.

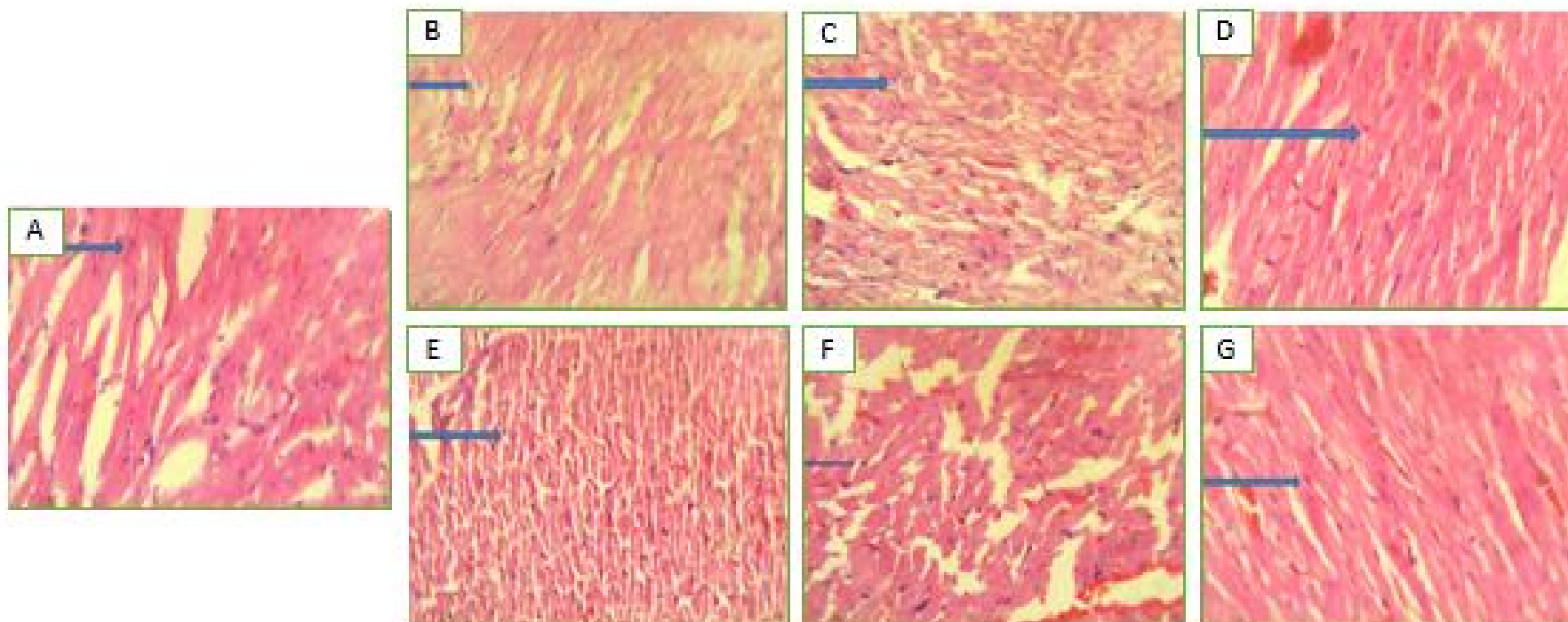


Plate 4.1: Effect of *Musanga cecropioides* leaf extracts on the histology of the heart of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal myocyte; B: MCL Aq (500 mg/kg) shows normal myocyte; C: MCL Aq (1000 mg/kg) shows normal myocyte; D: MCL Aq (2500 mg/kg) shows normal myocyte; E: MCL Meth (500 mg/kg) shows normal myocyte; F: MCL Meth (1000 mg/kg) shows normal myocyte; G: MCL Meth (2500 mg/kg) shows normal myocyte; H and E $\times 400$

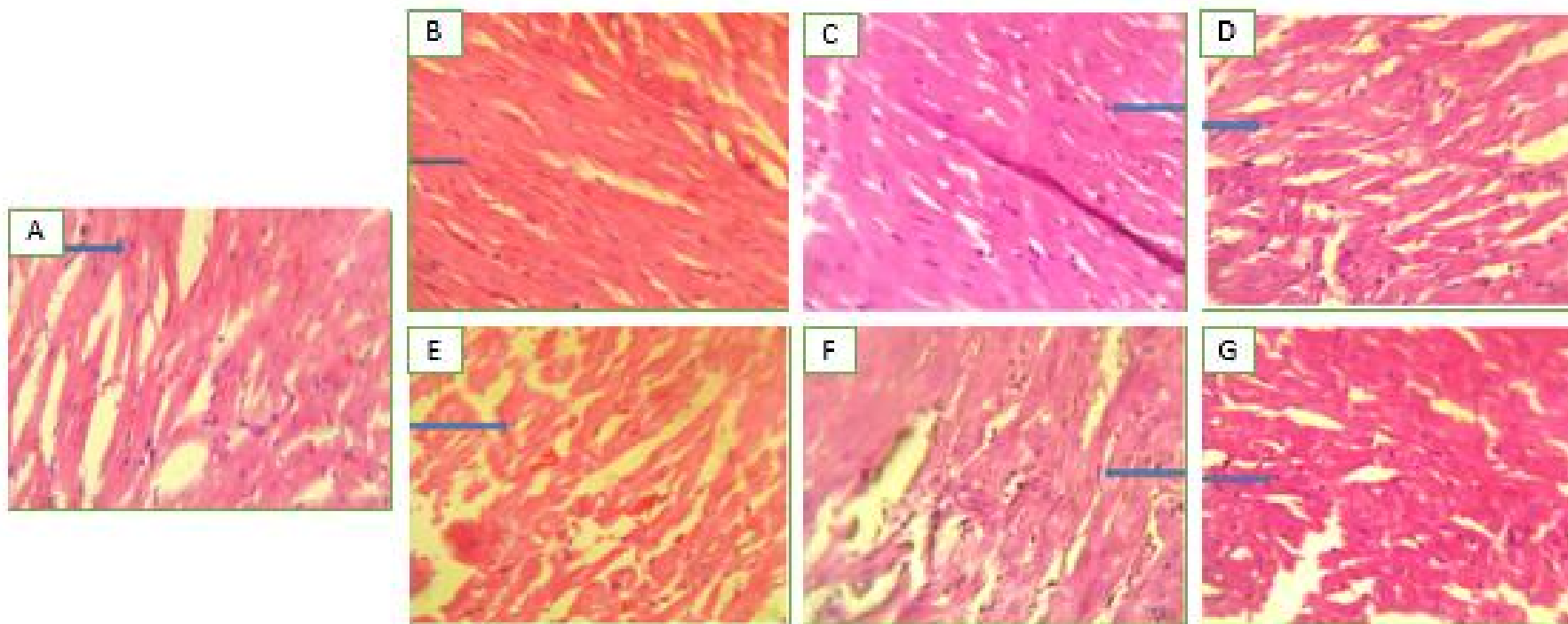


Plate 4.2: Effect of *Musanga cecropioides* root extracts on the histology of the heart of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal myocyte; B: MCR Aq (500 mg/kg) shows normal myocyte; C: MCR Aq (1000 mg/kg) arrow shows normal myocyte; d: MCR Aq (2500 mg/kg) arrow shows normal myocyte; E: MCR Meth (500 mg/kg) arrow shows normal myocyte; F: MCR Meth (1000 mg/kg) arrow shows normal myocyte; G: MCR Meth (2500 mg/kg) arrow shows normal myocyte; H and E $\times 400$

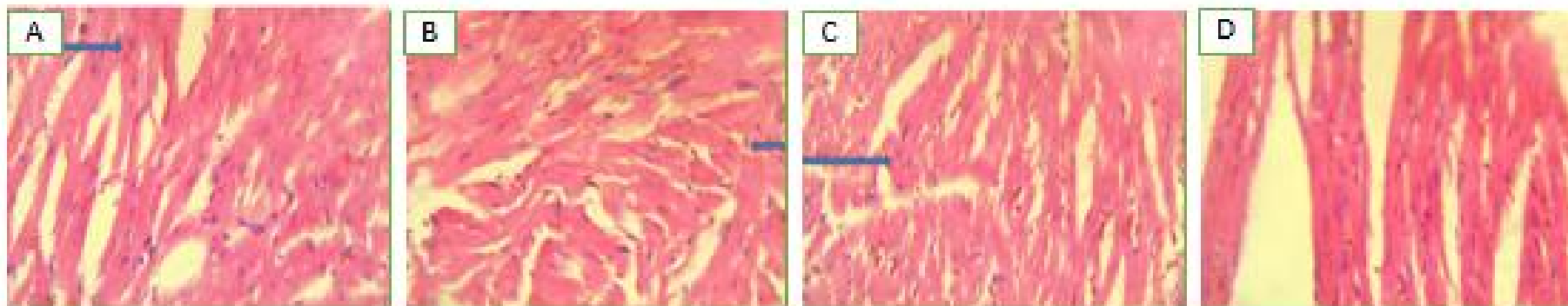


Plate 4.3: Effect of *Musanga cecropioides* crude root sap on the histology of the heart of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal myocyte; B: MCCRS (5 ml/kg) shows normal myocyte; C: MCCRS (10 ml/kg) shows normal myocyte; D: MCCRS (25 ml/kg) shows normal myocyte: H and E $\times 400$

4.2.2.8.2 Histology of the Kidney

Plates 4.4, 4.5 and 4.6 show photomicrographs of sections of the kidney of rats treated with *Musanga cecropioides* leaf extracts, root extracts, and crude root sap after the 28 days sub-acute toxicity assessment respectively. There were no visible signs of pathological alterations observed, all photomicrographs of the various treatments showed normal glomerulus and normal tubules.

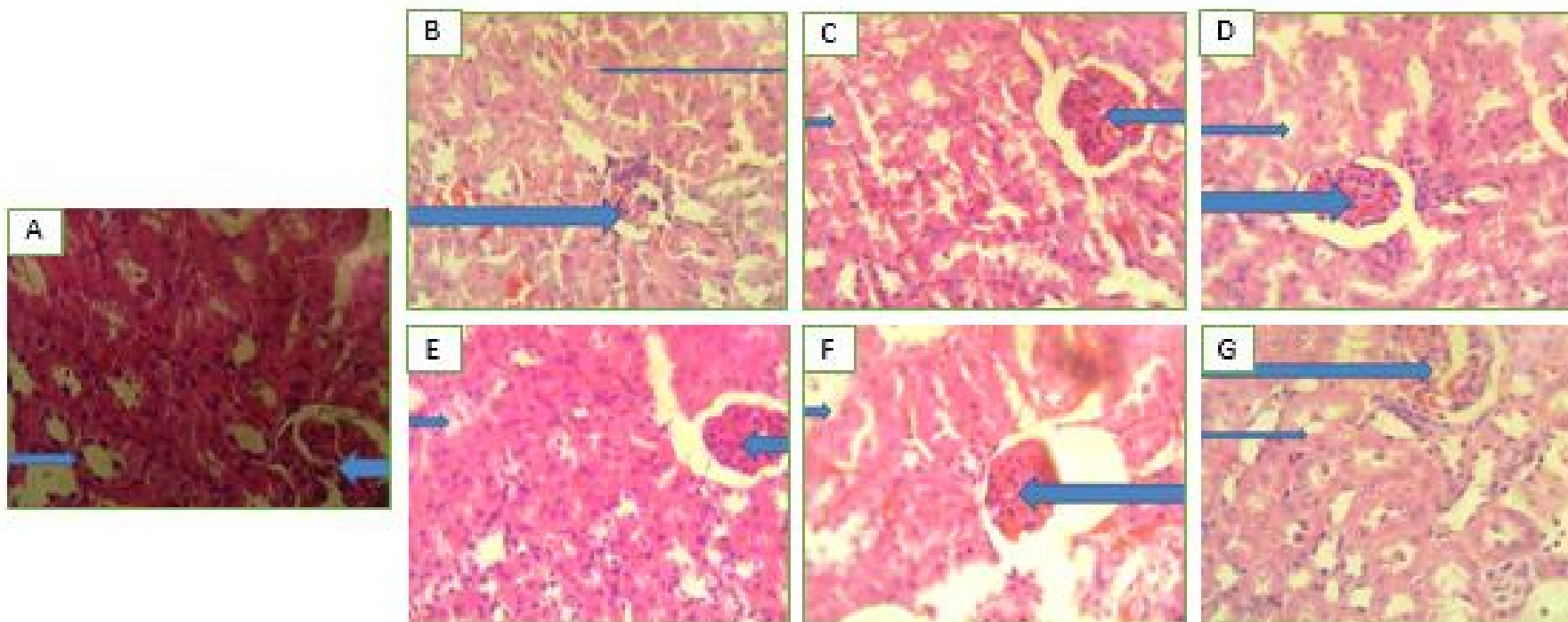


Plate 4.4: Effect of *Musanga cecropioides* leaf extracts on the histology of the kidney of rats in 28 days sub-acute toxicity study.

A: Normal control, thick arrow shows normal glomerulus and thin arrow shows normal tubules; B: MCL Aq (500 mg/kg) normal glomerulus and normal tubules seen; C: MCL Aq (1000 mg/kg) normal glomerulus and normal tubules seen; D: MCL Aq (2500 mg/kg) normal glomerulus and normal tubules seen; E: MCL Meth (500 mg/kg) normal glomerulus and normal tubules seen; F: MCL Meth (1000 mg/kg) normal glomerulus and normal tubules seen; G: MCL Meth (2500 mg/kg) normal glomerulus and normal tubules seen; H and E $\times 400$

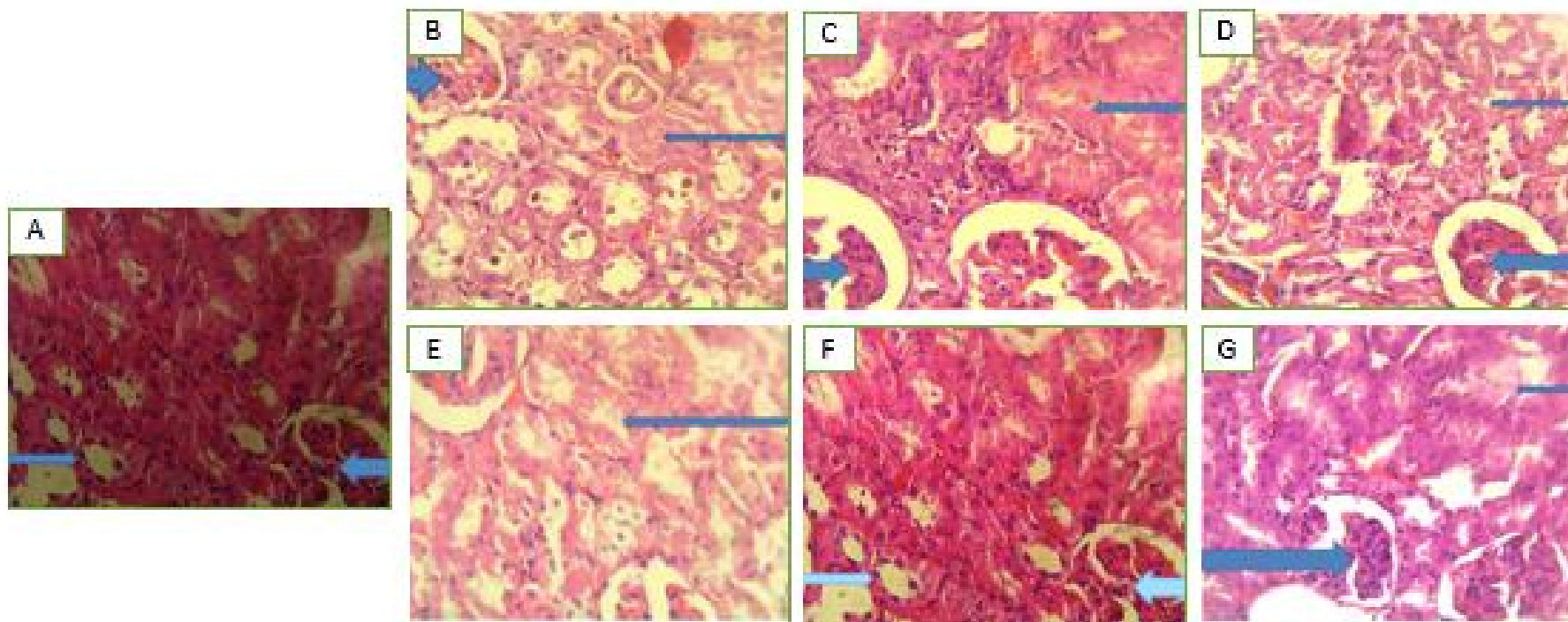


Plate 4.5: Effect of *Musanga cecropioides* root extracts on the histology of the kidney of rats in 28 days sub-acute toxicity study.

A: Normal control, thick arrow shows normal glomerulus and thin arrow shows normal tubules; B: MCR Aq (500 mg/kg) normal glomerulus and normal tubules seen; C: MCR Aq (1000 mg/kg) normal glomerulus and normal tubules seen; D: MCR Aq (2500 mg/kg) normal glomerulus and normal tubules seen; E: MCR Meth (500 mg/kg) normal glomerulus and normal tubules seen; F: MCR Meth (1000 mg/kg) normal glomerulus and normal tubules seen; G: MCR Meth (2500 mg/kg) normal glomerulus and normal tubules seen: H and E $\times 400$

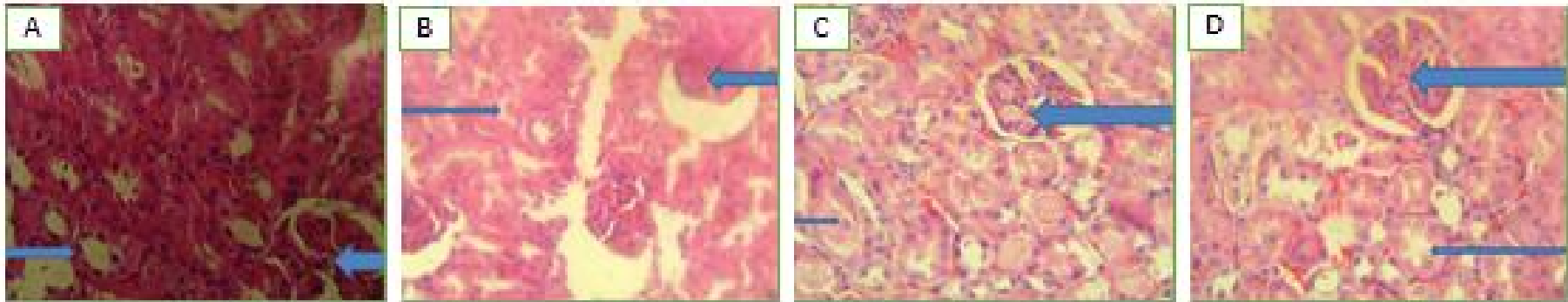


Plate 4.6: Effect of *Musanga cecropioides* crude root sap on the histology of the kidney of rats in 28 days sub-acute toxicity study.

A: Normal control, thick arrow shows normal glomerulus and thin arrow shows normal tubules; B: MCCRS (5 ml/kg) normal glomerulus and normal tubules seen; C: MCCRS (10 ml/kg) normal glomerulus and normal tubules seen; D: MCCRS (25 ml/kg) normal glomerulus and normal tubules seen: H and E $\times 400$

4.2.2.8.3 Histology of the Liver

Plates 4.7, 4.8 and 4.9 show photomicrographs of sections of the liver of rats treated with *Musanga cecropioides* leaf extracts, root extracts, and crude root sap after the 28 days sub-acute toxicity assessment respectively. All treatment groups showed signs of pathological alterations with a few exceptions.

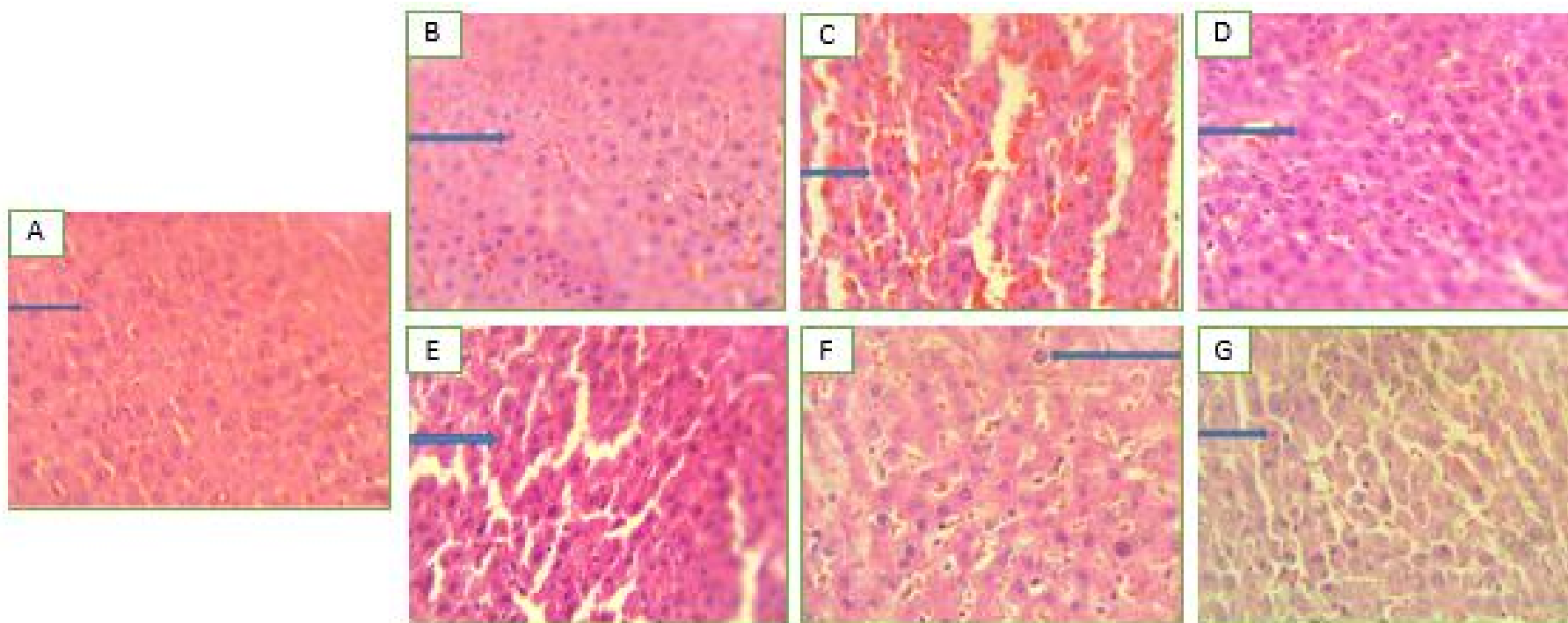


Plate 4.7: Effect of *Musanga cecropioides* leaf extracts on the histology of the liver of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal hepatocyte; B: MCL Aq (500 mg/kg) shows mildly pyknotic nuclei; C: MCL Aq (1000 mg/kg) shows features of congestion in normal hepatocytes; D: MCL Aq (2500 mg/kg) arrow shows karyolysis of hepatocyte nuclei (sign of necrosis); E: MCL Meth (500 mg/kg) shows mildly pyknotic nuclei; F: MCL Meth (1000 mg/kg) arrow shows features of ballooning degeneration; G: MCL Meth (2500 mg/kg) arrow shows pyknotic hepatocyte; : H and E $\times 400$

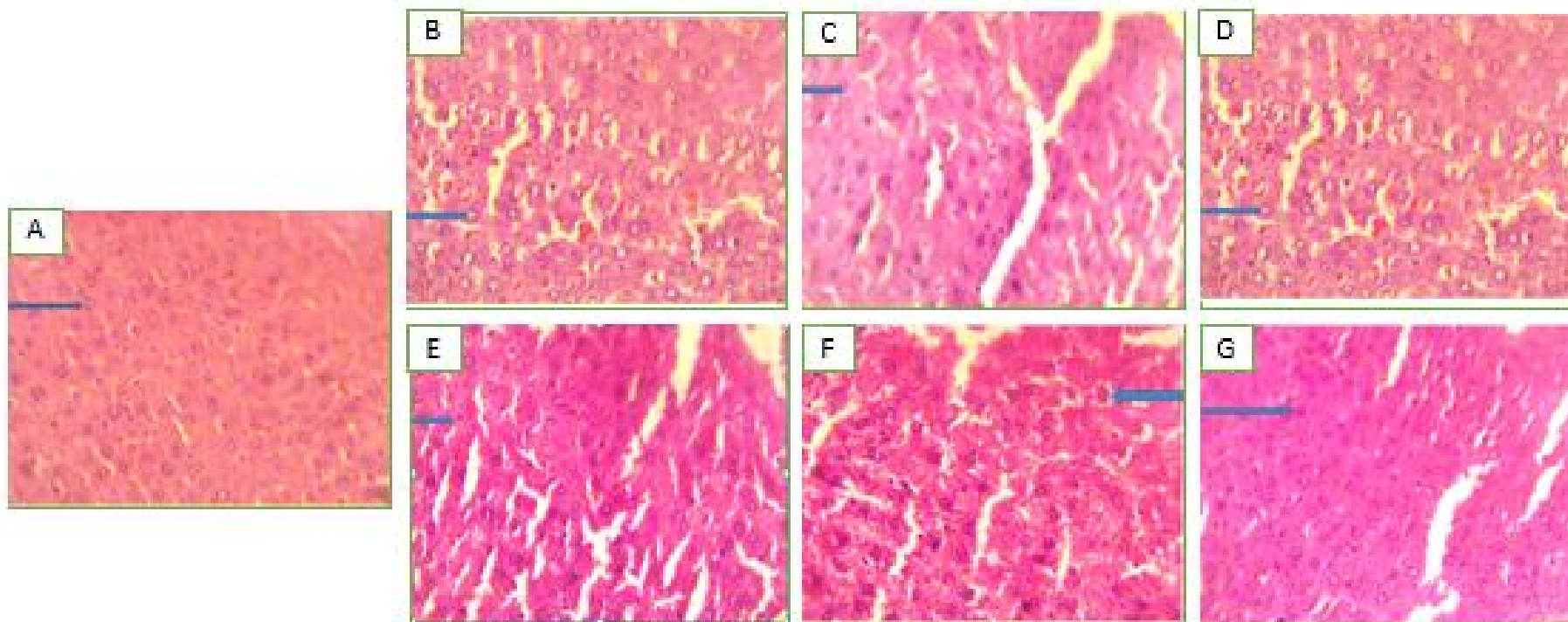


Plate 4.8: Effect of *Musanga cecropioides* root extracts on the histology of the liver of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal hepatocyte; B: MCR Aq (500 mg/kg) shows normal hepatocyte; C: MCR Aq (1000 mg/kg) arrow shows karyolysis of hepatocytes (sign of necrosis); D: MCR Aq (2500 mg/kg) shows normal hepatocyte; E: MCR Meth (500 mg/kg) arrow shows pyknosis of hepatocyte nuclei (sign of necrosis); F: MCR Meth (1000 mg/kg) arrow shows ballooning degeneration of hepatocytes; G: MCR Meth (2500 mg/kg) arrow shows karyolysis of hepatocyte nuclei with hypereosinophilia of cytoplasm (signs of necrosis) : H and E $\times 400$

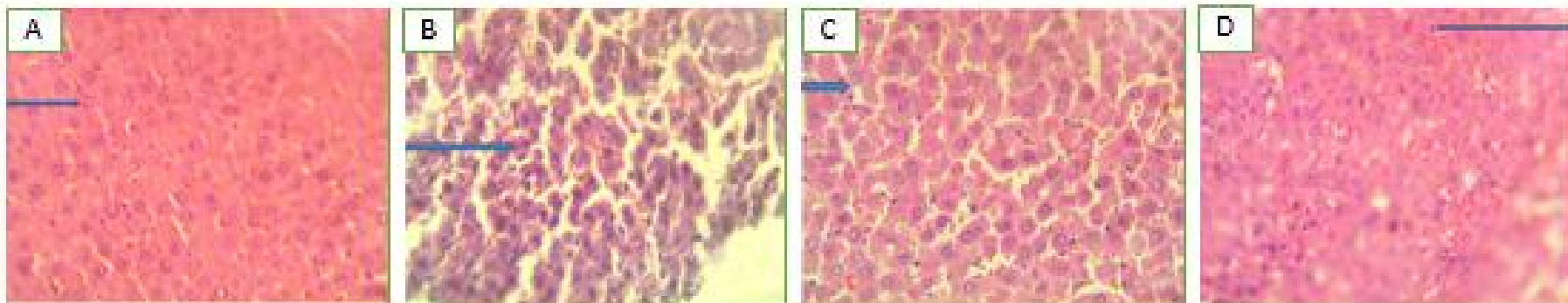


Plate 4.9: Effect of *Musanga cecropioides* crude root sap on the histology of the liver of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal hepatocyte; B: MCCRS (5 ml/kg) arrow shows hepatocyte with pyknotic nuclei (sign of necrosis); C: MCCRS (10 ml/kg) shows normal hepatocyte ; D: MCCRS (25 ml/kg) shows hepatocyte with pyknotic nuclei : H and E $\times 400$

4.2.2.8.4 Histology of the Lungs

Plates 4.10, 4.11 and 4.12 show photomicrographs of sections of the lungs of rats treated with *Musanga cecropioides* leaf extracts, root extracts, and crude root sap after the 28 days sub-acute toxicity assessment respectively. Thickening of the alveoli septae was observed in most treatment groups with a few exceptions.

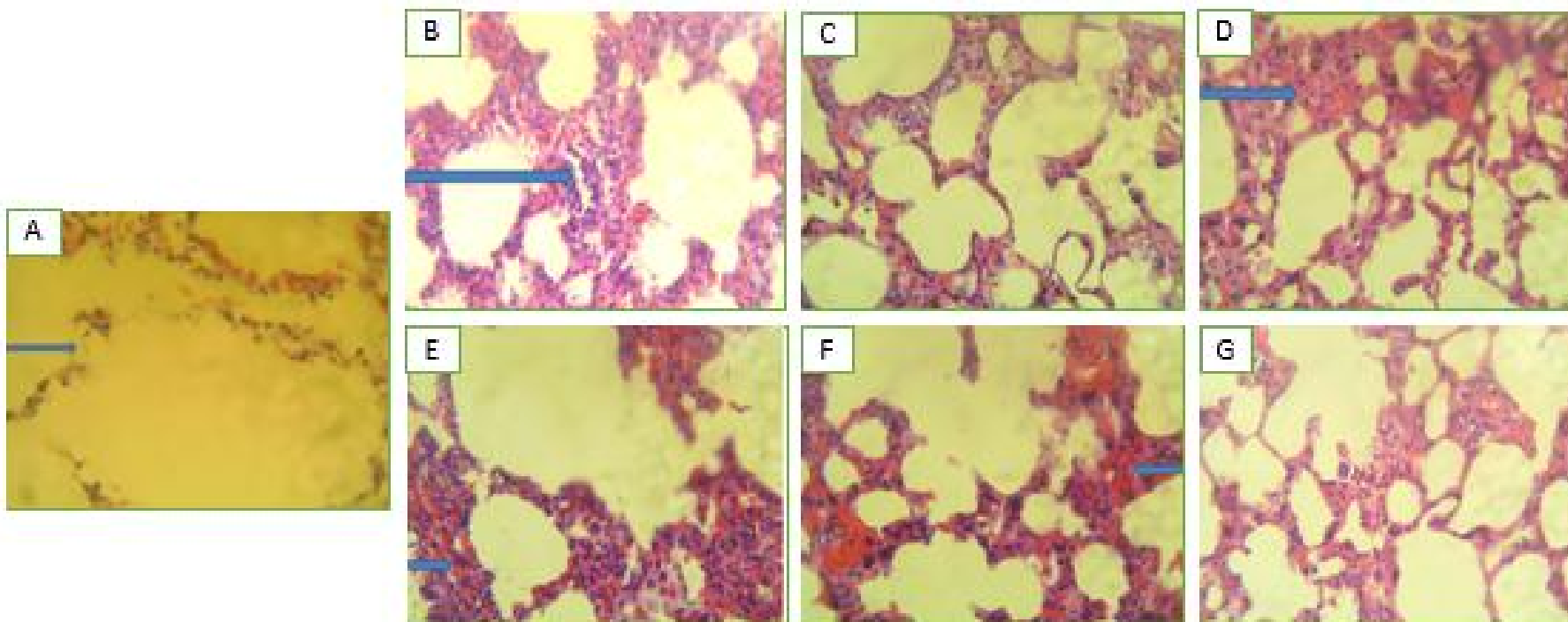


Plate 4.10: Effect of *Musanga cecropioides* leaf extracts on the histology of the lungs of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal alveoli space; B: MCL Aq (500 mg/kg) shows mild thickening of the alveoli septae; C: MCL Aq (1000 mg/kg) appears normal; D: MCL Aq (2500 mg/kg) shows mild thickening of parts of the alveoli septae; E: MCL Meth (500 mg/kg) shows mild thickening of parts of the alveoli septae; F: MCL Meth (1000 mg/kg) shows mild thickening of the alveoli septae; G: MCL Meth (2500 mg/kg) appears normal; : H and E $\times 400$

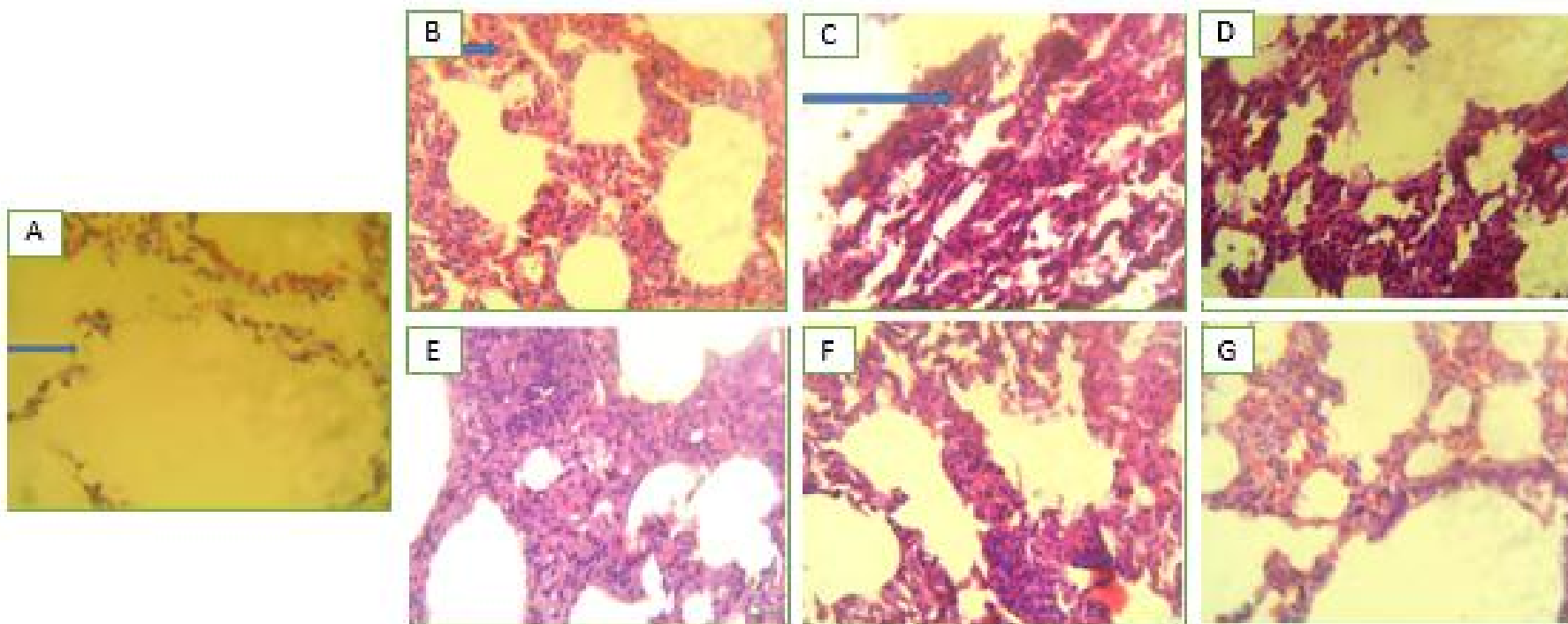


Plate 4.11: Effect of *Musanga cecropioides* root extracts on the histology of the lungs of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal alveoli space; B: MCR Aq (500 mg/kg) shows thickening of the alveoli septae; C: MCR Aq (1000 mg/kg) shows thickening of the alveoli septae and destruction of normal architecture; D: MCR Aq (2500 mg/kg) shows thickening of the alveoli septae and destruction of normal architecture; E: MCR Meth (500 mg/kg) shows thickening of the alveoli septae ; F: MCR Meth (1000 mg/kg) thickening of the alveoli septae and desquamation of alveoli lining (features suggestive of diffuse alveolar damage); G: MCR Meth (2500 mg/kg) shows thickening of the alveoli septae: H and E $\times 400$

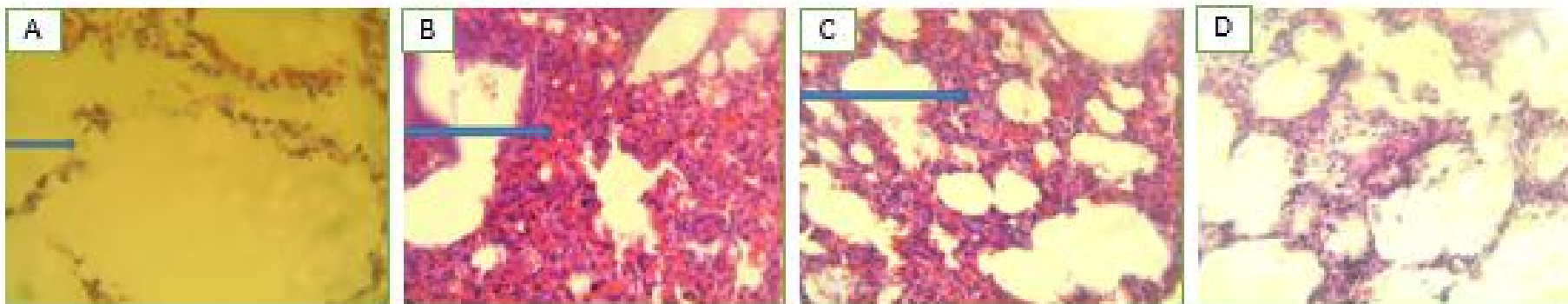


Plate 4.12: Effect of *Musanga cecropioides* crude root sap on the histology of the lungs of rats in 28 days sub-acute toxicity study.

A: Normal control shows normal alveoli space; B: MCCRS (5 ml/kg) shows thickening of the alveoli septae; C: MCCRS (10 ml/kg) shows thickening of the alveoli septae; D: MCCRS (25 ml/kg) appears normal: H and E $\times 400$

4.3 Antioxidant Assessment

4.3.1 DPPH Radical Scavenging Activity

In Figure 4.11, *Musanga cecropioides* aqueous extract showed minimal DPPH radical scavenging activity, however a progression in activity was observed at increasing concentrations with the peak at the highest concentration (100 µg/ml) causing 33.72% inhibition. On the other hand, *Musanga cecropioides* methanol extract showed maximum scavenging activity with its most effective concentration at 60 µg/ml, recording 112.33% inhibition.

Figure 4.12 shows DPPH radical scavenging activity of *Musanga cecropioides* root aqueous and methanol extracts with reference to Ascorbic acid. Both extracts showed less than 50% percentage inhibition, with the aqueous extract showing better activity than the methanol extract.

Figure 4.13 shows DPPH radical scavenging activity of *Musanga cecropioides* crude root sap. Less than 50% percentage inhibition was also observed however a concentration or dose dependent increase in percentage inhibition was observed.

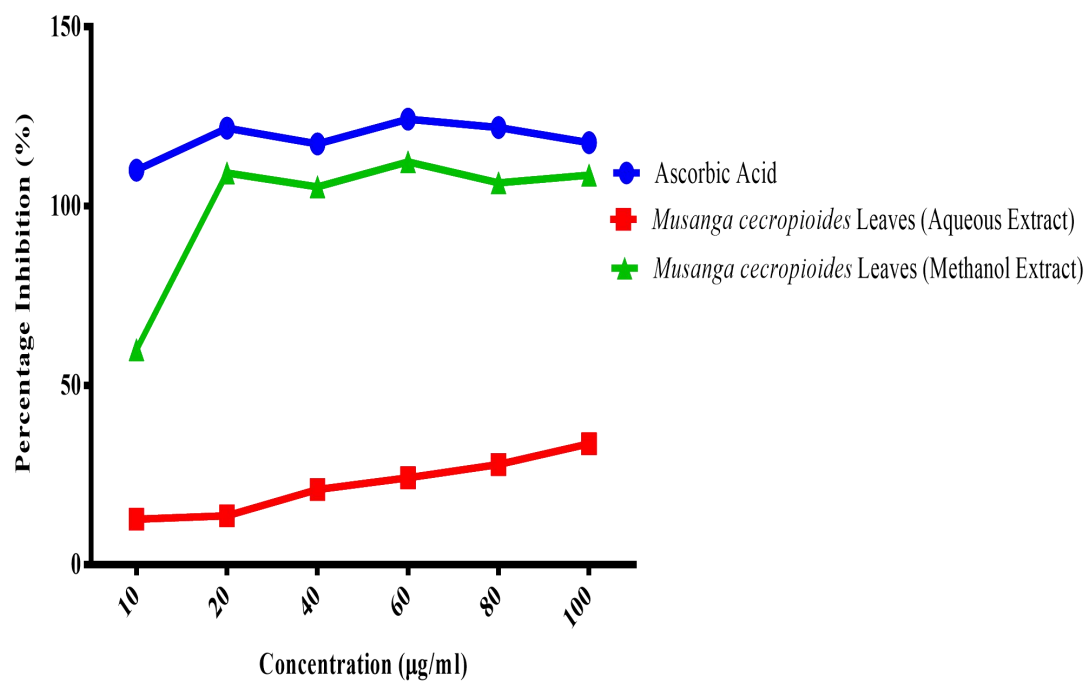


Figure 4.11: DPPH radical scavenging activity of *Musanga cecropioides* leaf extracts

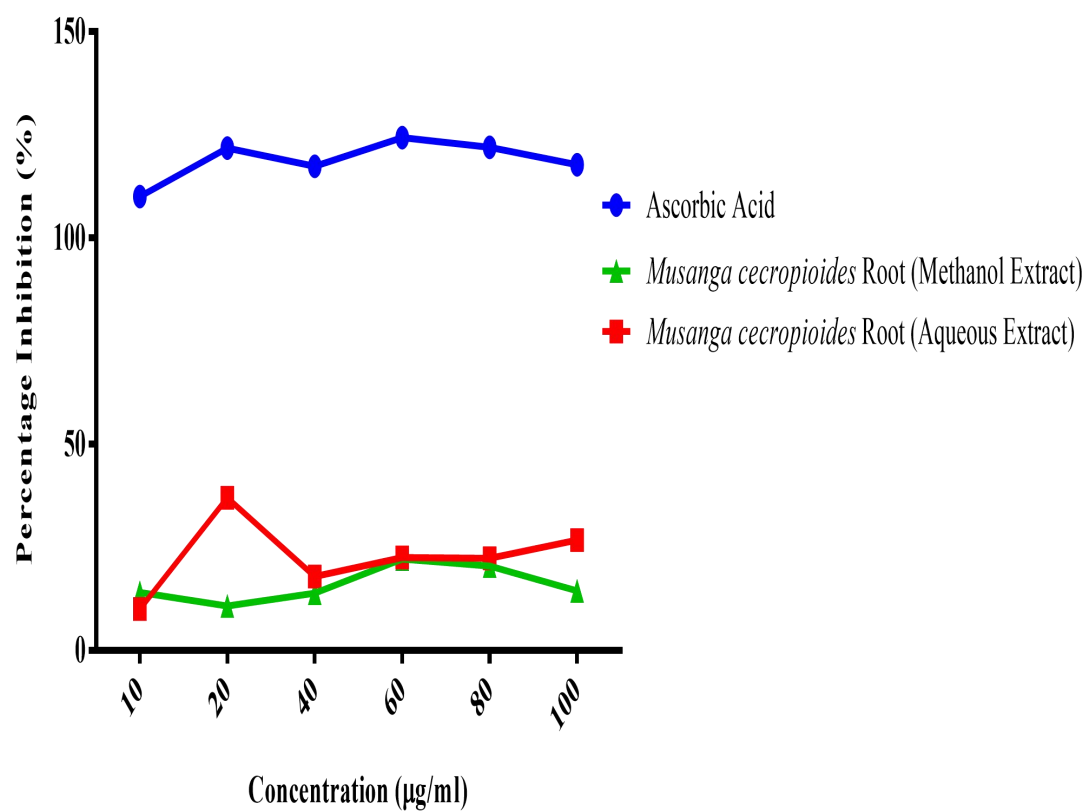


Figure 4.12: DPPH radical scavenging activity of *Musanga cecropioides* root extracts

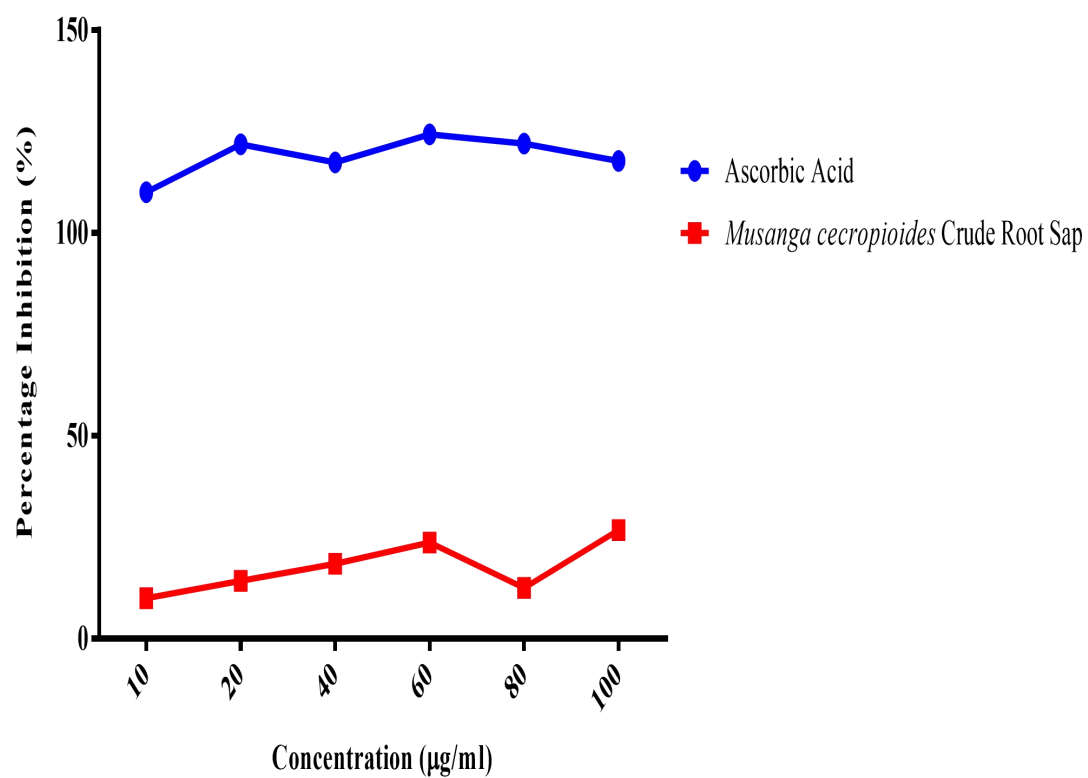


Figure 4.13: DPPH radical scavenging activity of *Musanga cecropioides* crude root sap

4.3.2 ABTS Radical Scavenging Activity

Figure 4.14 shows the ABTS radical scavenging activity of *Musanga cecropioides* leaves aqueous and methanol extracts. As observed in Figure 4.11 the methanol extracts of *Musanga cecropioides* also showed better radical scavenging activity than the aqueous extract with all concentrations showing over 50% percentage inhibition.

Figure 4.15 shows the ABTS radical scavenging activity of *Musanga cecropioides* root aqueous and methanol extracts. Both extracts also showed less than 50% radical scavenging activity as is also observed in Figure 4.12.

Figure 4.16 shows the ABTS radical scavenging activity of *Musanga cecropioides* crude root sap. This sample showed better antioxidant activity in the ABTS model than in the DPPH model.

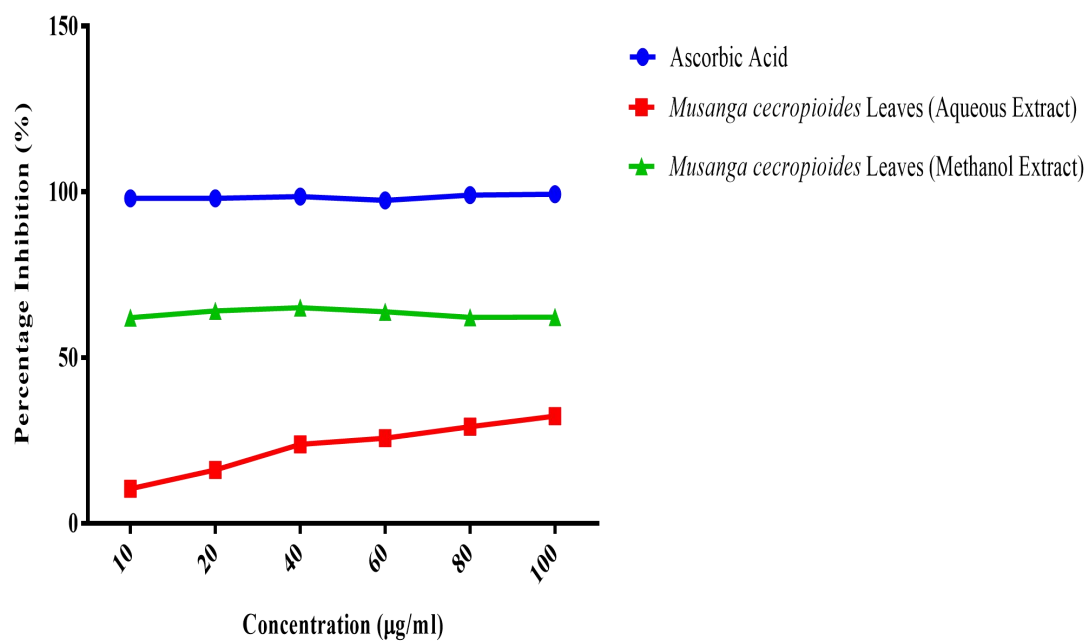


Figure 4.14: ABTS radical scavenging activity of *Musanga cecropioides* leaf extracts

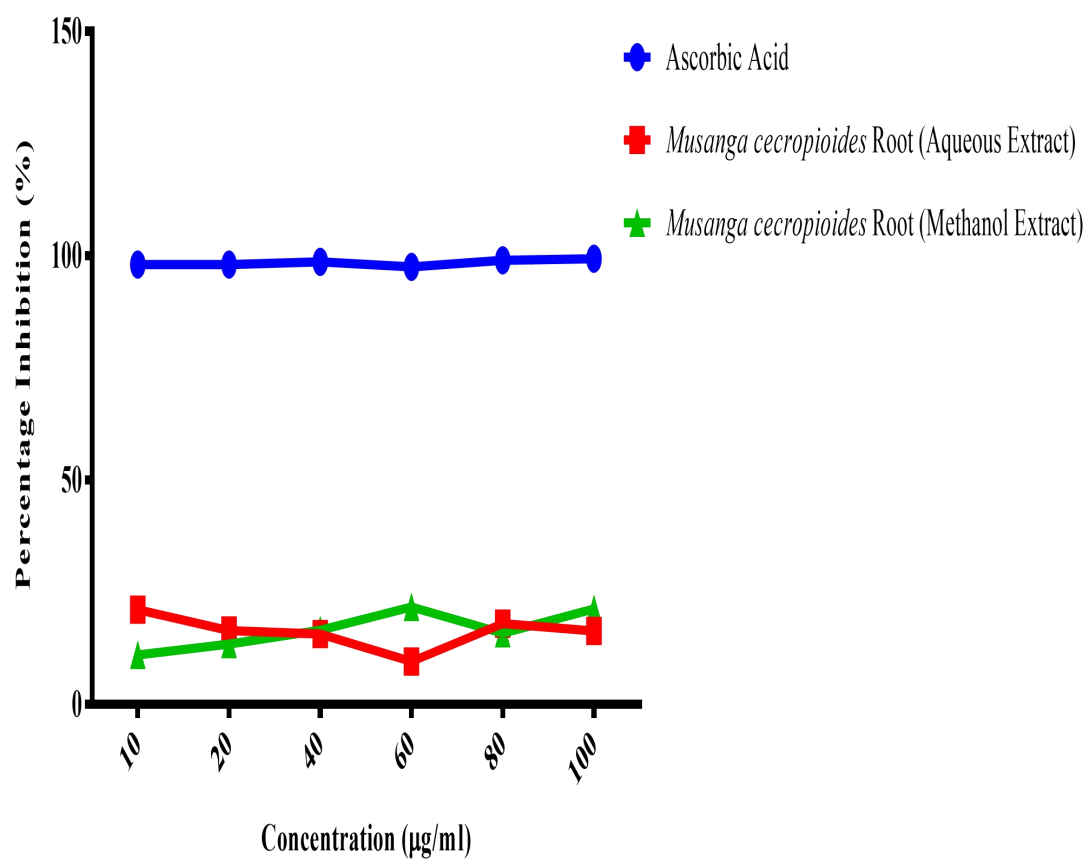


Figure 4.15: ABTS radical scavenging activity of *Musanga cecropioides* root extracts

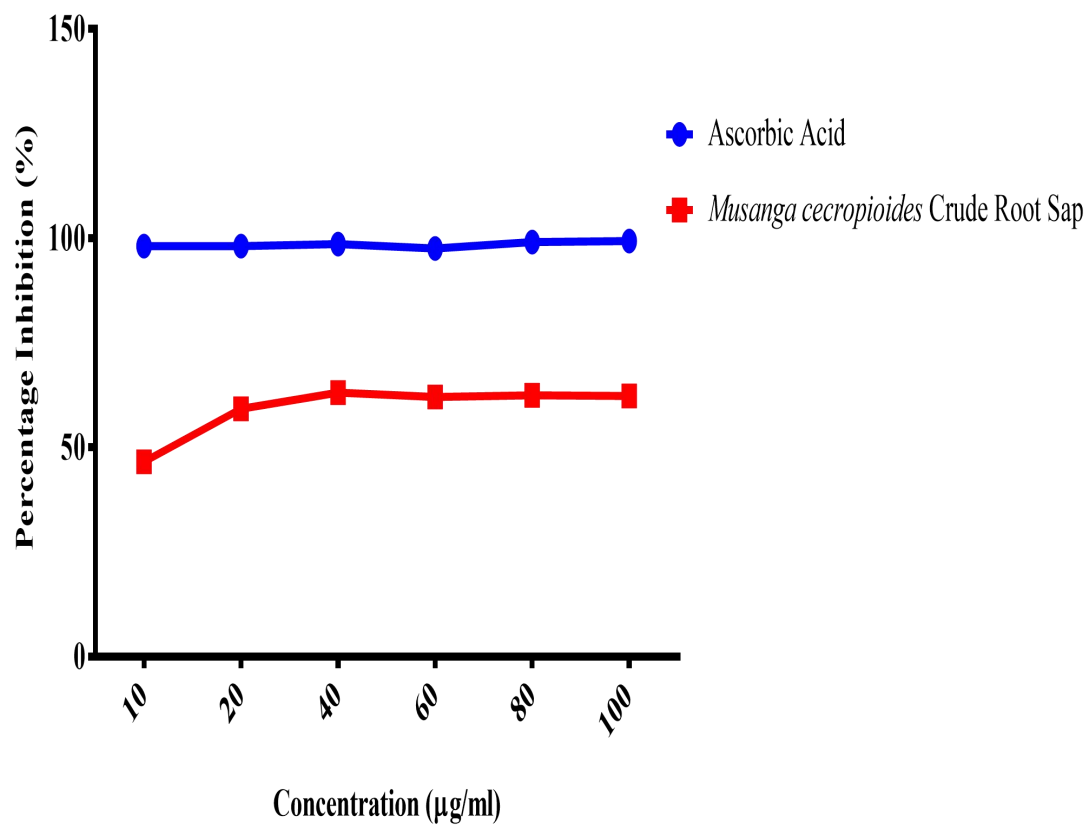


Figure 4.16: ABTS radical scavenging activity of *Musanga cecropioides* crude root sap

4.3.3 DNA Nicking Assay

Figure 4.17 shows results on the DNA protective effect of *Musanga cecropioides* leaf and root extracts on oxidative DNA nicking of pCAMBIA 1301 DNA caused by hydroxyl radicals in Fenton's reagent. Bands comparable with the positive control (Lane C: quercetin 50 μ M) were observed in all treatment groups. Lane D (methanol leaf extract) and Lane G (methanol root extract) revealed the protection of the supercoiled DNA form, while Lane E (aqueous leaf extract), Lane F (aqueous root extract) revealed the protection of the open circular DNA form while the supercoiled form was partially nicked at concentration of 100 μ g/ml, as opposed to the negative control (Lane A: DNA + Fenton's reagent alone), which was completely nicked.

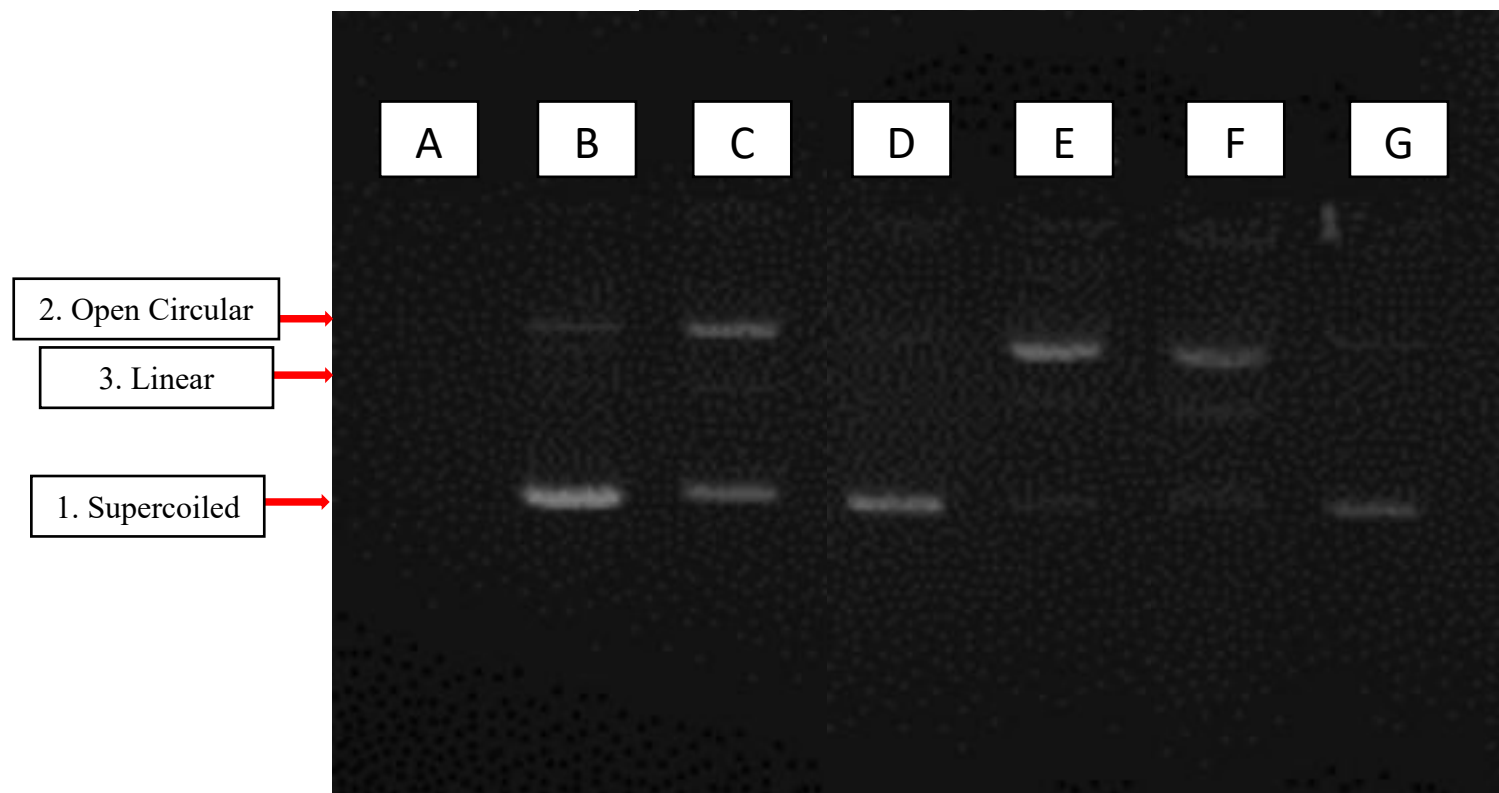


Figure 4.17: DNA protective effect of *Musanga cecropioides* leaf and root extracts on Fenton's induced DNA damage of pCAMBIA 1301 DNA.

Effect of the extracts on oxidative DNA nicking caused by hydroxyl radicals. Lane A: DNA + Fenton's reagent; Lane B: DNA + DMSO (50 $\mu\text{g/ml}$); Lane C: DNA + Fenton's reagent + quercetin (50 μM); Lane D: DNA + Fenton's reagent + *Musanga cecropioides* leaves methanol extract (100 $\mu\text{g/ml}$), Lane E: DNA + Fenton's reagent + *Musanga cecropioides* leaves aqueous extract (100 $\mu\text{g/ml}$) Lane F: DNA + Fenton's reagent + *Musanga cecropioides* root aqueous extract (100 $\mu\text{g/ml}$), Lane G: DNA + Fenton's reagent + *Musanga cecropioides* root methanol extract (100 $\mu\text{g/ml}$).

4.4 Antidiarrheal Study

4.4.1 Castor oil – induced Diarrhoea

Tables 4.45, 4.46, 4.47 show the results on the effects of *Musanga cecropioides* leave extracts, root extracts and crude root sap respectively, on castor oil – induced diarrhoea in mice.

In Table 4.45, *Musanga cecropioides* aqueous leaf extract at 200 mg/kg caused significantly higher ($P < 0.01$) percentage inhibition of diarrhoea (66.67%), while methanol leaf extract at 50 mg/kg caused significantly higher ($P < 0.01$) percentage inhibition of diarrhoea (71.11%), when compared with the control group treated with only normal saline.

In Table 4.46, *Musanga cecropioides* aqueous root extract at 200 mg/kg caused significantly higher ($P < 0.01$) percentage inhibition of diarrhoea (68.89%), while the group treated with methanol root extract at 50 mg/kg caused significantly higher ($P < 0.001$) percentage inhibition of diarrhoea (88.89%), which was higher than the group administered the standard drug-loperamide (82.22%) at a dose of 5 mg/kg, when compared with the control group treated with only normal saline.

In Table 4.47, *Musanga cecropioides* crude root sap at 0.5 ml/kg caused significantly higher ($P < 0.01$) percentage inhibition of diarrhoea (64.44%), when compared with the control group treated with only normal saline.

Table 4.45: Effect of *Musanga cecropioides* leave extracts on castor oil – induced diarrhoea in mice

Treatment/Dose	Total number of faeces	Total number of diarrhoeal faeces	Percentage (%) Inhibition of diarrhoea
Normal Saline 2 ml/kg	15.75 ± 0.48	11.25 ± 1.44	-
Loperamide 5 mg/kg	6.25 ± 1.18**	2.00 ± 0.91***	82.22
MCL Aq 50 mg/kg	10.75 ± 1.38	4.50 ± 0.96*	60.00
MCL Aq 100 mg/kg	9.50 ± 0.65	4.50 ± 0.65*	60.00
MCL Aq 200 mg/kg	8.75 ± 1.80	3.75 ± 1.32**	66.67
MCL Meth 50 mg/kg	8.75 ± 1.11	3.25 ± 1.11**	71.11
MCL Meth 100 mg/kg	12.25 ± 1.55	6.75 ± 0.25**	40.00
MCL Meth 200 mg/kg	8.00 ± 1.35*	4.00 ± 1.00**	64.44

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; Meth: methanol extract

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group treated with only Normal Saline

Table 4.46: Effect of *Musanga cecropioides* root extracts on castor oil – induced diarrhoea in mice

Treatment/Dose	Total number of faeces	Total number of diarrhoeal faeces	Percentage (%) Inhibition of diarrhoea
Normal Saline 2 ml/kg	15.75 ± 0.48	11.25 ± 1.44	-
Loperamide 5 mg/kg	6.25 ± 1.18**	2.00 ± 0.91***	82.22
MCR Aq 50 mg/kg	13.25 ± 0.75	5.25 ± 0.95*	53.33
MCR Aq 100 mg/kg	16.50 ± 0.87**	8.00 ± 1.16	28.89
MCR Aq 200 mg/kg	7.25 ± 3.20	3.50 ± 2.36**	68.89
MCR Meth 50 mg/kg	5.50 ± 0.87***	1.25 ± 0.95***	88.89
MCR Meth 100 mg/kg	11.50 ± 0.50	4.50 ± 0.29**	60.00
MCR Meth 200 mg/kg	5.75 ± 1.60***	2.75 ± 1.70***	75.56

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; Meth: methanol extract

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group treated with only Normal Saline

Table 4.47: Effect of *Musanga cecropioides* crude root sap on castor oil – induced diarrhoea in mice

Treatment/Dose	Total number of faeces	Total number of diarrhoeal faeces	Percentage (%) Inhibition of diarrhoea
Normal Saline 2 ml/kg	15.75 ± 0.48	11.25 ± 1.44	-
Loperamide 5 mg/kg	6.25 ± 1.18**	2.00 ± 0.91***	82.22
MCCRS 0.5 ml/kg	8.00 ± 0.82*	4.00 ± 1.08**	64.44
MCCRS 1 ml/kg	8.50 ± 1.56*	5.00 ± 1.35*	55.56
MCCRS 2 ml/kg	13.00 ± 1.00	5.75 ± 0.25	48.89

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* Crude Root Sap;

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group treated with only Normal Saline

4.4.2 Castor oil – induced Enteropooling

Tables 4.48, 4.49, 4.50 show the results on the effects of *Musanga cecropioides* leave extracts, root extracts and crude root sap respectively, on castor oil – induced enteropooling in mice.

In Table 4.48, all treatments significantly reduced the volume of intestinal content in mice at $P < 0.01$ and $P < 0.001$ when compared with the control group given only normal saline. *Musanga cecropioides* aqueous leaf extract at 100 mg/kg caused significantly higher $P < 0.001$ percentage inhibition of volume of intestinal content (65.69%), while the methanol leaf extract at 100 mg/kg caused significantly higher $P < 0.001$ percentage inhibition of volume of intestinal content (70.80%), when compared with the control group treated with only normal saline.

In Table 4.49, all treatments significantly reduced the volume of intestinal content in mice at $P < 0.001$ when compared with the control group given only normal saline. *Musanga cecropioides* aqueous root extract at 200 mg/kg caused significantly higher $P < 0.001$ percentage inhibition of volume of intestinal content (87.59%), while the methanol root extract at 50 and 200 mg/kg caused significantly higher $P < 0.001$ percentage inhibition of volume of intestinal content (78.10% at both dose levels), when compared with the control group treated with only normal saline.

In Table 4.50, all treatments significantly reduced the volume of intestinal content in mice at $P < 0.001$ when compared with the control group given only normal saline. *Musanga cecropioides* crude root sap at 0.5 and 2 ml/kg caused significantly higher $P < 0.001$ percentage inhibition of volume of intestinal content (70.80%), when compared with the control group treated with only normal saline.

Table 4.48: Effect of *Musanga cecropioides* leave extracts on castor oil – induced enteropooling in mice

Treatment/Dose	Total weight of intestinal content (g)	Volume of intestinal content (mL)	Percentage (%) Inhibition in volume of intestinal content
Normal Saline 2 ml/kg	2.89 ± 0.10	1.37 ± 0.09	-
Loperamide 5 mg/kg	1.30 ± 0.43***	0.63 ± 0.17**	54.01
MCL Aq 50 mg/kg	1.49 ± 0.06***	0.70 ± 0.12**	48.90
MCL Aq 100 mg/kg	1.21 ± 0.08***	0.47 ± 0.07***	65.69
MCL Aq 200 mg/kg	1.16 ± 0.18***	0.57 ± 0.18***	58.39
MCL Meth 50 mg/kg	1.32 ± 0.34***	0.63 ± 0.30**	54.01
MCL Meth 100 mg/kg	1.25 ± 0.17***	0.40 ± 0.10***	70.80
MCL Meth 200 mg/kg	1.35 ± 0.06***	0.63 ± 0.03**	54.01

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; Meth: methanol extract

** Significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group treated with only Normal Saline

Table 4.49: Effect of *Musanga cecropioides* root extracts on castor oil – induced enteropooling in mice

Treatment/Dose	Total weight of intestinal content (g)	Volume of intestinal content (mL)	Percentage (%) Inhibition in volume of intestinal content
Normal Saline 2 ml/kg	2.89 ± 0.10	1.37 ± 0.09	-
Loperamide 5 mg/kg	1.30 ± 0.43***	0.63 ± 0.17**	54.01
MCR Aq 50 mg/kg	0.82 ± 0.13***	0.37 ± 0.15***	72.99
MCR Aq 100 mg/kg	1.67 ± 0.08***	0.53 ± 0.03***	61.31
MCR Aq 200 mg/kg	0.72 ± 0.07***	0.17 ± 0.03***	87.59
MCR Meth 50 mg/kg	0.91 ± 0.01***	0.30 ± 0.00***	78.10
MCR Meth 100 mg/kg	0.99 ± 0.19***	0.47 ± 0.08***	65.69
MCR Meth 200 mg/kg	0.87 ± 0.07***	0.30 ± 0.06***	78.10

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; Meth: methanol extract

** Significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group treated with only Normal Saline

Table 4.50: Effect of *Musanga cecropioides* crude root sap on castor oil – induced enteropooling in mice

Treatment/Dose	Total weight of intestinal content (g)	Volume of intestinal content (mL)	Percentage (%) Inhibition in volume of intestinal content
Normal Saline 2 ml/kg	2.89 ± 0.10	1.37 ± 0.09	-
Loperamide 5 mg/kg	1.30 ± 0.43***	0.63 ± 0.17**	54.01
MCCRS 0.5 ml/kg	1.05 ± 0.13***	0.40 ± 0.06***	70.80
MCCRS 1 ml/kg	1.17 ± 0.06***	0.47 ± 0.13***	65.69
MCCRS 2 ml/kg	1.15 ± 0.08***	0.40 ± 0.10***	70.80

Values are expressed as Mean ± SEM, $P < 0.05$; n=4

MCCRS: *Musanga cecropioides* Crude Root Sap;

** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to control group treated with only Normal Saline

4.5 Antitussive Study

4.5.1 Mucus Expectoration (Phenol Red) Experiment

Figures 4.18, 4.19, 4.20, 4.21 and 4.22 show the results on the effects of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap respectively, on mucus expectoration in mice using phenol red dye as an indicator.

In Figure 4.18 *Musanga cecropioides* aqueous leaf extract at 50 mg/kg significantly increased ($P < 0.05$) the phenol red dye concentration when compared to the control group treated with only distilled water, however at the higher concentrations administered (100 and 200 mg/kg), concentration of phenol red was reduced but not significantly different from the control.

In Figure 4.19 *Musanga cecropioides* methanol leaf extract at 100 mg/kg significantly increased ($P < 0.05$) the concentration of phenol red.

In Figure 4.20 *Musanga cecropioides* aqueous root extract at 100 mg/kg significantly increased ($P < 0.05$) the concentration of phenol red.

In Figure 4.21 *Musanga cecropioides* methanol root extract did not significantly alter the phenol red dye concentration when compared to the control group treated with only distilled water.

In Figure 4.22 *Musanga cecropioides* crude root sap did not significantly alter the phenol red dye concentration when compared to the control group treated with only distilled water.

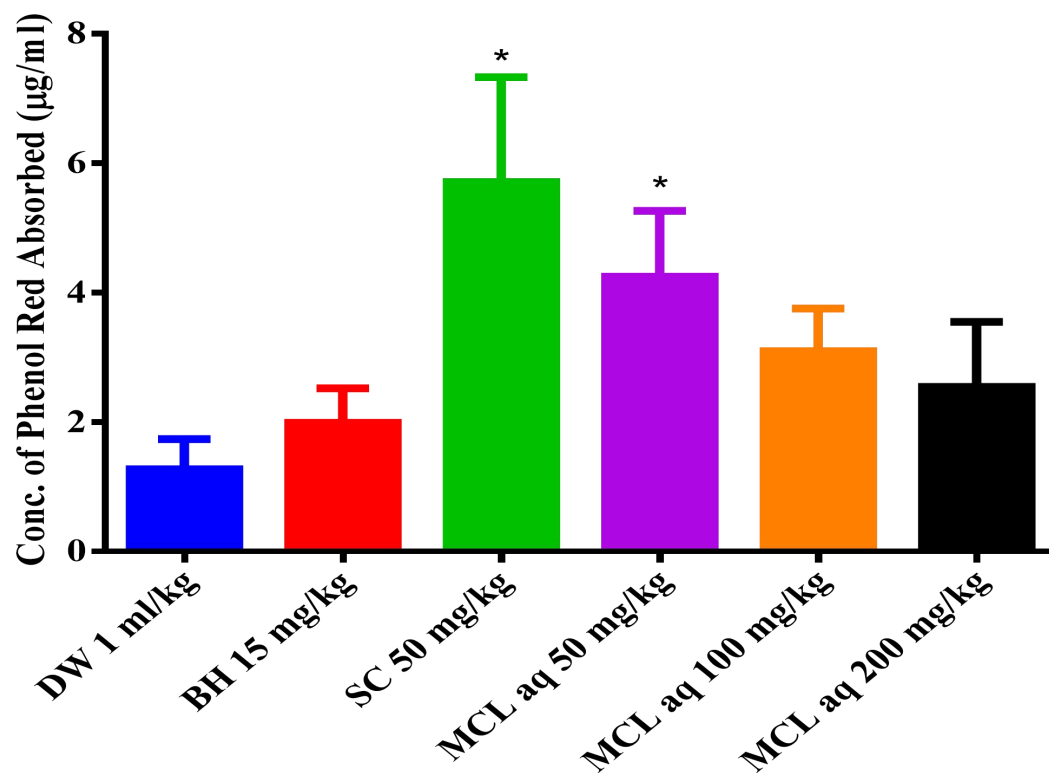


Figure 4.18: Effect of *Musanga cecropioides* aqueous leaf extract on phenol red dye secretion in mice trachea

DW: distilled water; BH: Bromohexine hydrochloride; SC: Sodium cromoglycate; MCL: *Musanga cecropioides* leaves; AQ: aqueous; n=5; * significant values at $P < 0.05$, when compared to control group treated with only distilled water

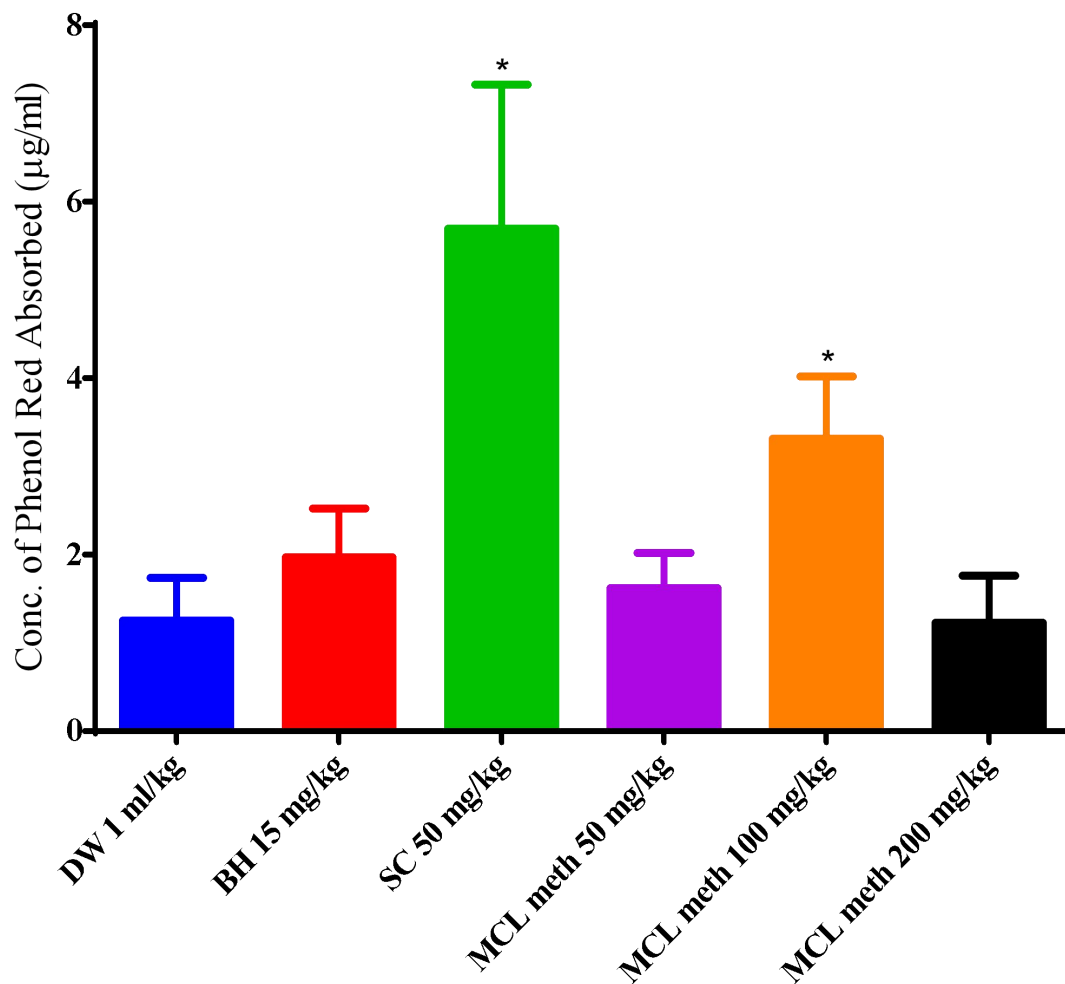


Figure 4.19: Effect of *Musanga cecropioides* methanol leaf extract on phenol red secretion in mice trachea

DW: distilled water; BH: Bromhexine hydrochloride; SC: Sodium cromoglycate; MCL: *Musanga cecropioides* leaves; METH: Methanol; n=5; * significant values at $P < 0.05$, when compared to control group treated with only distilled water

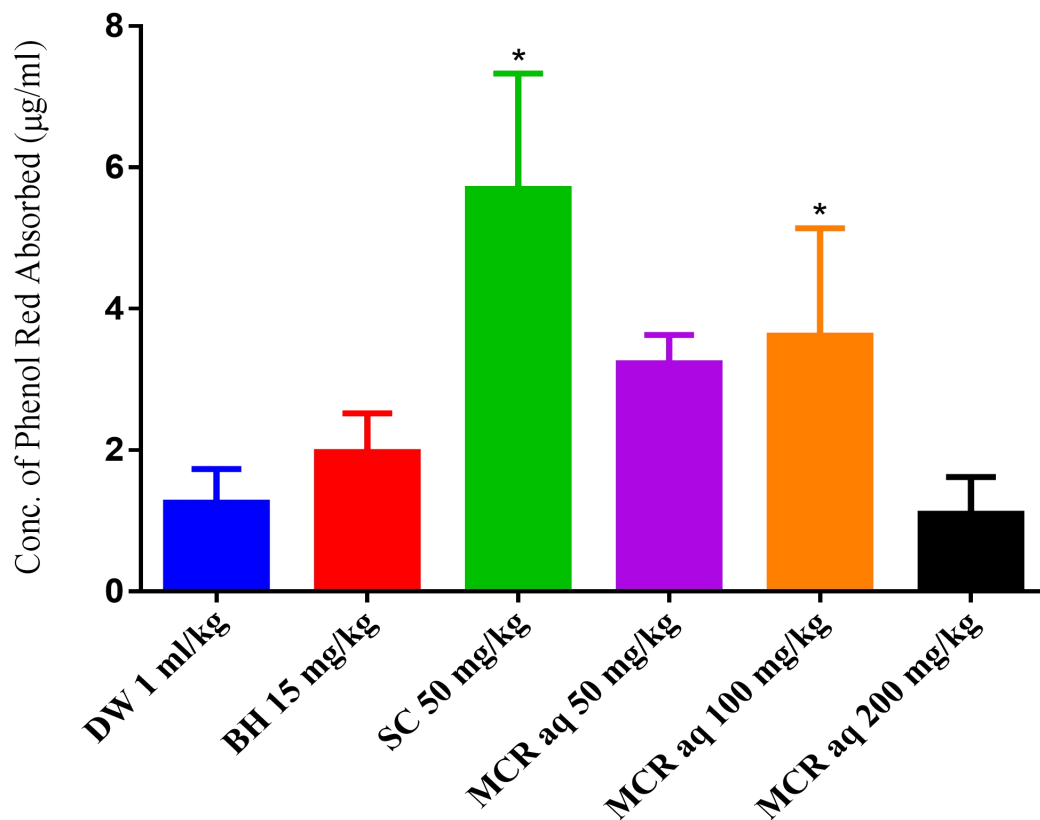


Figure 4.20: Effect of *Musanga cecropioides* aqueous root extract on phenol red secretion in mice trachea

DW: distilled water; BH: Bromhexine hydrochloride; SC: Sodium cromoglycate; MCR: *Musanga cecropioides* root; AQ: aqueous; n=5; * significant values at $P < 0.05$, when compared to control group treated with only distilled water

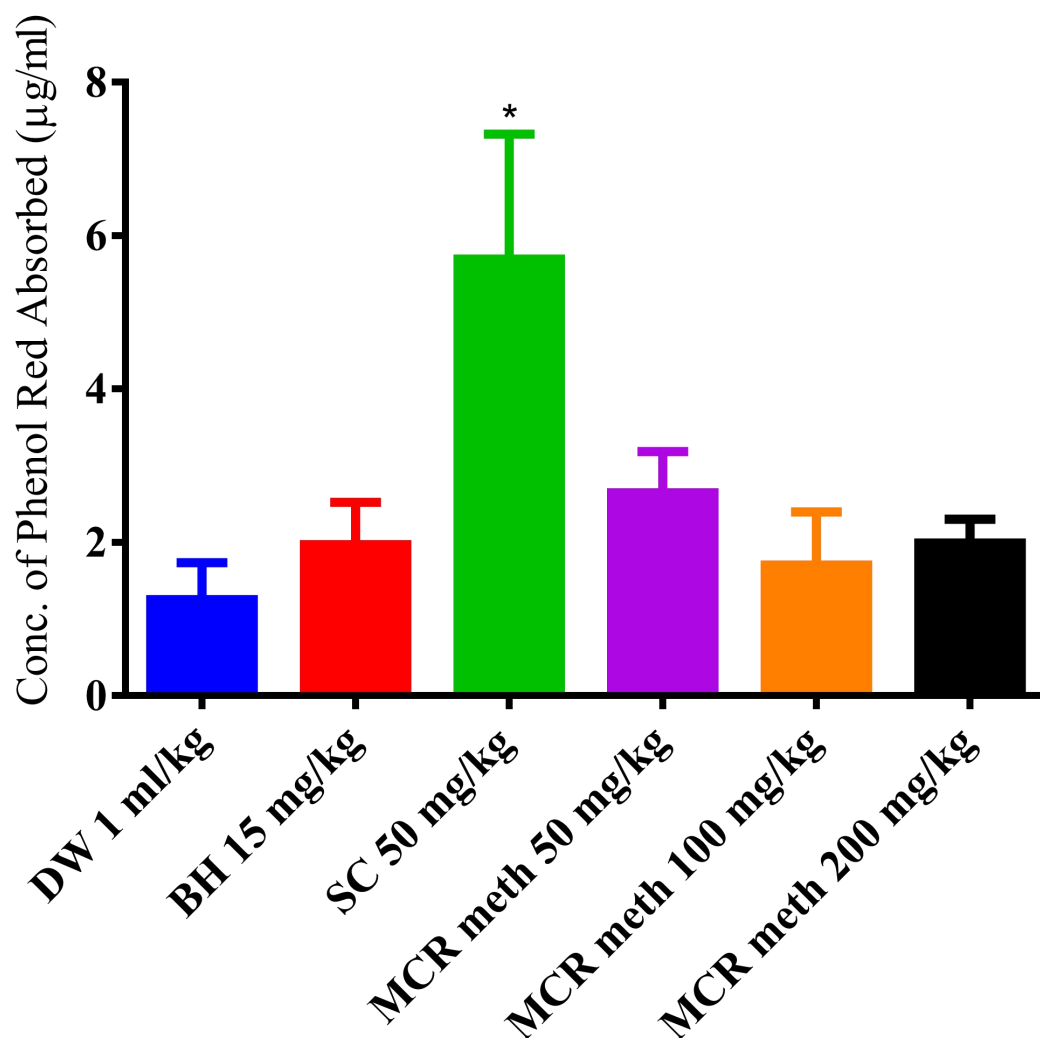


Figure 4.21: Effect of *Musanga cecropioides* methanol root extract on phenol red secretion in mice trachea

DW: distilled water; BH: Bromhexine hydrochloride; SC: Sodium cromoglycate; MCR: *Musanga cecropioides* root; METH: Methanol; n=5; * significant values at $P < 0.05$, when compared to control group treated with only distilled water

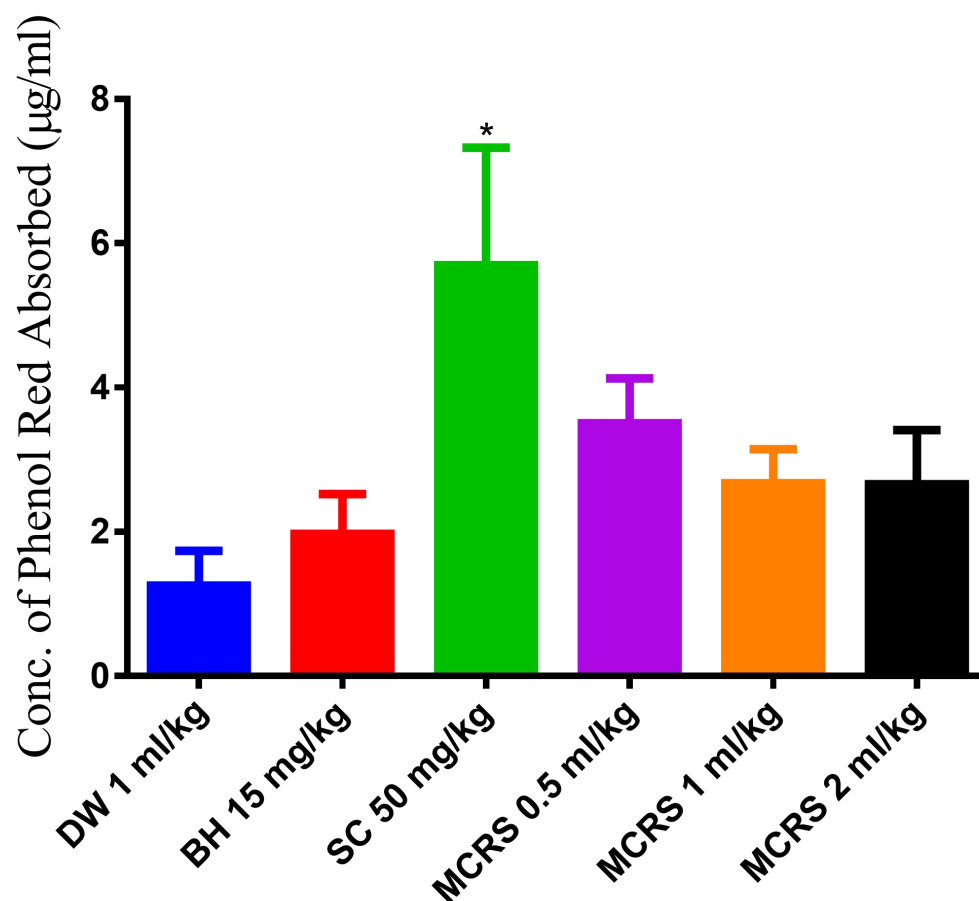


Figure 4.22: Effect of *Musanga cecropioides* crude root sap on phenol red secretion in mice trachea

DW: distilled water; BH: Bromhexine hydrochloride; SC: Sodium cromoglycate; MCR: *Musanga cecropioides* root sap; n=5; * significant values at $P < 0.05$, when compared to control group treated with only distilled water

4.5.2 Antitussive Experiment (Citric acid-induced cough)

Figures 4.23, 4.24 and 4.25 shows the effect of *Musanga cecropioides* leaf extracts, root extracts and crude root sap respectively, on citric acid induced cough in guinea pigs. All samples significantly inhibited cough bouts (at $P < 0.05$, $P < 0.01$ and $P < 0.001$) when compared to the control group treated with 1 ml/kg distilled water. The antitussive activities observed in Figures 4.23, 4.24 and 4.25 were comparable to the control group treated with dihydrocodeine 25 mg/kg ($76.81 \pm 6.20\%$) however, *Musanga cecropioides* aqueous leaf extract at 50 mg/kg (figure 4.23) and methanol root extract at 100 mg/kg (figure 4.24) showed the best percentage inhibition of cough at $91.97 \pm 5.90\%$ and $86.50 \pm 4.80\%$ respectively. The lowest percentage inhibition was observed in the groups treated with *Musanga cecropioides* crude root sap (figure 4.25) at 0.5 ml/kg and 1 ml/kg, showing $62.98 \pm 8.89\%$ and $64.50 \pm 6.88\%$ respectively.

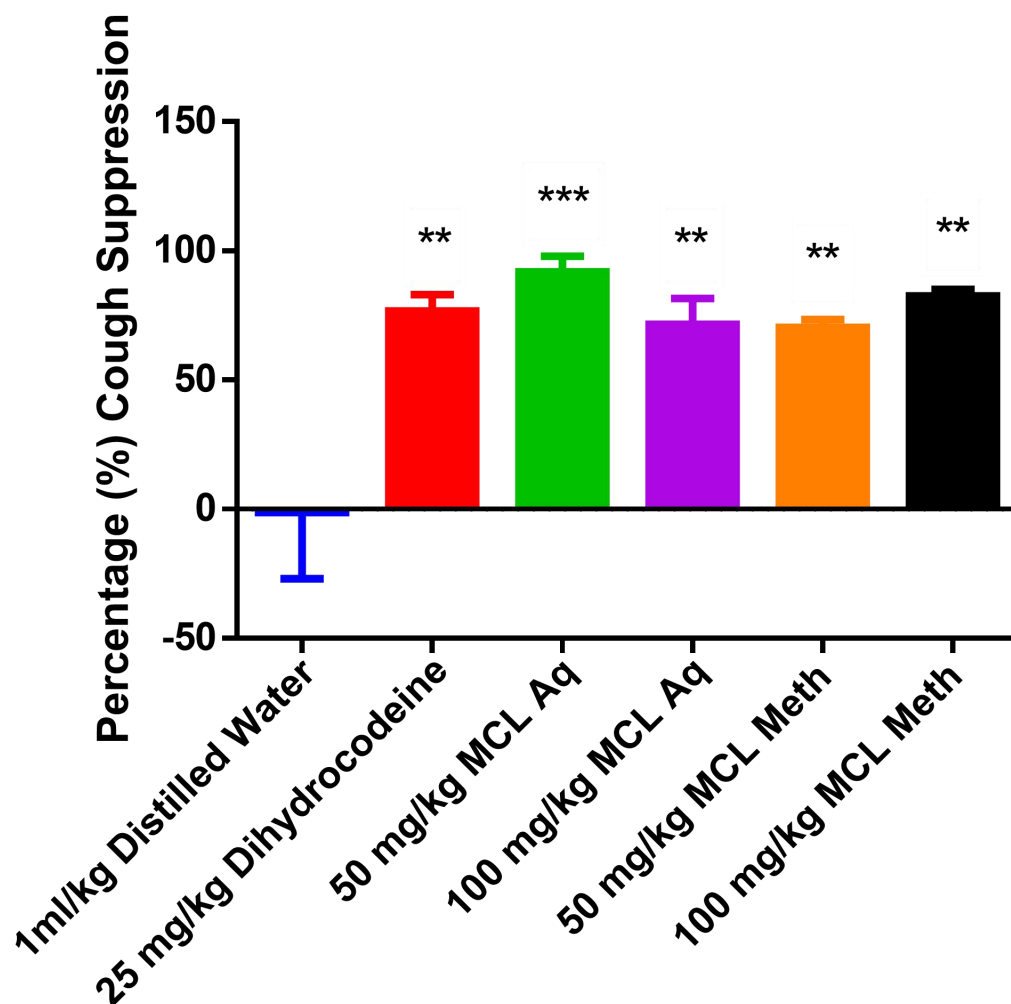


Figure 4.23: Antitussive effect of *Musanga cecropioides* leaf aqueous and methanol extracts on citric acid-induced cough in guinea pigs

** significant values at $P < 0.01$; *** significant values at $P < 0.001$ when groups compared to control groups. AQ: aqueous; METH: Methanol. n=4 per group.

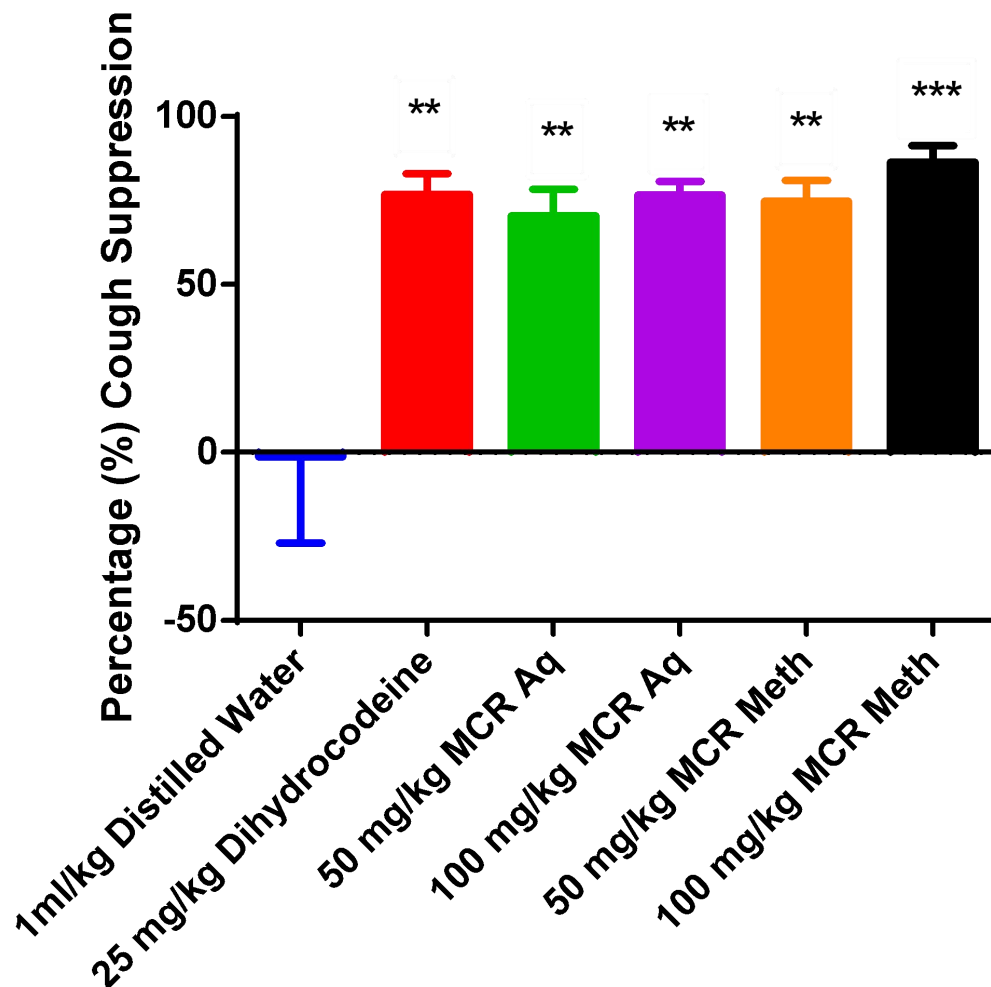


Figure 4.24: Antitussive effect of *Musanga cecropioides* root aqueous and methanol extracts on citric acid-induced cough in guinea pigs

** significant values at $P < 0.01$; *** significant values at $P < 0.001$ when groups compared to control groups. AQ: aqueous; METH: Methanol. n=4 per group.

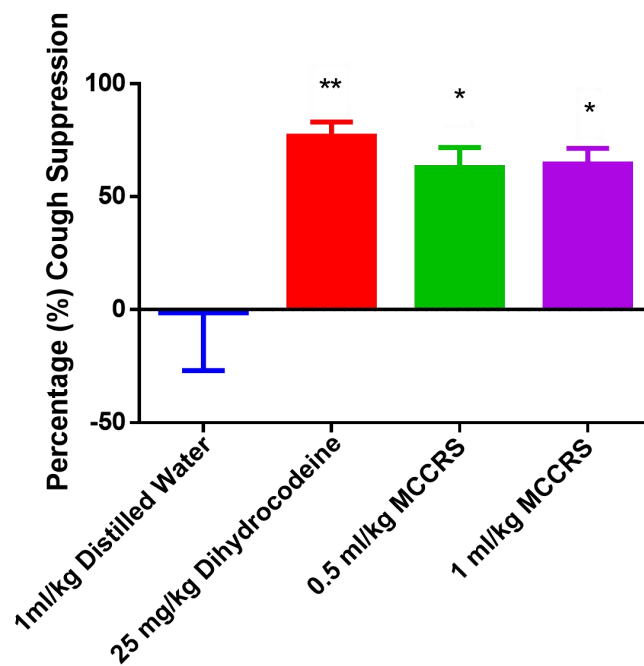


Figure 4.25: Antitussive effect of *Musanga cecropioides* crude root sap on citric acid-induced cough in guinea pigs

* significant values at $P < 0.05$; ** significant values at $P < 0.01$ when groups compared to control groups. MCCRS: *Musanga cecropioides* crude root sap. n=4 per group.

4.6 Antiasthma Study

4.6.1 Latency to Pre-convulsive Dyspnoea

Figures 4.26, 4.27 and 4.28 shows the effect of *Musanga cecropioides* leaf extracts, root extracts and crude root sap on the time taken for ovalbumin-induced asthmatic guinea pigs to show pre-convulsive dyspnoea.

In Figure 4.26, *Musanga cecropioides* leaf extracts increased the time taken before pre-convulsive dyspnoea was observed, however, only the aqueous leaf extract at 100 mg/kg significantly increased ($P < 0.01$) the time taken before pre-convulsive dyspnoea was observed when compared to the ovalbumin sensitized control group administered only distilled water.

In Figure 4.27, *Musanga cecropioides* root extracts increased the time taken before pre-convulsive dyspnoea was observed, however, the values were not statistically significant (at $P < 0.05$) when compared to the ovalbumin sensitized control group administered only distilled water.

In Figure 4.28, *Musanga cecropioides* crude root sap increased the time taken before pre-convulsive dyspnoea was observed, however, the values were not statistically significant (at $P < 0.05$) when compared to the ovalbumin sensitized control group administered only distilled water.

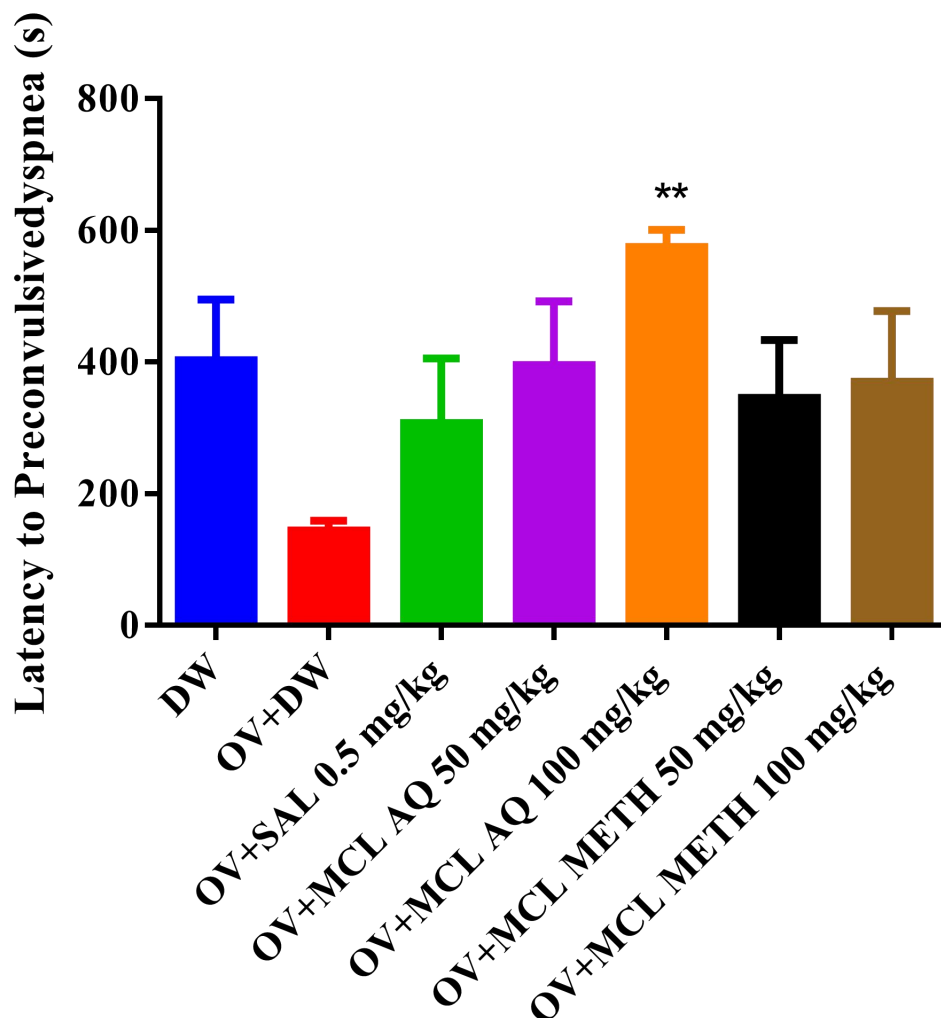


Figure 4.26: Effect of *Musanga cecropioides* leaf extracts on latency to pre-convulsive dyspnoea in ovalbumin sensitized guinea pigs.

** significant values at $P < 0.01$ when groups compared to the ovalbumin control group. DW: non-sensitized but distilled water treated; OV+DW: sensitized but distilled water; DW: distilled water; OV: ovalbumin; SAL: salbutamol; MCL: *Musanga cecropioides* leaf; AQ: aqueous; METH: Methanol. n=6 per group.

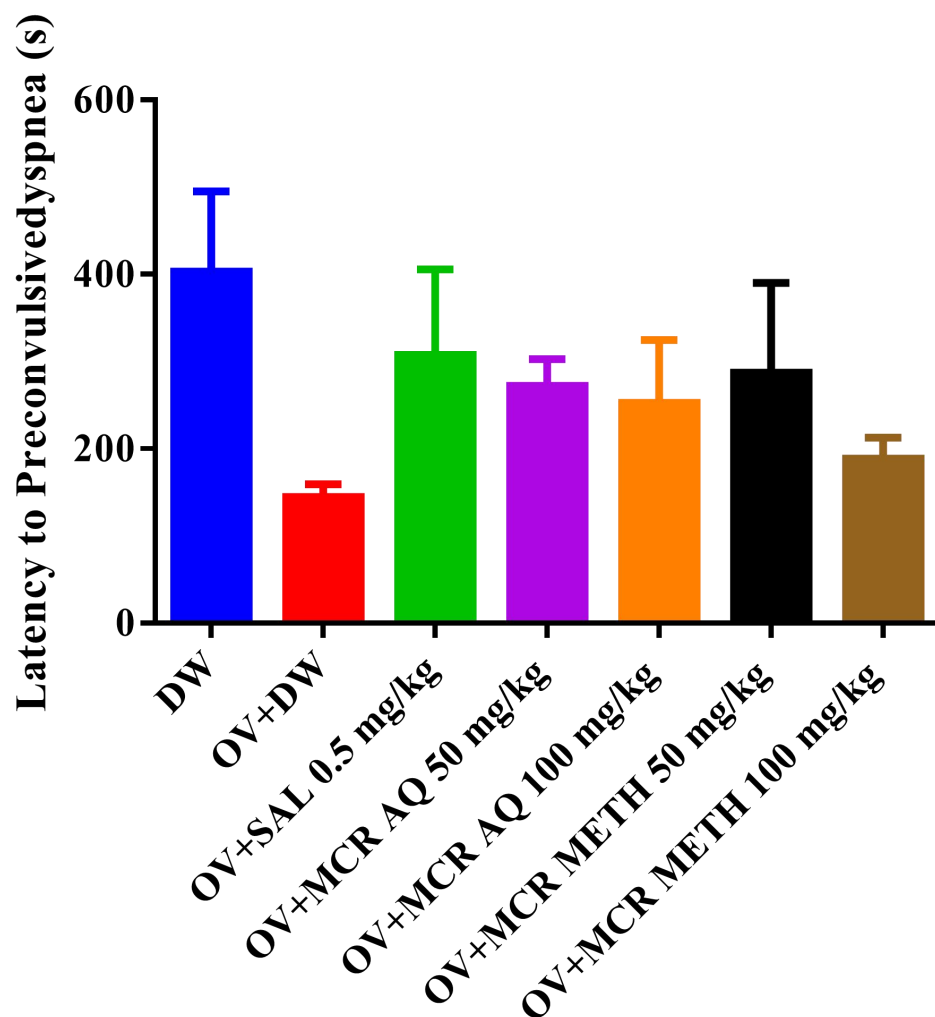


Figure 4.27: Effect of *Musanga cecropioides* root extracts on latency to pre-convulsive dyspnoea in ovalbumin sensitized guinea pigs.

No significant difference at $P < 0.05$ when groups compared to the ovalbumin control group. DW: non-sensitized but distilled water treated; OV+DW: sensitized but distilled water; DW: distilled water; OV: ovalbumin; SAL: salbutamol; MCR: *Musanga cecropioides* root; AQ: aqueous; METH: Methanol. n=6 per group.

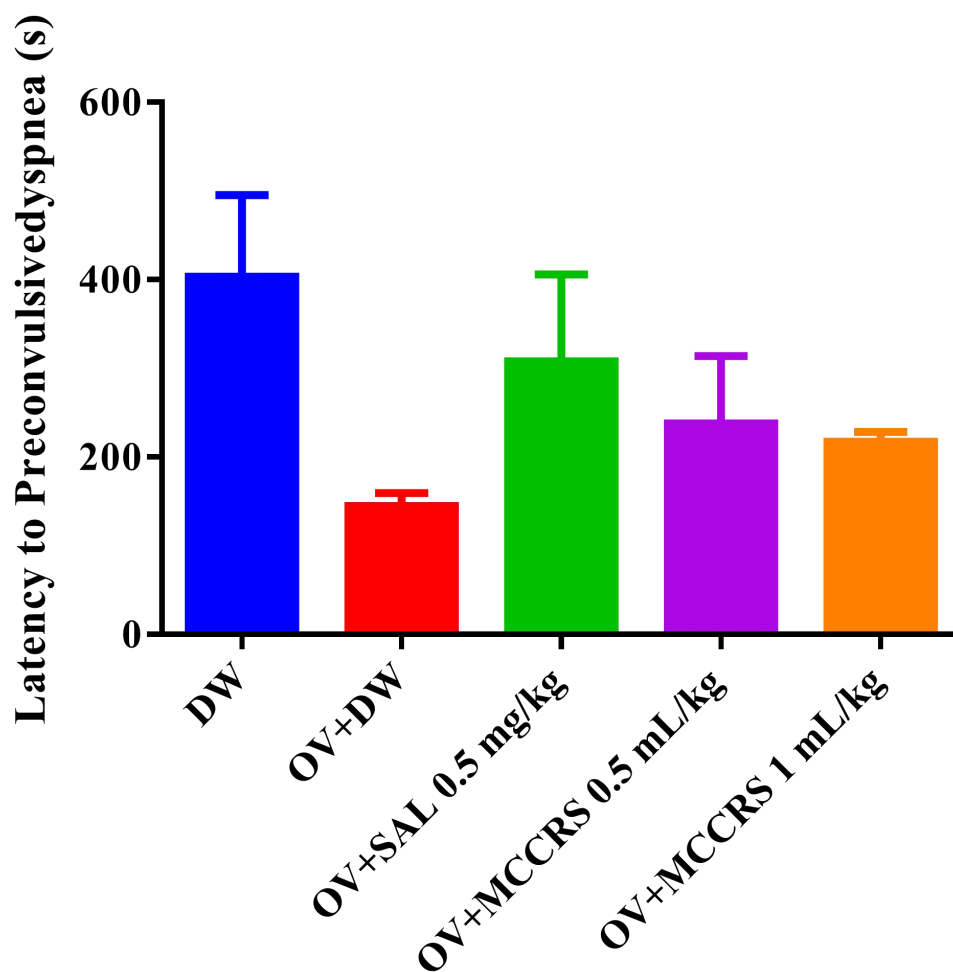


Figure 4.28: Effect of *Musanga cecropioides* crude root sap on latency to pre-convulsive dyspnoea in ovalbumin sensitized guinea pigs.

No significant difference at $P < 0.05$ when compared to the ovalbumin control group. DW: non-sensitized but distilled water treated; OV+DW: sensitized but distilled water; DW: distilled water; OV: ovalbumin; SAL: salbutamol; MCCRS: *Musanga cecropioides* crude root sap; n=6 per group.

4.6.2 Flow Rate

Figures 4.29, 4.30 and 4.31 shows the effect of *Musanga cecropioides* leaf extracts, root extracts and crude root sap on the trachea fluid viscosity, measured as flow rate of trachea fluid in ovalbumin-induced asthmatic guinea pigs.

In Figure 4.29, *Musanga cecropioides* aqueous leaf extract at 50 and 100 mg/kg significantly increased the flow rate at $P < 0.001$ while the methanol leaf extract at 50 and 100 mg/kg significantly increased the flow rate at $P < 0.01$ and $P < 0.05$ respectively when compared to the ovalbumin control group administered only distilled water.

In Figure 4.30, only the group treated with *Musanga cecropioides* aqueous root extract at 50 mg/kg significantly increased the flow rate at $P < 0.05$ when compared to the ovalbumin control group administered only distilled water.

In Figure 4.31, the flow rate of group treated with 1 ml/kg *Musanga cecropioides* crude root sap was significantly lower at $P < 0.001$ when compared with the ovalbumin control group.

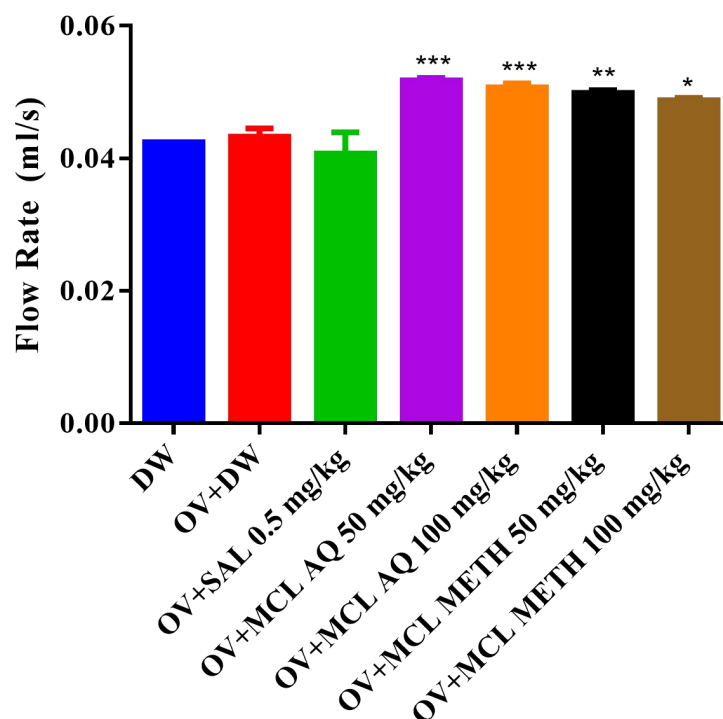


Figure 4.29: Effect of *Musanga cecropioides* leaf extracts on tracheal fluid viscosity in ovalbumin sensitized guinea pigs.

Flow rate of group treated with extracts were significantly higher at $P < 0.001$, $P < 0.01$ and $P < 0.05$ when compared with the control group. DW: non-sensitized but distilled water treated; OV+DW: sensitized but distilled water; DW: distilled water; OV: ovalbumin; SAL: salbutamol; MCL: *Musanga cecropioides* leaf; AQ: Aqueous; METH: Methanol; n=6 per group.

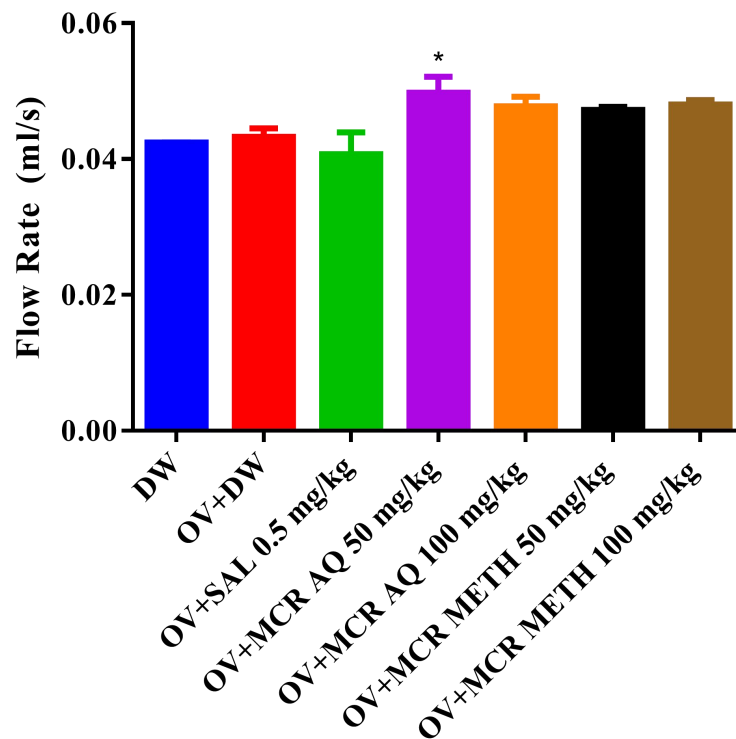


Figure 4.30: Effect of *Musanga cecropioides* root extracts on tracheal fluid viscosity in ovalbumin sensitized guinea pigs.

$P < 0.05$ when compared with the ovalbumin control group. DW: non-sensitized but distilled water treated; OV+DW: sensitized but distilled water; DW: distilled water; OV: ovalbumin; SAL: salbutamol; MCR: *Musanga cecropioides* root; AQ: Aqueous; METH: Methanol; n=6 per group.

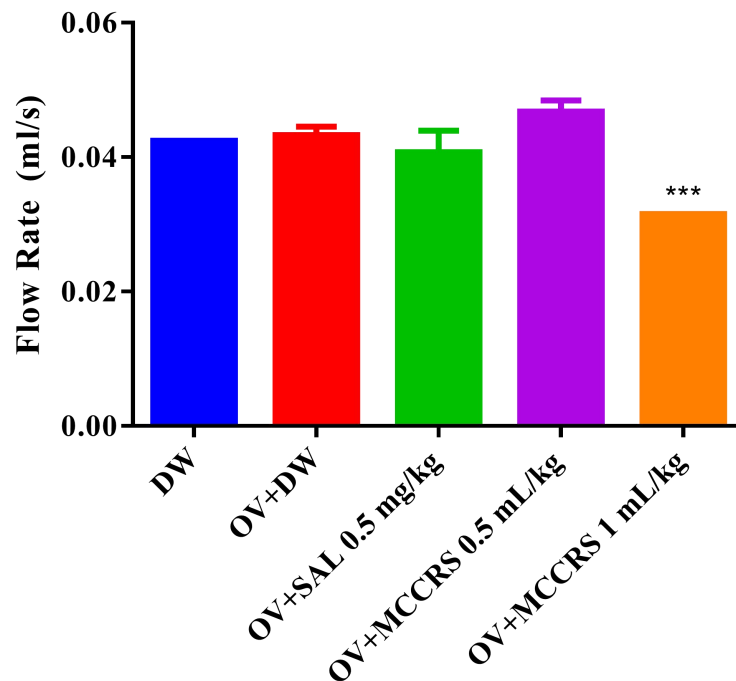


Figure 4.31: Effect of *Musanga cecropioides* crude root sap on tracheal fluid viscosity in ovalbumin sensitized guinea pigs.

Flow rate of group treated with 1 ml/kg *Musanga cecropioides* crude root sap (MCCRS) was significantly lower at $P < 0.001$ when compared with the ovalbumin control group. DW: non-sensitized but distilled water treated; OV+DW: sensitized but distilled water; SAL: salbutamol. n=6 per group.

4.6.3 Haematology

Tables 4.51, 4.52 and 4.53 show results on the haematology analysis of guinea pigs treated with *Musanga cecropioides* leaf extracts, root extracts and crude root sap in the 21 days anti-asthmatic study.

In Table 4.51, *Musanga cecropioides* aqueous leaf extract at 100 mg/kg significantly increase the granulocyte concentration (5.57 ± 0.59 at $P < 0.001$) when compared to the control group (1.20 ± 0.27), while the methanol leaf extract at 100 mg/kg significantly reduced the white blood cell count (6.35 ± 0.96 at $P < 0.05$), lymphocyte count (4.00 ± 0.13 at $P < 0.01$), monocyte count (0.80 ± 0.22 at $P < 0.05$), red blood cell count (2.88 ± 0.33 at $P < 0.01$), haemoglobin concentration (9.30 ± 0.31 at $P < 0.05$) and haematocrit concentration (24.20 ± 6.28 at $P < 0.001$) when compared to the control group.

In Table 4.52, *Musanga cecropioides* aqueous root extract at 50 mg/kg significantly reduced the monocyte count (0.60 ± 0.18 at $P < 0.01$), red blood cell count (2.90 ± 0.62 at $P < 0.01$), haemoglobin concentration (6.60 ± 1.34 at $P < 0.001$) and haematocrit count (32.40 ± 6.35 at $P < 0.05$), while the methanol root extract at the doses used did not significantly alter any of the haematological parameters when compared with the control group.

In Table 4.53, *Musanga cecropioides* crude root sap at 1 ml/kg significantly reduced the white blood cell count (5.70 ± 2.09 at $P < 0.01$) when compared with the normal control group (13.80 ± 2.91). Lymphocyte (4.40 ± 1.02 at $P < 0.01$) and monocyte (0.60 ± 0.13 at $P < 0.01$) count were also significantly reduced at the dose of 1 ml/kg when compared to the control group (10.70 ± 2.10 and 1.90 ± 0.54 respectively).

Musanga cecropioides crude root sap at 0.5 ml/kg did not significantly alter any of the haematological parameters in this study.

Table 4.51: Effect of *Musanga cecropioides* leaves on the haematological parameters of guinea pigs in 21 days anti-asthmatic study

Parameters	WBC 10 ⁻³ /uL	LYM 10 ⁻³ /uL	MON 10 ⁻³ /uL	GRAN 10 ⁻³ /uL	RBC 10 ⁻⁶ UL	HGB g/dL	HCT %	PLT 10 ⁻³ /uL
Normal control + 1 ml/kg DW	13.80 ± 2.91	10.70 ± 2.10	1.90 ± 0.54	1.20 ± 0.27	4.43 ± 0.16	13.58 ± 0.66	46.50 ± 3.58	594.0 ± 8.05
OV + 1 ml/kg DW	20.60 ± 0.49*	17.60 ± 0.09**	1.50 ± 0.13	1.50 ± 0.27	4.66 ± 0.07	12.95 ± 0.25	44.95 ± 0.02	1070.0 ± 188.7
OV + Salbutamol 0.5 mg/kg	14.83 ± 1.52	11.48 ± 0.99	1.75 ± 0.37	1.75 ± 0.70	3.95 ± 0.06	12.92 ± 0.80	47.37 ± 1.91	1287.0 ± 384.9*
OV + MCL Aq 50 mg/kg	16.95 ± 1.32	13.40 ± 1.30	1.75 ± 0.16	1.80 ± 0.18	4.41 ± 0.01	13.10 ± 0.22	49.00 ± 0.13	476.5 ± 34.66
OV + MCL Aq 100 mg/kg	18.80 ± 0.83	10.57 ± 0.71	2.67 ± 0.17	5.57 ± 0.59***	4.40 ± 0.17	13.67 ± 0.37	47.80 ± 2.51	1075.0 ± 118.7
OV + MCL Meth 50 mg/kg	11.23 ± 0.64	8.30 ± 0.79	1.27 ± 0.18	1.53 ± 0.30	4.13 ± 0.42	12.52 ± 1.56	45.22 ± 4.15	640.3 ± 105.9
OV + MCL Meth 100 mg/kg	6.35 ± 0.96*	4.00 ± 0.13**	0.80 ± 0.22*	0.20 ± 0.09	2.88 ± 0.33**	9.30 ± 0.31*	24.20 ± 6.28***	611.0 ± 59.48

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; Meth: Methanol; DW: distilled water

WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.52: Effect of *Musanga cecropioides* root on the haematological parameters of guinea pigs in 21 days anti-asthmatic study

Parameters	WBC 10 ³ /uL	LYM 10 ³ /uL	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ /uL	HGB g/dL	HCT %	PLT 10 ³ /uL
Normal control + 1 ml/kg DW	13.80 ± 2.91	10.70 ± 2.10	1.90 ± 0.54	1.20 ± 0.27	4.43 ± 0.16	13.58 ± 0.66	46.50 ± 3.58	594.0 ± 8.050
OV + 1 ml/kg DW	20.60 ± 0.49*	17.60 ± 0.09**	1.50 ± 0.13	1.50 ± 0.27	4.66 ± 0.07	12.95 ± 0.25	44.95 ± 0.02	1070.0 ± 188.7
OV + Salbutamol 0.5 mg/kg	14.83 ± 1.52	11.48 ± 0.99	1.75 ± 0.37	1.75 ± 0.70	3.95 ± 0.06	12.92 ± 0.80	47.37 ± 1.91	1287.0 ± 384.9*
OV + MCR Aq 50 mg/kg	10.33 ± 2.39	7.53 ± 1.94	0.60 ± 0.18**	2.40 ± 0.94	2.90 ± 0.62**	6.60 ± 1.34***	32.40 ± 6.35*	528.7 ± 150.8
OV + MCR Aq 100 mg/kg	15.75 ± 2.93	10.72 ± 2.24	1.60 ± 0.40	2.30 ± 1.15	3.89 ± 0.57	11.78 ± 1.90	43.58 ± 6.33	781.7 ± 116.2
OV + MCR Meth 50 mg/kg	14.17 ± 1.11	10.93 ± 1.25	1.63 ± 0.11	1.60 ± 0.24	4.10 ± 0.16	12.07 ± 0.82	45.03 ± 1.54	866.0 ± 173.8
OV + MCR Meth 100 mg/kg	15.70 ± 0.58	12.68 ± 0.15	1.42 ± 0.22	1.60 ± 0.46	4.31 ± 0.08	13.42 ± 0.33	46.70 ± 0.95	911.5 ± 93.33

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; Meth: Methanol; DW: distilled water

WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Hematocrit; PLT: Platelet count

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.53: Effect of *Musanga cecropioides* crude root sap on the haematological parameters of guinea pigs in 21 days anti-asthmatic study

Parameters	WBC 10 ³ /uL	LYM 10 ³ /uL	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ /UL	HGB g/dL	HCT %	PLT 10 ³ /uL
Normal control + 1 ml/kg DW	13.80 ± 2.91	10.70 ± 2.10	1.90 ± 0.54	1.20 ± 0.27	4.43 ± 0.16	13.58 ± 0.65	46.50 ± 3.58	594.0 ± 8.05
OV + 1 ml/kg DW	20.60 ± 0.49*	17.60 ± 0.09**	1.50 ± 0.13	1.50 ± 0.27	4.66 ± 0.07	12.95 ± 0.25	44.95 ± 0.02	1070.0 ± 188.7
OV + Salbutamol 0.5 mg/kg	14.83 ± 1.52	11.48 ± 0.99	1.75 ± 0.37	1.75 ± 0.70	3.95 ± 0.06	12.92 ± 0.80	47.37 ± 1.91	1287.0 ± 384.9*
OV + MCCRS 0.5 ml/kg	15.97 ± 1.48	11.68 ± 1.26	2.30 ± 0.12	2.00 ± 0.20	4.30 ± 0.16	13.25 ± 0.47	47.00 ± 1.92	808.5 ± 89.67
OV + MCCRS 1 ml/kg	5.70 ± 2.09**	4.40 ± 1.02**	0.60 ± 0.13**	0.70 ± 0.09	4.16 ± 0.20	13.60 ± 0.34	44.90 ± 0.93	544.0 ± 9.83

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCCRS: *Musanga cecropioides* Crude Root Sap; DW: distilled water; WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Hematocrit; PLT: Platelet count; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$, when compared to normal control group

4.6.4 Histology of the Lungs

Plates 4.13, 4.14 and 4.15 shows the effects of *Musanga cecropioides* leaf extracts, root extracts and crude root sap on the histology of guinea pigs lungs in anti-asthmatic study. All ovalbumin sensitized groups showed presence of fluid mixed with desquamated cells and inflammatory cells blocking the airway.

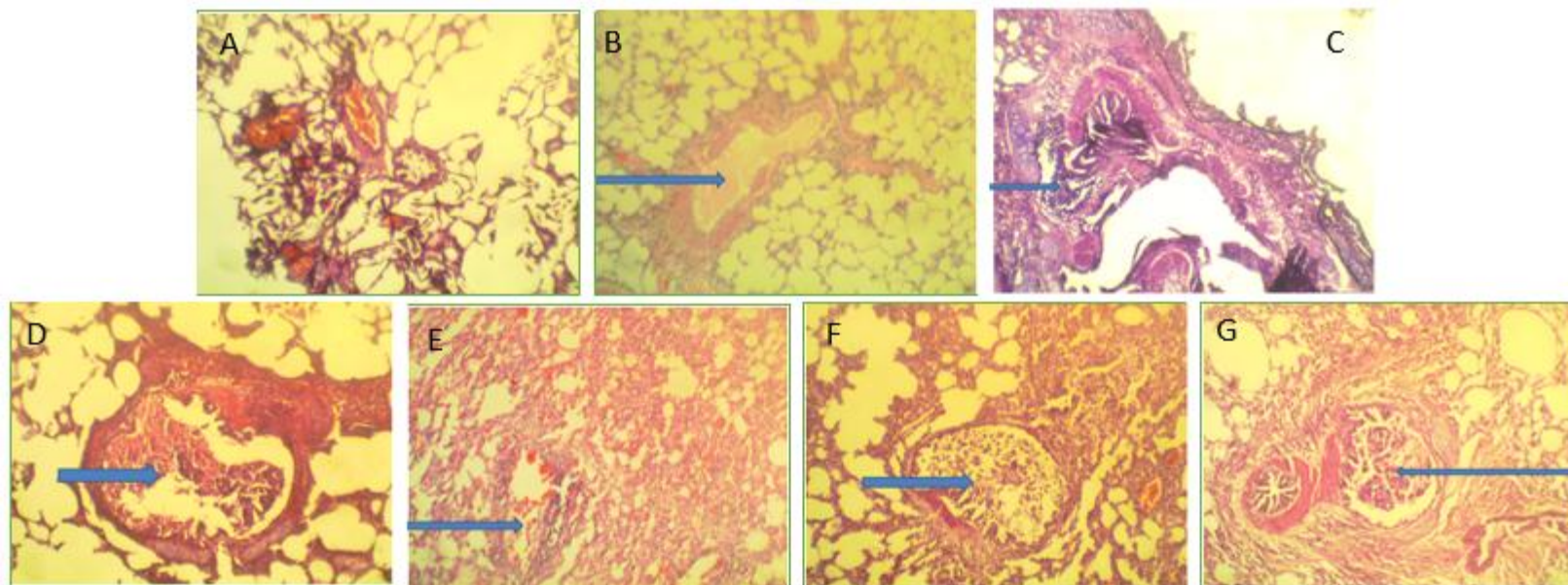


Plate 4.13: Effect of *Musanga cecropioides* leaf extracts on the histology of guinea pigs lungs in anti-asthmatic study.

(a.) Normal control + 1 ml/kg distilled water showing very scanty cells within the airway; (b.) Ovalbumin + 1 ml/kg distilled water arrow shows presence of fluid material blocking the airway; (c.) Ovalbumin + Salbutamol 0.5 mg/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells blocking the airway; (d.) Ovalbumin + MCL aq 50 mg/kg arrow shows airway filled with fluid and desquamated cells; (e.) Ovalbumin + MCL aq 100 mg/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells partially blocking the airway; (f.) Ovalbumin + MCL meth 50 mg/kg arrow shows airway blocked by desquamated cells and inflammatory cells; (g.) Ovalbumin + MCL meth 100 mg/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells blocking the airway; H and E; $\times 100$

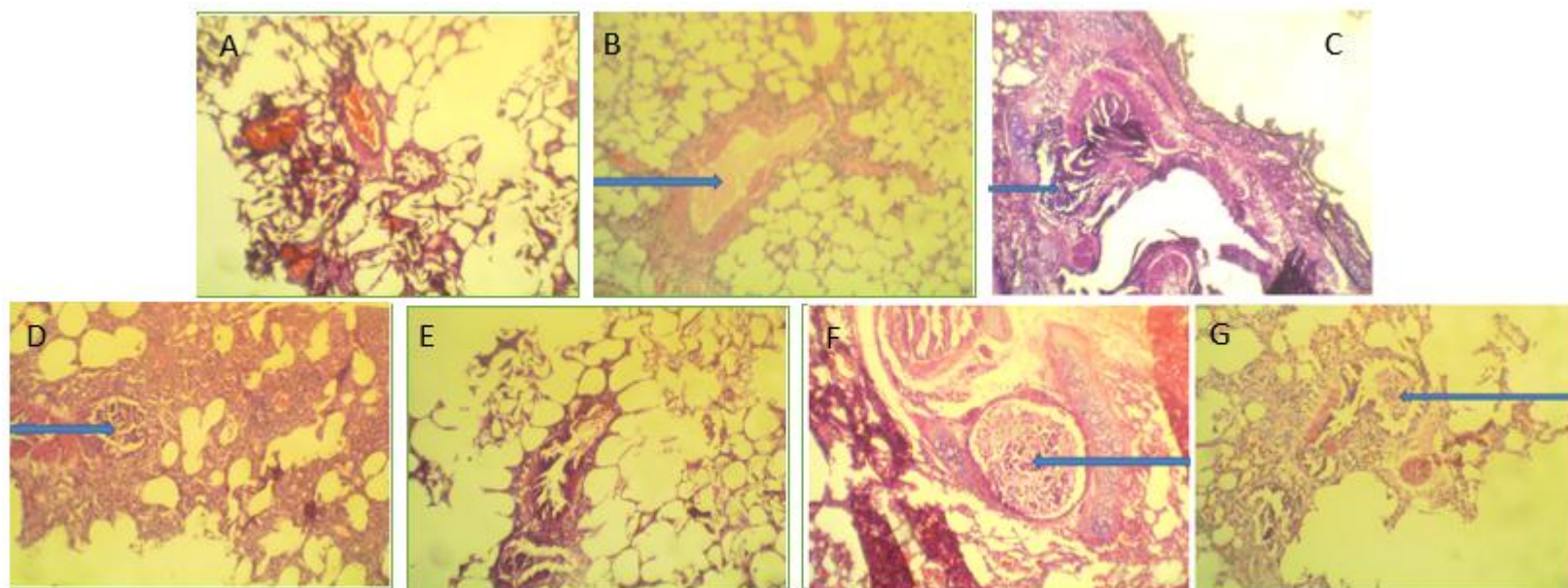


Plate 4.14: Effect of *Musanga cecropioides* root extracts on the histology of guinea pigs lungs in anti-asthmatic study.

(a.) Normal control + 1 ml/kg distilled water showing very scanty cells within the airway; (b.) Ovalbumin + 1 ml/kg distilled water arrow shows presence of fluid material blocking the airway; (c.) Ovalbumin + Salbutamol 0.5 mg/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells blocking the airway; (d.) Ovalbumin + MCR aq 50 mg/kg arrow shows airway blocked by desquamated cells and inflammatory cells; (e.) Ovalbumin + MCR aq 100 mg/kg arrow shows presence of fluid mixed with desquamated cells partially blocking the airway; (f.) Ovalbumin + MCR meth 50 mg/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells blocking the airway; (g.) Ovalbumin + MCR meth 100 mg/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells blocking the airway; H and E; $\times 100$

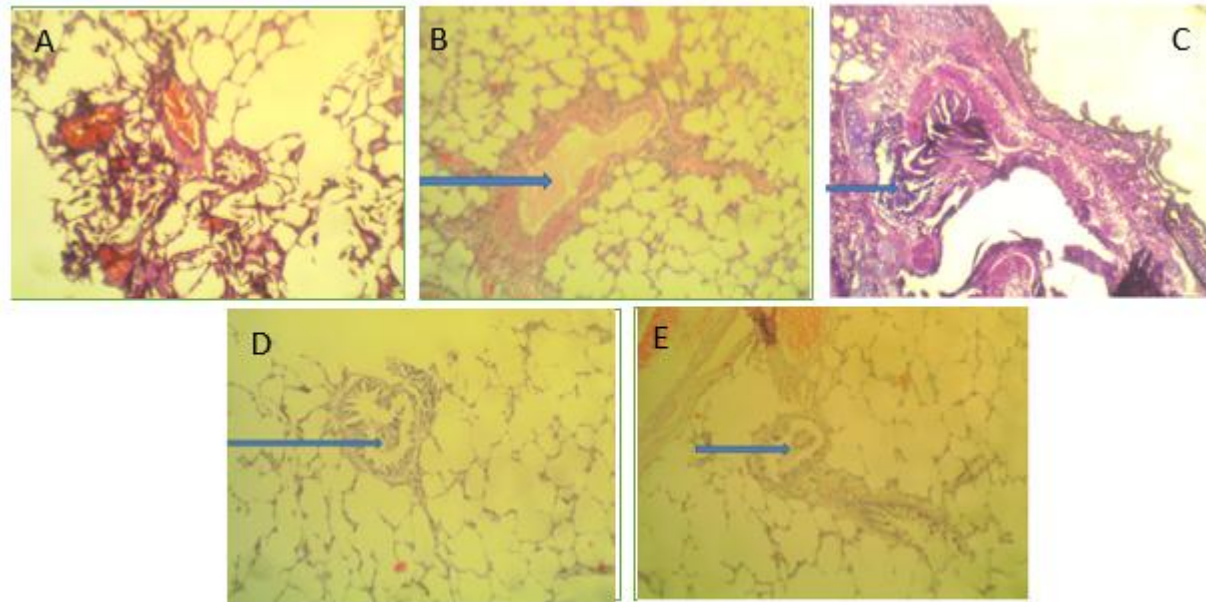


Plate 4.15: Effect of *Musanga cecropioides* crude root sap histology of guinea pigs lungs in anti-asthmatic study.

- (a.) Normal control + 1 ml/kg distilled water showing very scanty cells within the airway
- (b.) Ovalbumin + 1 ml/kg distilled water arrow shows presence of fluid material blocking the airway
- (c.) Ovalbumin + Salbutamol 0.5 mg/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells blocking the airway
- (d.) Ovalbumin + MCCRS 0.5 ml/kg arrow shows presence of fluid mixed with desquamated cells and inflammatory cells partially blocking the airway
- (e.) Ovalbumin + MCCRS 1 ml/kg arrow shows airway with fluid and inflammatory cells; H and E; $\times 100$

4.6.5 Trachea Wall Thickness

Figures 4.32, 4.33 and 4.34 show the results on the effect of *Musanga cecropioides* leaf extracts, root extracts and crude root sap on tracheal wall thickness in ovalbumin sensitized guinea pigs. The trachea wall thickness of the ovalbumin control group administered only 1 ml/kg distilled water was significantly higher than the non-sensitized control group at $P < 0.001$. All other treatments did not significantly alter the trachea wall thickness when compared with the non-sensitized control group.

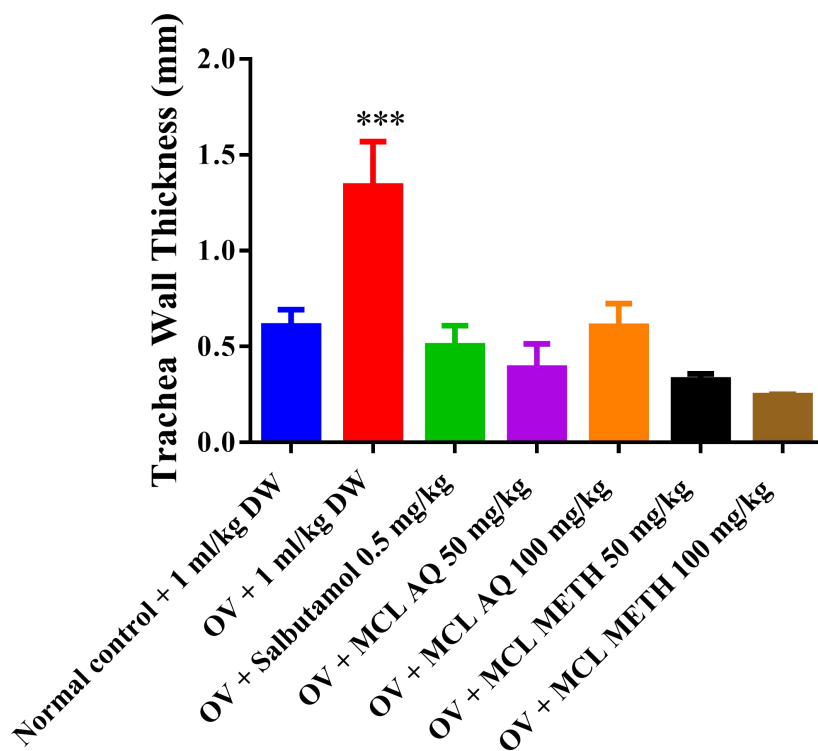


Figure 4.32: Effect of *Musanga cecropioides* leaf extracts on tracheal wall thickness in ovalbumin sensitized guinea pigs.

DW: distilled water; OV: Ovalbumin; MCL: *Musanga cecropioides* leaf; AQ: aqueous extract; METH: methanol extract; n=6 per group; $P < 0.05$.

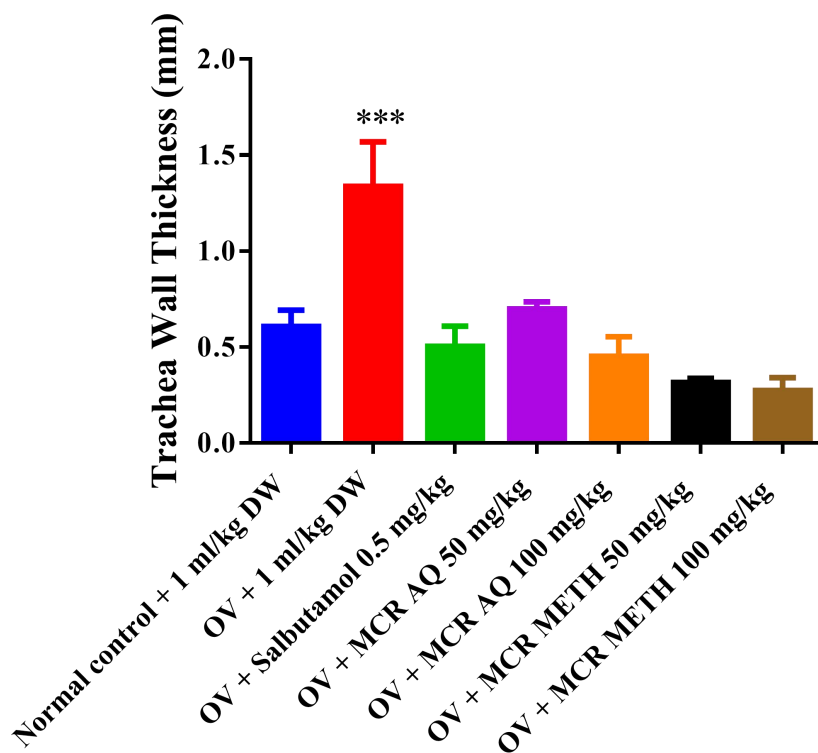


Figure 4.33: Effect of *Musanga cecropioides* root extracts on tracheal wall thickness in ovalbumin sensitized guinea pigs.

DW: distilled water; OV: Ovalbumin; MCR: *Musanga cecropioides* root; AQ: aqueous extract; METH: methanol extract; n=6 per group; $P < 0.05$.

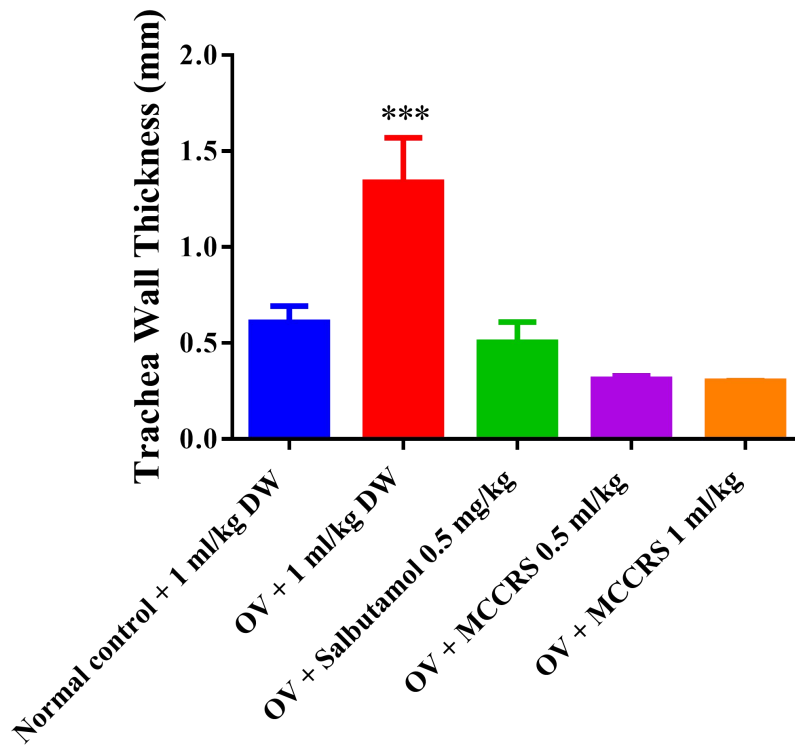


Figure 4.34: Effect of *Musanga cecropioides* crude root sap on tracheal wall thickness in ovalbumin sensitized guinea pigs.

DW: distilled water; OV: Ovalbumin; MCCRS: *Musanga cecropioides* crude root sap; n=6 per group; $P < 0.05$.

4.7 Anti Diabetic Study

4.7.1 Blood Glucose Levels

Tables 4.54, 4.55, 4.56, 4.57 and 4.58 show results on the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on blood sugar levels of STZ-induced diabetic rats in the 28 days anti-diabetic study.

In Table 4.54, *Musanga cecropioides* aqueous leaf extract at 50 mg/kg showed highly significantly reduced blood glucose level at $P < 0.001$ (104.5 ± 29.68 mg/dl) when compared with the diabetic control group (495.5 ± 19.69 mg/dl) on the 28th day of the experiment.

In Table 4.55, *Musanga cecropioides* methanol leaf extract 200 mg/kg showed highly significantly reduced blood glucose level at $P < 0.001$ (126.5 ± 24.68 mg/dl) when compared with the diabetic control group (495.5 ± 19.69 mg/dl) on the 28th day of the experiment.

In Table 4.56, *Musanga cecropioides* aqueous root extract 200 mg/kg showed highly significantly reduced and normal blood glucose level at $P < 0.001$ (76.67 ± 8.77 mg/dl) when compared with the diabetic control group (495.5 ± 19.69 mg/dl) on the 28th day of the experiment.

In Table 4.57, *Musanga cecropioides* methanol root extract 30 mg/kg showed significantly reduced blood glucose level at $P < 0.01$ (247.2 ± 51.99 mg/dl) when compared with the diabetic control group (495.5 ± 19.69 mg/dl) on the 28th day of the experiment. However, this extract showed the least potential in reducing elevated blood glucose levels.

In Table 4.58, *Musanga cecropioides* crude root sap at 2 ml/kg showed highly significantly reduced and normal blood glucose level at $P < 0.001$ (79.00 ± 7.16 mg/dl) when compared with the diabetic control group (495.5 ± 19.69 mg/dl) on the 28th day of the experiment.

Table 4.54: Effect of aqueous extracts of *Musanga cecropioides* leaves on blood sugar levels in STZ-induced diabetic rats

Treatment groups/Dose	Mean change of blood glucose (mg/dl) weeks after treatment					% reduction
	Day 1	Day 7	Day 14	Day 21	Day 28	
Normal control 1 ml/kg DW	88.17 ± 5.78	81.67 ± 1.91	75.83 ± 5.02	97.00 ± 6.45	79.33 ± 5.67	10.03
STZ control 1 ml/kg DW	469.2 ± 21.56	493.0 ± 27.78	473.8 ± 17.72	497.0 ± 18.63	495.5 ± 19.69	-5.61
STZ + Glibenclamide 10 mg/kg	476.3 ± 25.17	318.2 ± 61.79	365.0 ± 15.88	226.5 ± 65.64	179.5 ± 36.96***	62.31
STZ + MCL Aq 30 mg/kg	359.2 ± 0.17	362.0 ± 12.60	359.7 ± 19.47	329.5 ± 11.90	351.3 ± 13.80*	2.20
STZ + MCL Aq 50 mg/kg	445.5 ± 30.76	499.2 ± 19.17	415.5 ± 59.66	204.8 ± 36.63*	104.5 ± 29.68***	76.54
STZ + MCL Aq 100 mg/kg	362.3 ± 43.15	335.3 ± 13.35	265.3 ± 50.91	289.0 ± 59.84	245.3 ± 28.18**	32.29
STZ + MCL Aq 200 mg/kg	530.0 ± 14.31	456.0 ± 49.64	481.5 ± 7.38	441.0 ± 7.603	510.0 ± 0.45	3.77

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; DW: distilled water; STZ: Streptozotocin

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to diabetic control group

Treatment groups/Dose	Mean change of blood glucose (mg/dl) weeks after treatment					% reduction
	Day 1	Day 7	Day 14	Day 21	Day 28	
Normal control 1 ml/kg DW	88.17 ± 5.78	81.67 ± 1.91	75.83 ± 5.02	97.00 ± 6.45	79.33 ± 5.67	10.03
STZ control 1 ml/kg DW	469.2 ± 21.56	493.0 ± 27.78	473.8 ± 17.72	497.0 ± 18.63	495.5 ± 19.69	-5.61
STZ + Glibenclamide 10 mg/kg	476.3 ± 25.17	318.2 ± 61.79	365.0 ± 15.88	226.5 ± 65.64	179.5 ± 36.96***	62.31
STZ + MCL meth 30 mg/kg	377.7 ± 67.74	346.0 ± 67.61	311.7 ± 78.17	266.7 ± 62.91	244.7 ± 58.41**	35.21
STZ + MCL meth 50 mg/kg	437.0 ± 38.18	377.5 ± 52.26	318.8 ± 70.78	339.2 ± 75.60	288.8 ± 60.68*	33.91
STZ + MCL meth 100 mg/kg	382.0 ± 12.07	382.0 ± 12.07	377.0 ± 13.42	412.5 ± 33.32	303.0 ± 8.050	20.68
STZ + MCL meth 200 mg/kg	450.2 ± 32.57	346.3 ± 40.42	453.0 ± 66.91	248.2 ± 52.90	126.5 ± 24.68***	71.90

Table 4.55: Effect of methanol extracts of *Musanga cecropioides* leaves on blood sugar levels in STZ-induced diabetic rats

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* Leaves; Meth: Methanol extract; DW: distilled water

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to diabetic control group

Treatment groups/Dose	Mean change of blood glucose (mg/dl) weeks after treatment					% reduction
	Day 1	Day 7	Day 14	Day 21	Day 28	
Normal control 1 ml/kg DW	88.17 $\pm$ 5.78	81.67 $\pm$ 1.91	75.83 $\pm$ 5.02	97.00 $\pm$ 6.45	79.33 $\pm$ 5.67	10.03
STZ control 1 ml/kg DW	469.2 $\pm$ 21.56	493.0 $\pm$ 27.78	473.8 $\pm$ 17.72	497.0 $\pm$ 18.63	495.5 $\pm$ 19.69	-5.61
STZ + Glibenclamide 10 mg/kg	476.3 $\pm$ 25.17	318.2 $\pm$ 61.79	365.0 $\pm$ 15.88	226.5 $\pm$ 65.64	179.5 $\pm$ 36.96***	62.31
STZ + MCR Aq 30 mg/kg	380.2 $\pm$ 59.96	334.0 $\pm$ 47.06	293.3 $\pm$ 50.89	268.3 $\pm$ 52.89	212.8 $\pm$ 53.65***	44.03
STZ + MCR Aq 50 mg/kg	513.0 $\pm$ 16.23	414.7 $\pm$ 22.27	218.0 $\pm$ 46.24**	218.0 $\pm$ 29.75*	253.3 $\pm$ 68.68**	50.62
STZ + MCR Aq 100 mg/kg	386.3 $\pm$ 54.86	289.7 $\pm$ 32.13	229.3 $\pm$ 30.86*	234.3 $\pm$ 45.42	225.3 $\pm$ 37.38***	41.68
STZ + MCR Aq 200 mg/kg	477.0 $\pm$ 45.73	491.3 $\pm$ 21.74	385.7 $\pm$ 21.97	234.7 $\pm$ 31.48	76.67 $\pm$ 8.77***	83.93

Table 4.56: Effect of aqueous extracts of *Musanga cecropioides* root on blood sugar levels in STZ-induced diabetic rats

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; DW: distilled water

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to diabetic control group

Table 4.57: Effect of methanol extract of *Musanga cecropioides* root on blood sugar levels in STZ-induced diabetic rats

Treatment groups/Dose	Mean change of blood glucose (mg/dl) weeks after treatment					% reduction
	Day 1	Day 7	Day 14	Day 21	Day 28	
Normal control 1 ml/kg DW	88.17 ± 5.78	81.67 ± 1.91	75.83 ± 5.02	97.00 ± 6.45	79.33 ± 5.67	10.03
STZ control 1 ml/kg DW	469.2 ± 21.56	493.0 ± 27.78	473.8 ± 17.72	497.0 ± 18.63	495.5 ± 19.69	-5.61
STZ + Glibenclamide 10 mg/kg	476.3 ± 25.17	318.2 ± 61.79	365.0 ± 15.88	226.5 ± 65.64	179.5 ± 36.96***	62.31
STZ + MCR meth 30 mg/kg	357.3 ± 26.27	460.0 ± 6.33	547.2 ± 3.27	286.2 ± 40.15	247.2 ± 51.99**	30.81
STZ + MCR meth 50 mg/kg	472.7 ± 26.15	413.3 ± 27.04	306.0 ± 25.60	375.2 ± 70.23	417.2 ± 54.25	11.74
STZ + MCR meth 100 mg/kg	375.7 ± 25.79	337.5 ± 48.23	341.2 ± 40.10	320.5 ± 60.55	269.8 ± 51.23**	28.19
STZ + MCR meth 200 mg/kg	463.3 ± 33.33	352.0 ± 48.71	332.7 ± 19.19	307.5 ± 15.06	299.7 ± 3.11	35.31

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* Root; Meth: Methanol extract; DW: distilled water

** Significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to diabetic control group

Table 4.58: Effect of *Musanga cecropioides* crude root sap on blood sugar levels in STZ-induced diabetic rats

Treatment groups/Dose	Mean change of blood glucose (mg/dl) weeks after treatment					% reduction
	Day 1	Day 7	Day 14	Day 21	Day 28	
Normal control 1 ml/kg DW	88.17 ± 5.78	81.67 ± 1.91	75.83 ± 5.02	97.00 ± 6.45	79.33 ± 5.67	10.03
STZ control 1 ml/kg DW	469.2 ± 21.56	493.0 ± 27.78	473.8 ± 17.72	497.0 ± 18.63	495.5 ± 19.69	-5.61
STZ + Glibenclamide 10 mg/kg	476.3 ± 25.17	318.2 ± 61.79	365.0 ± 15.88	226.5 ± 65.64	179.5 ± 36.96***	62.31
STZ + MCCRS 0.5 ml/kg	378.5 ± 45.56	304.5 ± 82.98	380.0 ± 56.22	278.0 ± 83.12	219.3 ± 51.53***	42.06
STZ + MCCRS 1 ml/kg	424.3 ± 34.09	449.2 ± 39.25	507.5 ± 5.40	265.3 ± 25.39	280.2 ± 18.85*	33.96
STZ + MCCRS 2 ml/kg		295.5 ± 49.46	217.5	± 207.2	± 79.00 ± 7.16***	
	515.0 ± 5.37		33.32**	79.79*		84.66
STZ + MCCRS 3 ml/kg	551.0 ± 14.03	368.0 ± 49.93	436.7 ± 72.26	335.3 ± 84.65	394.0 ± 34.18	28.49

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* Crude Root Sap; DW: distilled water

* Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to diabetic control group

4.7.2 Changes in Body Weight

Tables 4.59, 4.60, 4.61, 4.62 and 4.63 show results on the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on mean body weight changes of STZ-induced diabetic rats in the 28 days anti-diabetic study. No significant difference was observed (at $P < 0.05$) in the mean body weights of experimental animals in all treatment groups when compared to the diabetic control group.

Table 4.59: Effect of aqueous extracts of *Musanga cecropioides* leaves on the body weights of STZ-induced diabetic rats

Treatment groups/Dose	Mean weight of animals (grams) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Normal control + 1 ml/kg DW	189.6 ± 13.56	177.7 ± 15.14	169.1 ± 13.81	176.9 ± 8.88	179.3 ± 7.86
STZ control + 1 ml/kg DW	147.2 ± 6.99	141.9 ± 8.92	135.8 ± 7.61	134.6 ± 7.42	135.3 ± 7.39
STZ + Glibenclamide 10 mg/kg	146.1 ± 8.42	142.2 ± 5.86	150.4 ± 4.47	142.5 ± 4.13	143.1 ± 5.79
STZ + MCL Aq 30 mg/kg	172.3 ± 6.00	163.7 ± 4.19	155.0 ± 4.91	160.4 ± 4.50	165.7 ± 5.09
STZ + MCL Aq 50 mg/kg	150.0 ± 3.66	138.9 ± 6.47	157.6 ± 7.37	147.1 ± 7.89	149.2 ± 7.83
STZ + MCL Aq 100 mg/kg	160.8 ± 14.76	166.1 ± 13.07	157.8 ± 11.71	169.6 ± 9.08	159.4 ± 13.70
STZ + MCL Aq 200 mg/kg	120.4 ± 8.82	121.2 ± 12.39	120.7 ± 9.35	115.3 ± 7.15	113.8 ± 6.80

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; DW: distilled water

No significant difference in treatment groups, when compared to diabetic control group

Table 4.60: Effect of methanol extracts of *Musanga cecropioides* leaves on the body weights of STZ-induced diabetic rats

Treatment groups/Dose	Mean weight of animals (grams) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Normal control + 1 ml/kg DW	189.6 ± 13.56	177.7 ± 15.14	169.1 ± 13.81	176.9 ± 8.88	179.3 ± 7.86
STZ control + 1 ml/kg DW	147.2 ± 6.99	141.9 ± 8.92	135.8 ± 7.61	134.6 ± 7.42	135.3 ± 7.39
STZ + Glibenclamide 10 mg/kg	146.1 ± 8.42	142.2 ± 5.86	150.4 ± 4.47	142.5 ± 4.13	143.1 ± 5.79
STZ + MCL Meth 30 mg/kg	149.4 ± 8.58	138.0 ± 7.89	131.5 ± 7.57	127.5 ± 7.90	133.0 ± 7.51
STZ + MCL Meth 50 mg/kg	150.5 ± 2.85	158.3 ± 5.36	147.0 ± 7.62	155.3 ± 8.66	156.9 ± 9.53
STZ + MCL Meth 100 mg/kg	171.4 ± 0.81	172.8 ± 1.45	154.5 ± 1.54	151.3 ± 0.54	151.4 ± 0.60
STZ + MCL Meth 200 mg/kg	136.2 ± 11.01	146.9 ± 14.5	168.7 ± 21.77	158.7 ± 22.01	162.4 ± 21.84

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* Leaves; Meth: Methanol extract; DW: distilled water

No significant difference in treatment groups, when compared to diabetic control group

Table 4.61: Effect of aqueous extracts of *Musanga cecropioides* root on the weight of STZ-induced diabetic rats

Treatment groups/Dose	Mean weight of animals (grams) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Normal control + 1 ml/kg DW	189.6 ± 13.56	177.7 ± 15.14	169.1 ± 13.81	176.9 ± 8.88	179.3 ± 7.86
STZ control + 1 ml/kg DW	147.2 ± 6.99	141.9 ± 8.92	135.8 ± 7.61	134.6 ± 7.42	135.3 ± 7.39
STZ + Glibenclamide 10 mg/kg	146.1 ± 8.42	142.2 ± 5.86	150.4 ± 4.47	142.5 ± 4.13	143.1 ± 5.79
STZ + MCR aq 30 mg/kg	189.7 ± 15.34	173.1 ± 15.90	156.9 ± 11.00	159.1 ± 10.62	158.6 ± 13.21
STZ + MCR aq 50 mg/kg	144.1 ± 10.20	137.2 ± 12.47	138.0 ± 14.86	143.8 ± 17.94	142.8 ± 17.35
STZ + MCR aq 100 mg/kg	148.1 ± 9.04	130.1 ± 4.15	138.6 ± 4.86	145.9 ± 4.29	150.9 ± 5.32
STZ + MCR aq 200 mg.kg	139.3 ± 5.14	138.2 ± 4.41	139.6 ± 3.89	132.2 ± 5.32	129.1 ± 4.67

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; DW: distilled water

No significant difference in treatment groups, when compared to diabetic control group

Table 4.62: Effect of methanol extracts of *Musanga cecropioides* root on the weight of STZ-induced diabetic rats

Treatment groups/Dose	Mean weight of animals (grams) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Normal control + 1 ml/kg DW	189.6 ± 13.56	177.7 ± 15.14	169.1 ± 13.81	176.9 ± 8.88	179.3 ± 7.86
STZ control + 1 ml/kg DW	147.2 ± 6.99	141.9 ± 8.92	135.8 ± 7.61	134.6 ± 7.42	135.3 ± 7.39
STZ + Glibenclamide 10 mg/kg	146.1 ± 8.42	142.2 ± 5.86	150.4 ± 4.47	142.5 ± 4.13	143.1 ± 5.79
STZ + MCR meth 30 mg/kg	171.5 ± 2.19	155.9 ± 0.83	150.6 ± 1.43	140.9 ± 6.87	138.3 ± 6.02
STZ + MCR meth 50 mg/kg	132.5 ± 10.42	118.1 ± 5.96	121.9 ± 5.71	126.8 ± 5.20	129.7 ± 3.35
STZ + MCR meth 100 mg/kg	181.7 ± 7.35	172.3 ± 5.44	165.2 ± 7.53	162.1 ± 6.51	164.8 ± 6.93
STZ + MCR meth 200 mg/kg	144.0 ± 1.79	150.0 ± 7.76	142.4 ± 3.78	143.7 ± 2.48	136.5 ± 2.33

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* Root; Meth: Methanol extract; DW: distilled water

No significant difference in treatment groups, when compared to diabetic control group

Table 4.63: Effect of *Musanga cecropioides* crude root sap on the weight of STZ-induced diabetic rats

Treatment groups/Dose	Mean weight of animals (grams) during experiment				
	Day 1	Day 7	Day 14	Day 21	Day 28
Normal control + 1 ml/kg DW	189.6 ± 13.56	177.7 ± 15.14	169.1 ± 13.81	176.9 ± 8.88	179.3 ± 7.86
STZ control + 1 ml/kg DW	147.2 ± 6.99	141.9 ± 8.92	135.8 ± 7.61	134.6 ± 7.42	135.3 ± 7.39
STZ + Glibenclamide 10 mg/kg	146.1 ± 8.42	142.2 ± 5.86	150.4 ± 4.47	142.5 ± 4.13	143.1 ± 5.79
STZ + MCCRS 0.5 ml/kg	108.9 ± 10.35	103.2 ± 14.58	117.9 ± 21.20	124.2 ± 24.55	132.2 ± 26.02
STZ + MCCRS 1 ml/kg	129.6 ± 13.66	113.1 ± 12.72	111.9 ± 14.05	108.6 ± 12.73	108.5 ± 11.97
STZ + MCCRS 2 ml/kg	127.9 ± 13.24	125.6 ± 11.17	140.2 ± 11.34	128.7 ± 10.90	134.0 ± 11.38
STZ + MCCRS 3 ml/kg	113.5 ± 3.17	111.1 ± 2.58	117.7 ± 2.72	113.1 ± 2.117	107.2 ± 2.47

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* Crude Root Sap; DW: distilled water

No significant difference in treatment groups, when compared to diabetic control group

4.7.3 Organ to Body Weight Ratio

Tables 4.64, 4.65, 4.66, 4.67 and 4.68 shows results on the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on organ to body weight ratios of STZ-induced diabetic rats in the 28 days anti-diabetic study. All treatment groups showed significantly different spleen, heart, liver, kidney, lungs and brain to body weight values at $P < 0.05$, $P < 0.01$ and $P < 0.001$, when compared to normal control group.

Table 4.64: Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with aqueous extracts of *Musanga cecropioides* leaves

Groups	Organ to body weight ratio (g/kg)						
	B: BW	H: BW	L: BW	LG: BW	K: BW	S: BW	P: BW
Normal control + 1 ml/kg DW	7.35 ± 0.14	3.65 ± 0.13	32.33 ± 0.45	9.49 ± 1.64	5.63 ± 0.13	4.79 ± 0.22	2.98 ± 0.40
STZ control + 1 ml/kg DW	10.16 ± 0.27**	3.80 ± 0.14	42.70 ± 2.82***	8.61 ± 0.55	8.72 ± 0.63***	4.12 ± 1.24	2.76 ± 0.47
STZ + Glibenclamide 10 mg/kg	10.34 ± 0.28**	4.18 ± 0.16	43.35 ± 1.35***	7.70 ± 0.23	8.03 ± 0.10***	3.23 ± 0.28*	3.14 ± 0.28
STZ + MCL Aq 30 mg/kg	9.39 ± 0.01	4.66 ± 0.02***	40.87 ± 2.00**	8.43 ± 0.34	8.43 ± 0.51***	4.28 ± 0.52	2.62 ± 0.30
STZ + MCL Aq 50 mg/kg	11.13 ± 0.73***	4.10 ± 0.22	32.17 ± 1.14	7.83 ± 0.29	7.53 ± 0.22**	2.74 ± 0.24**	3.58 ± 0.17
STZ + MCL Aq 100 mg/kg	8.99 ± 0.56	3.61 ± 0.12	37.56 ± 2.79	10.86 ± 1.15	7.31 ± 0.73*	3.82 ± 0.42	2.39 ± 0.08
STZ + MCL Aq 200 mg/kg	12.35 ± 0.03***	3.94 ± 0.13	44.41 ± 1.21***	8.25 ± 0.81	11.54 ± 0.33***	2.12 ± 0.38***	2.63 ± 0.35

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; DW: distilled water; S: Spleen; H: Heart; L: Liver; K: Kidney; LG: Lungs; B: Brain; BW: Body weight; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.65: Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with methanol extracts of *Musanga cecropioides* Leaves

Groups	Organ to body weight ratio (g/kg)						
	B: BW	H: BW	L: BW	LG: BW	K: BW	S: BW	P: BW
Normal control + 1 ml/kg DW	7.35 ± 0.14	3.65 ± 0.13	32.33 ± 0.45	9.49 ± 1.64	5.63 ± 0.13	4.79 ± 0.22	2.98 ± 0.40
STZ control + 1 ml/kg DW	10.16 ± 0.27**	3.80 ± 0.14	42.70 ± 2.82***	8.61 ± 0.55	8.72 ± 0.63***	4.12 ± 1.24	2.76 ± 0.47
STZ + Glibenclamide 10 mg/kg	10.34 ± 0.28**	4.18 ± 0.16	43.35 ± 1.35***	7.70 ± 0.23	8.03 ± 0.10***	3.23 ± 0.28*	3.14 ± 0.28
STZ + MCL meth 30 mg/kg	10.08 ± 0.39*	3.84 ± 0.06	43.97 ± 1.84***	7.99 ± 0.83	7.64 ± 0.04**	5.49 ± 0.89	2.45 ± 0.07
STZ + MCL meth 50 mg/kg	9.05 ± 0.47	3.71 ± 0.27	40.24 ± 4.09*	7.88 ± 0.21	7.50 ± 0.85**	3.52 ± 0.04	2.13 ± 0.05
STZ + MCL meth 100 mg/kg	9.23 ± 0.22	5.17 ± 0.10***	41.78 ± 3.19**	22.14 ± 0.51***	8.45 ± 0.28***	5.76 ± 0.54	2.10 ± 0.28*
STZ + MCL meth 200 mg/kg	11.12 ± 0.87***	4.11 ± 0.13	37.51 ± 1.43	7.92 ± 0.47	8.74 ± 0.37***	2.20 ± 0.25***	4.40 ± 0.22***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* Leaves; Meth: Methanol extract; DW: distilled water; S: Spleen; H: Heart; L: Liver; K: Kidney; LG: Lungs; B: Brain; BW: Body weight; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.66: Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with aqueous extracts of *Musanga cecropioides* root

Groups	Organ to body weight ratio (g/kg) $\times 10^{-3}$						
	B: BW	H: BW	L: BW	LG: BW	K: BW	S: BW	P: BW
Normal control + 1 ml/kg DW	7.35 $\pm$ 0.14	3.65 $\pm$ 0.13	32.33 $\pm$ 0.45	9.49 $\pm$ 1.64	5.63 $\pm$ 0.13	4.79 $\pm$ 0.22	2.98 $\pm$ 0.40
STZ control + 1 ml/kg DW	10.16 $\pm$ 0.27**	3.80 $\pm$ 0.14	42.70 $\pm$ 2.82***	8.61 $\pm$ 0.55	8.72 $\pm$ 0.63***	4.12 $\pm$ 1.24	2.76 $\pm$ 0.47
STZ + Glibenclamide 10 mg/kg	10.34 $\pm$ 0.28**	4.18 $\pm$ 0.16	43.35 $\pm$ 1.35***	7.70 $\pm$ 0.23	8.03 $\pm$ 0.10***	3.23 $\pm$ 0.28*	3.14 $\pm$ 0.28
STZ + MCR Aq 30 mg/kg	9.46 $\pm$ 0.19	3.77 $\pm$ 0.12	33.15 $\pm$ 0.59	6.12 $\pm$ 0.33***	7.31 $\pm$ 0.32*	3.92 $\pm$ 0.21	1.77 $\pm$ 0.18***
STZ + MCR Aq 50 mg/kg	6.97 $\pm$ 0.02	3.67 $\pm$ 0.21	36.06 $\pm$ 0.82	5.98 $\pm$ 0.19***	6.34 $\pm$ 0.28	5.71 $\pm$ 0.11	1.57 $\pm$ 0.32***
STZ + MCR Aq 100 mg/kg	8.84 $\pm$ 0.47	3.15 $\pm$ 0.01	43.25 $\pm$ 2.21***	6.91 $\pm$ 0.29*	8.40 $\pm$ 0.03***	4.95 $\pm$ 0.28	2.77 $\pm$ 0.01
STZ + MCR Aq 200 mg/kg	11.94 $\pm$ 0.24***	3.26 $\pm$ 0.18	38.11 $\pm$ 0.08	8.09 $\pm$ 0.04	8.83 $\pm$ 0.16***	2.50 $\pm$ 0.13***	3.51 $\pm$ 0.13

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; n=6; MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; DW: distilled water; S: Spleen; H: Heart; L: Liver; K: Kidney; LG: Lungs; B: Brain; BW: Body weight; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.67: Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with methanol extracts of *Musanga cecropioides* root

Groups	Organ to body weight ratio (g/kg)						
	B: BW	H: BW	L: BW	LG: BW	K: BW	S: BW	P: BW
Normal control + 1 ml/kg DW	7.35 ± 0.14	3.65 ± 0.13	32.33 ± 0.45	9.49 ± 1.64	5.63 ± 0.13	4.79 ± 0.22	2.98 ± 0.40
STZ control + 1 ml/kg DW	10.16 ± 0.27**	3.80 ± 0.14	42.70 ± 2.82***	8.61 ± 0.55	8.72 ± 0.63***	4.12 ± 1.24	2.76 ± 0.47
STZ + Glibenclamide 10 mg/kg	10.34 ± 0.28**	4.18 ± 0.16	43.35 ± 1.35***	7.70 ± 0.23	8.03 ± 0.10***	3.23 ± 0.28*	3.14 ± 0.28
STZ + MCR meth 30 mg/kg	9.95 ± 0.12*	3.69 ± 0.22	51.35 ± 1.22***	17.34 ± 0.39***	8.77 ± 0.29***	3.36 ± 0.32	2.04 ± 0.51*
STZ + MCR meth 50 mg/kg	11.42 ± 0.01***	4.47 ± 0.18***	39.24 ± 0.83	5.71 ± 0.42***	7.95 ± 0.31***	5.38 ± 0.58	1.33 ± 0.33***
STZ + MCR meth 100 mg/kg	9.31 ± 0.22	3.69 ± 0.14	40.61 ± 1.32*	8.71 ± 0.32	6.56 ± 0.34	4.68 ± 0.32	2.98 ± 0.21
STZ + MCR meth 200 mg/kg	10.28 ± 0.03**	3.52 ± 0.33	36.41 ± 1.22	7.76 ± 0.51	8.29 ± 0.50***	2.06 ± 0.53***	3.45 ± 0.31

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCR: *Musanga cecropioides* Root; Meth: Methanol extract; DW: distilled water; S: Spleen; H: Heart; L: Liver; K: Kidney; LG: Lungs; B: Brain; BW: Body weight; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.68: Comparison between ratios of weight of organ in grams (g) to weight of animal in kilograms (kg) treated with *Musanga cecropioides* crude root sap

Groups	Organ to body weight ratio (g/kg)						
	B: BW	H: BW	L: BW	LG: BW	K: BW	S: BW	P: BW
Normal control + 1 ml/kg DW	7.35 ± 0.14	3.65 ± 0.13	32.33 ± 0.45	9.49 ± 1.64	5.63 ± 0.13	4.79 ± 0.22	2.98 ± 0.40
STZ control + 1 ml/kg DW	10.16 ± 0.27**	3.80 ± 0.14	42.70 ± 2.82***	8.61 ± 0.55	8.72 ± 0.63***	4.12 ± 1.24	2.76 ± 0.47
STZ + Glibenclamide 10 mg/kg	10.34 ± 0.28**	4.18 ± 0.16	43.35 ± 1.35***	7.70 ± 0.23	8.03 ± 0.10***	3.23 ± 0.28*	3.14 ± 0.28
STZ + MCCRS 0.5 ml/kg	11.53 ± 1.63***	2.75 ± 0.21***	43.26 ± 4.24***	8.08 ± 1.05	9.22 ± 0.95***	3.54 ± 0.11	4.29 ± 0.62***
STZ + MCCRS 1 ml/kg	15.77 ± 1.40***	4.82 ± 2.86***	48.63 ± 0.98***	8.08 ± 0.27	10.01 ± 0.32***	3.27 ± 0.51	4.25 ± 0.08***
STZ + MCCRS 2 ml/kg	9.18 ± 0.71	3.23 ± 0.91	29.67 ± 1.81	9.57 ± 1.01	6.79 ± 0.13	3.75 ± 0.44	3.17 ± 0.13
STZ + MCCRS 3 ml/kg	5.80 ± 0.39	6.79 ± 0.31***	44.15 ± 1.51***	12.68 ± 9.33**	10.82 ± 0.19***	3.84 ± 0.51	6.29 ± 0.28***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCCRS: *Musanga cecropioides* Crude Root Sap; DW: distilled water; S: Spleen; H: Heart; L: Liver; K: Kidney; LG: Lungs; B: Brain; BW: Body weight; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.4 Haematology

Tables 4.69, 4.70, 4.71, 4.72 and 4.73 shows results on the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on haematological parameters of STZ-induced diabetic rats in the 28 days anti-diabetic study.

In Table 4.69, *Musanga cecropioides* aqueous leaf extract at all administered doses significantly altered some of the haematological parameters at $P < 0.05$, $P < 0.01$ and $P < 0.001$, while some values were not significantly different when compared to normal control group.

In Table 4.70, *Musanga cecropioides* methanol leaf extract at 50 mg/kg significantly increased the white blood cell count ($11.65 \pm 1.05 \times 10^3/\text{uL}$) and lymphocyte count ($10.50 \pm 0.98 \times 10^3/\text{uL}$) at $P < 0.01$ and $P < 0.001$ respectively while at a dose of 200 mg/kg the red blood cell count ($4.59 \pm 0.56 \times 10^6/\text{UL}$) was significantly reduced at $P < 0.001$ when compared to the normal control group. Other parameters were not significantly altered.

In Table 4.71, *Musanga cecropioides* aqueous root extract at 30 mg/kg significantly increased the platelet count at $P < 0.001$, 50 mg/kg significantly increased the lymphocyte and platelet count at $P < 0.01$, while the dose of 200 mg/kg significantly increased the haemoglobin and haematocrit concentration at $P < 0.05$ and $P < 0.001$ respectively.

In Table 4.72, *Musanga cecropioides* methanol root extract at 30 mg/kg significantly increased the white blood cell and monocyte counts at $P < 0.001$, at 50 mg/kg red blood

cell count, haemoglobin and haematocrit concentration were significantly reduced at $P < 0.001$, at 100 mg/kg red blood cell count was significantly increased at $P < 0.001$ and the dose of 200 mg/kg, lymphocyte count significantly increased while red blood cell count significantly reduced at $P < 0.001$.

In Table 4.73, *Musanga cecropioides* crude root sap at all administered doses significantly reduced the red blood cell count (at $P < 0.05$ and $P < 0.001$) while the haematocrit was significantly increased (at $P < 0.05$, $P < 0.01$ and $P < 0.001$) when compared to the normal control group. All other haematological parameters were not significantly altered when compared to the normal control group.

Table 4.69: Effect of aqueous extract of *Musanga cecropioides* leaves on the haematological parameters of STZ-induced diabetic rats

Parameters	WBC 10 ³ /uL	LYM 10 ³ /uL	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ UL	HGB g/dL	HCT %	PLT 10 ³ /uL
Normal control + 1 ml/kg DW	8.32 ± 0.54	5.68 ± 0.50	0.87 ± 0.27	1.80 ± 0.79	7.03 ± 0.14	12.97 ± 0.25	40.92 ± 1.25	544.7 ± 103.3
STZ control + 1 ml/kg DW	9.00 ± 1.69	5.12 ± 0.71	0.93 ± 0.25	2.43 ± 1.08	5.63 ± 0.81**	11.83 ± 1.15	41.00 ± 3.40	525.3 ± 122.8
STZ + Glibenclamide 10 mg/kg	9.22 ± 1.10	6.48 ± 0.93	1.03 ± 0.28	1.70 ± 0.29	6.40 ± 0.42	15.08 ± 0.50*	52.00 ± 0.76***	787.2 ± 119.3**
STZ + MCL Aq 30 mg/kg	4.90 ± 1.22**	3.20 ± 0.24*	0.50 ± 0.33	1.20 ± 0.04	7.18 ± 0.22	14.90 ± 0.73	52.00 ± 1.24***	933.0 ± 61.57
STZ + MCL Aq 50 mg/kg	8.53 ± 1.12	6.87 ± 0.86	0.68 ± 0.16	0.98 ± 0.16	5.75 ± 0.10**	14.53 ± 0.30	53.65 ± 2.25***	370.7 ± 67.61***
STZ + MCL Aq 100 mg/kg	7.43 ± 0.21	4.97 ± 0.63	0.60 ± 0.06	1.87 ± 0.40	8.23 ± 0.12*	15.57 ± 0.31**	50.93 ± 1.13***	1077.0 ± 181.8
STZ + MCL Aq 200 mg/kg	22.30 ± 3.20***	12.70 ± 0.03***	2.20 ± 0.38***	7.40 ± 0.38	4.17 ± 0.32***	12.00 ± 0.22	34.90 ± 3.57	384.0 ± 32.45

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCL: *Musanga cecropioides* Leaves; Aq: Aqueous extract; DW: distilled water; WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.70: Effect of methanol extract of *Musanga cecropioides* leaves on the haematological parameters of STZ-induced diabetic rats

Parameters	WBC 10 ³ /uL	LYM 10 ³ /uL	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ UL	HGB g/dL	HCT %	PLT 10 ³ /uL
Normal control + 1 ml/kg DW	8.32 ± 0.54	5.68 ± 0.50	0.87 ± 0.27	1.80 ± 0.79	7.03 ± 0.14	12.97 ± 0.25	40.92 ± 1.25	544.7 ± 103.3
STZ control + 1 ml/kg DW	9.00 ± 1.69	5.12 ± 0.71	0.93 ± 0.25	2.43 ± 1.08	5.63 ± 0.81**	11.83 ± 1.15	41.00 ± 3.40	525.3 ± 122.8
STZ + Glibenclamide 10 mg/kg	9.22 ± 1.10	6.48 ± 0.93	1.03 ± 0.28	1.70 ± 0.29	6.40 ± 0.42	15.08 ± 0.50*	52.00 ± 0.76***	787.2 ± 119.3**
STZ + MCL Meth 30 mg/kg	8.87 ± 0.80	6.87 ± 0.55	0.93 ± 0.43	1.07 ± 0.45	7.20 ± 0.28	14.20 ± 0.75	45.90 ± 1.55	577.3 ± 54.04
STZ + MCL Meth 50 mg/kg	11.65 ± 1.05**	10.50 ± 0.98***	0.55 ± 0.02	0.65 ± 0.07	7.47 ± 0.09	14.05 ± 0.11	45.10 ± 1.21	680.5 ± 83.41
STZ + MCL Meth 100 mg/kg	9.40 ± 1.30	4.70 ± 0.03	1.40 ± 0.03	3.30 ± 0.04	6.42 ± 0.28	11.60 ± 0.38	37.80 ± 1.28	281.0 ± 79.65
STZ + MCL Meth 200 mg/kg	7.30 ± 0.10	5.90 ± 0.36	0.57 ± 0.11	0.83 ± 0.21	4.59 ± 0.56***	11.53 ± 1.17	43.37 ± 4.16	735.7 ± 32.52

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCL: *Musanga cecropioides* Leaves; Meth: Methanol extract; DW: distilled water; WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.71: Effect of aqueous extract of *Musanga cecropioides* root on the haematological parameters of STZ-induced diabetic rats

Parameters	WBC 10 ⁻³ /uL	LYM 10 ⁻³ /uL	MON 10 ⁻³ /uL	GRAN 10 ⁻³ /uL	RBC 10 ⁻⁶ UL	HGB g/dL	HCT %	PLT 10 ⁻³ /uL
Normal control + 1 ml/kg DW	8.32 ± 0.54	5.68 ± 0.50	0.87 ± 0.27	1.80 ± 0.79	7.03 ± 0.14	12.97 ± 0.25	40.92 ± 1.25	544.7 ± 103.3
STZ control + 1 ml/kg DW	9.00 ± 1.69	5.12 ± 0.71	0.93 ± 0.25	2.43 ± 1.08	5.63 ± 0.81**	11.83 ± 1.15	41.00 ± 3.40	525.3 ± 122.8
STZ + Glibenclamide 10 mg/kg	9.22 ± 1.10	6.48 ± 0.93	1.03 ± 0.28	1.70 ± 0.29	6.40 ± 0.42	15.08 ± 0.50*	52.00 ± 0.76***	787.2 ± 119.3**
STZ + MCR Aq 30 mg/kg	10.20 ± 0.81	8.00 ± 0.38	0.90 ± 0.04	1.30 ± 0.12	6.81 ± 0.42	12.80 ± 0.48	41.80 ± 5.05	1471.0 ± 79.88***
STZ + MCR Aq 50 mg/kg	10.60 ± 0.29	8.90 ± 0.93**	0.70 ± 0.09	1.00 ± 0.28	0.20 ± 0.51	12.10 ± 0.05	39.00 ± 0.98	987.0 ± 382.0**
STZ + MCR Aq 100 mg/kg	7.70 ± 1.30	5.90 ± 1.74	0.70 ± 0.18	1.10 ± 0.27	7.49 ± 0.07	13.95 ± 0.02	40.80 ± 0.40	634.0 ± 156.1
STZ + MCR Aq 200 mg/kg	9.20 ± 0.45	6.70 ± 0.09	1.00 ± 0.18	1.50 ± 0.36	6.07 ± 0.13	14.95 ± 0.16*	57.75 ± 2.35***	734.5 ± 110.7

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCR: *Musanga cecropioides* Root; Aq: Aqueous extract; DW: distilled water; WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.72: Effect of methanol extract of *Musanga cecropioides* root on the haematological parameters of STZ-induced diabetic rats

Parameters	WBC 10 ³ /uL	LYM 10 ³ /uL	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ /uL	HGB g/dL	HCT %	PLT 10 ³ /uL
Normal control + 1 ml/kg DW	8.32 ± 0.54	5.68 ± 0.50	0.87 ± 0.27	1.80 ± 0.79	7.03 ± 0.14	12.97 ± 0.25	40.92 ± 1.25	544.7 ± 103.3
STZ control + 1 ml/kg DW	9.00 ± 1.69	5.12 ± 0.71	0.93 ± 0.25	2.43 ± 1.08	5.63 ± 0.81**	11.83 ± 1.15	41.00 ± 3.40	525.3 ± 122.8
STZ + Glibenclamide 10 mg/kg	9.22 ± 1.10	6.48 ± 0.93	1.03 ± 0.28	1.70 ± 0.29	6.40 ± 0.42	15.08 ± 0.50*	52.00 ± 0.76***	787.2 ± 119.3**
STZ + MCR Meth 30 mg/kg	12.80 ± 0.34***	5.90 ± 0.03	2.30 ± 0.04***	4.60 ± 0.34	6.99 ± 0.33	12.70 ± 0.17	42.30 ± 0.33	597.0 ± 93.27
STZ + MCR Meth 50 mg/kg	8.00 ± 1.29	5.60 ± 0.34	0.90 ± 0.02	1.50 ± 0.09	3.52 ± 0.40***	7.30 ± 2.63***	26.30 ± 1.93***	330.0 ± 32.77
STZ + MCR Meth 100 mg/kg	8.80 ± 1.38	7.30 ± 0.29	0.40 ± 0.13	1.10 ± 0.00	4.56 ± 3.52***	13.50 ± 0.29	43.50 ± 4.51	556.0 ± 56.67
STZ + MCR Meth 200 mg/kg	12.00 ± 0.18	9.60 ± 0.31***	0.80 ± 0.38	1.00 ± 0.44	4.50 ± 0.32***	12.40 ± 0.17	35.40 ± 0.57	539.0 ± 45.45

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCR: *Musanga cecropioides* Root; Meth: Methanol extract; DW: distilled water; WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.73: Effect of *Musanga cecropioides* crude root sap on the haematological parameters of STZ-induced diabetic rats

Parameters	WBC 10 ³ /uL	LYM 10 ³ /UI	MON 10 ³ /uL	GRAN 10 ³ /uL	RBC 10 ⁶ UL	HGB g/dL	HCT %	PLT 10 ³ /uL
Normal control + 1 ml/kg DW	8.32 ± 0.54	5.68 ± 0.50	0.87 ± 0.27	1.80 ± 0.79	7.03 ± 0.14	12.97 ± 0.25	40.92 ± 1.25	544.7 ± 103.3
STZ control + 1 ml/kg DW	9.00 ± 1.69	5.12 ± 0.71	0.93 ± 0.25	2.43 ± 1.08	5.63 ± 0.81**	11.83 ± 1.15	41.00 ± 3.40	525.3 ± 122.8
STZ + Glibenclamide 10 mg/kg	9.22 ± 1.10	6.48 ± 0.93	1.03 ± 0.28	1.70 ± 0.29	6.40 ± 0.42	15.08 ± 0.50*	52.00 ± 0.76***	787.2 ± 119.3**
STZ + MCCRS 0.5 ml/kg	7.00 ± 0.72	5.55 ± 0.43	0.40 ± 0.09	1.00 ± 0.18	4.59 ± 0.35***	12.90 ± 1.07	48.00 ± 3.76*	499.5 ± 52.99
STZ + MCCRS 1 ml/kg	7.87 ± 0.31	5.53 ± 0.13	0.73 ± 0.15	1.60 ± 0.19	5.80 ± 0.10*	14.83 ± 0.12	51.17 ± 0.35***	680.0 ± 79.88
STZ + MCCRS 2 ml/kg	6.80 ± 0.28	5.60 ± 0.32	0.40 ± 0.03	0.80 ± 0.34	5.10 ± 0.41***	14.20 ± 0.12	50.60 ± 0.29**	637.0 ± 37.89
STZ + MCCRS 3 ml/kg	9.70 ± 2.13	5.50 ± 0.41	1.40 ± 0.32	2.80 ± 0.24	4.93 ± 0.52***	12.80 ± 0.98	49.30 ± 0.47**	478.0 ± 45.22

Values are expressed as Mean ± SEM, $P < 0.05$; n=6; MCCRS: *Musanga cecropioides* Crude Root Sap; DW: distilled water
WBC: White blood cell count; LYM: Lymphocytes; MON: Monocytes; GRAN: Granulocytes; RBC: Red blood cell count; HGB: Haemoglobin concentration; HCT: Haematocrit; PLT: Platelet count; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.5 Biochemical Analysis

4.7.5.1 Liver Function

Tables 4.74, 4.75, 4.76, 4.77 and 4.78 show results on the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on liver function parameters of STZ-induced diabetic rats in the 28 days anti-diabetic study.

In Table 4.74, *Musanga cecropioides* aqueous leaf extract at 30 mg/kg significantly increased gamma glutamyl transferase level at $P < 0.001$, at 50 mg/kg alkaline phosphate, gamma glutamyl transferase, total bilirubin, conjugated bilirubin levels were significantly increased at $P < 0.05$, $P < 0.01$ and $P < 0.001$. At the dose of 100 mg/kg, total protein concentration was significantly reduced at $P < 0.001$.

In Table 4.75, *Musanga cecropioides* methanol leaf extract at 30 mg/kg significantly increased gamma glutamyl transferase level and significantly reduced total protein concentration at $P < 0.001$. At the dose of 50 mg/kg, alanine aminotransferase and aspartate aminotransferase were significantly increased at $P < 0.05$, while gamma glutamyl transferase level significantly increased at $P < 0.001$. At the dose of 100 mg/kg, alanine aminotransferase significantly increased at $P < 0.001$, while gamma glutamyl transferase and total protein levels significantly increased at $P < 0.05$. At the dose of 200 mg/kg, aspartate aminotransferase level significantly decreased at $P < 0.001$, while total, conjugated and unconjugated bilirubin levels significantly increased at $P < 0.01$ and $P < 0.001$ when compared with the normal control.

In Table 4.76, *Musanga cecropioides* aqueous root extract at 30 and 50 mg/kg significantly increased ($P < 0.05$, $P < 0.01$ and $P < 0.001$) alanine aminotransferase

and aspartate aminotransferase levels, which were significantly reduced ($P < 0.001$) at 100 and 200 mg/kg.

In Table 4.77, *Musanga cecropioides* methanol root extract significantly increased ($P < 0.001$) alanine aminotransferase level at 30 mg/kg while alanine aminotransferase levels were significantly reduced ($P < 0.001$) at 50, 100 and 200 mg/kg. At all administered doses, aspartate aminotransferase and gamma glutamyl transferase levels were significantly reduced when compared to the normal control group.

In Table 4.78, *Musanga cecropioides* crude root sap at all administered doses significantly altered some of the liver function parameters at $P < 0.05$, $P < 0.01$ and $P < 0.001$, while some values were not significantly different when compared to normal control group.

Table 4.74: Effect of aqueous extract of *Musanga cecropioides* leaves on the liver function parameters of STZ-induced diabetic rats

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB (mg/dl)	CB (mg/dl)	UB (mg/dl)	TP (g/dl)
Normal control + 1 ml/kg DW	25.56 ± 1.17	46.33 ± 0.85	14.44 ± 0.46	0.54 ± 0.05	0.05 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	13.55 ± 0.50
STZ control + 1 ml/kg DW	26.32 ± 1.00	47.59 ± 3.08	14.71 ± 0.46	0.62 ± 0.05	0.06 ± 0.01	0.03 ± 0.00	0.03 ± 0.01	13.39 ± 0.77
STZ + Glibenclamide 10 mg/kg	25.85 ± 0.46	46.81 ± 0.89	15.62 ± 1.44	0.63 ± 0.01	0.09 ± 0.02**	0.04 ± 0.01**	0.04 ± 0.01	14.29 ± 0.27
STZ + MCL Aq 30 mg/kg	24.73 ± 0.34	46.50 ± 1.28	14.18 ± 0.67	0.67 ± 0.02***	0.05 ± 0.00	0.02 ± 0.00	0.03 ± 0.01	12.57 ± 0.32
STZ + MCL Aq 50 mg/kg	25.08 ± 0.62	44.70 ± 2.12	17.02 ± 0.70**	0.64 ± 0.03*	0.10 ± 0.01***	0.06 ± 0.01***	0.04 ± 0.01	14.72 ± 0.45
STZ + MCL Aq 100 mg/kg	25.90 ± 0.37	48.12 ± 1.61	14.95 ± 0.21	0.58 ± 0.04	0.04 ± 0.00	0.02 ± 0.00	0.02 ± 0.00	10.88 ± 0.18***
STZ + MCL Aq 200 mg/kg	26.10 ± 0.40	48.92 ± 1.11	14.62 ± 0.30	0.57 ± 0.03	0.05 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	12.21 ± 0.01

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water

ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.75: Effect of methanol extract of *Musanga cecropioides* leaves on the liver function parameters of STZ-induced diabetic rats

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB (mg/dl)	CB (mg/dl)	UB (mg/dl)	TP (g/dl)
Normal control + 1 ml/kg DW	25.56 ± 1.17	46.33 ± 0.85	14.44 ± 0.46	0.54 ± 0.05	0.05 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	13.55 ± 0.50
STZ control + 1 ml/kg DW	26.32 ± 1.00	47.59 ± 3.08	14.71 ± 0.46	0.62 ± 0.05	0.06 ± 0.01	0.03 ± 0.00	0.03 ± 0.01	13.39 ± 0.77
STZ + Glibenclamide 10 mg/kg	25.85 ± 0.46	46.81 ± 0.89	15.62 ± 1.44	0.63 ± 0.01	0.09 ± 0.02**	0.04 ± 0.01**	0.04 ± 0.01	14.29 ± 0.27
STZ + MCL Meth 30 mg/kg	27.06 ± 0.18	47.24 ± 0.94	14.56 ± 0.31	0.69 ± 0.05***	0.06 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	11.63 ± 0.46***
STZ + MCL Meth 50 mg/kg	27.52 ± 0.07*	50.31 ± 0.62*	13.85 ± 0.15	0.77 ± 0.01***	0.05 ± 0.00	0.03 ± 0.00	0.02 ± 0.01	14.05 ± 0.12
STZ + MCL Meth 100 mg/kg	29.23 ± 0.31***	48.53 ± 1.22	15.17 ± 0.22	0.64 ± 0.02*	0.05 ± 0.00	0.02 ± 0.01	0.03 ± 0.01	14.81 ± 0.41*
STZ + MCL Meth 200 mg/kg	24.63 ± 0.43	39.00 ± 0.61***	15.43 ± 0.65	0.53 ± 0.03	0.10 ± 0.01***	0.05 ± 0.00***	0.05 ± 0.00**	14.23 ± 0.46

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water

ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.76: Effect of aqueous extract of *Musanga cecropioides* root on the liver function parameters of STZ-induced diabetic rats

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB (mg/dl)	CB (mg/dl)	UB (mg/dl)	TP (g/dl)
Normal control + 1 ml/kg DW	25.56 ± 1.17	46.33 ± 0.85	14.44 ± 0.46	0.54 ± 0.05	0.05 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	13.55 ± 0.50
STZ control + 1 ml/kg DW	26.32 ± 1.00	47.59 ± 3.08	14.71 ± 0.46	0.62 ± 0.05	0.06 ± 0.01	0.03 ± 0.00	0.03 ± 0.01	13.39 ± 0.77
STZ + Glibenclamide 10 mg/kg	25.85 ± 0.46	46.81 ± 0.89	15.62 ± 1.44	0.63 ± 0.01	0.09 ± 0.02**	0.04 ± 0.01**	0.04 ± 0.01	14.29 ± 0.27
STZ + MCR Aq 30 mg/kg	29.62 ± 0.22***	50.32 ± 1.00*	14.11 ± 0.31	0.65 ± 0.01**	0.07 ± 0.01	0.04 ± 0.00*	0.03 ± 0.01	10.46 ± 0.60***
STZ + MCR Aq 50 mg/kg	28.44 ± 0.31***	51.76 ± 1.01**	13.63 ± 0.11	0.84 ± 0.01***	0.06 ± 0.00	0.03 ± 0.01	0.03 ± 0.01	10.98 ± 0.31***
STZ + MCR Aq 100 mg/kg	22.90 ± 0.12***	37.48 ± 0.48***	13.15 ± 0.43	0.36 ± 0.01***	0.06 ± 0.00	0.03 ± 0.00	0.03 ± 0.00	14.11 ± 0.23
STZ + MCR Aq 200 mg/kg	22.67 ± 0.35***	34.78 ± 0.14***	11.84 ± 0.16**	0.47 ± 0.01	0.09 ± 0.00**	0.06 ± 0.00***	0.03 ± 0.00	14.19 ± 0.25

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water

ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.77: Effect of methanol extract of *Musanga cecropioides* root on the liver function parameters of STZ-induced diabetic rats

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB (mg/dl)	CB (mg/dl)	UB (mg/dl)	TP (g/dl)
Normal control + 1 ml/kg DW	25.56 ± 1.17	46.33 ± 0.85	14.44 ± 0.46	0.54 ± 0.05	0.05 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	13.55 ± 0.50
STZ control + 1 ml/kg DW	26.32 ± 1.00	47.59 ± 3.08	14.71 ± 0.46	0.62 ± 0.05	0.06 ± 0.01	0.03 ± 0.00	0.03 ± 0.01	13.39 ± 0.77
STZ + Glibenclamide 10 mg/kg	25.85 ± 0.46	46.81 ± 0.89	15.62 ± 1.44	0.63 ± 0.01	0.09 ± 0.02**	0.04 ± 0.01**	0.04 ± 0.01	14.29 ± 0.27
STZ + MCR Meth 30 mg/kg	29.22 ± 0.12***	39.43 ± 1.00***	13.52 ± 0.18	0.41 ± 0.02**	0.04 ± 0.00	0.02 ± 0.01	0.02 ± 0.00	15.11 ± 0.29**
STZ + MCR Meth 50 mg/kg	21.45 ± 0.19***	35.13 ± 0.88***	13.53 ± 0.19	0.37 ± 0.03***	0.07 ± 0.00	0.04 ± 0.01*	0.03 ± 0.00	13.25 ± 0.28
STZ + MCR Meth 100 mg/kg	22.01 ± 0.11***	34.61 ± 0.99***	13.62 ± 0.21	0.38 ± 0.02***	0.07 ± 0.00	0.03 ± 0.01	0.02 ± 0.00	12.56 ± 0.12
STZ + MCR Meth 200 mg/kg	21.50 ± 0.32***	34.29 ± 0.83***	14.10 ± 0.08	0.38 ± 0.02***	0.06 ± 0.00	0.03 ± 0.01	0.03 ± 0.00	11.62 ± 0.01***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water

ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.78: Effect of *Musanga cecropioides* crude root sap on the liver function parameters of STZ-induced diabetic rats

Parameters	ALT (U/L)	AST (U/L)	ALP (U/L)	GGT (U/L)	TB (mg/dl)	CB (mg/dl)	UB (mg/dl)	TP (g/dl)
Normal control + 1 ml/kg DW	25.56 ± 1.17	46.33 ± 0.85	14.44 ± 0.46	0.54 ± 0.05	0.05 ± 0.00	0.02 ± 0.00	0.03 ± 0.00	13.55 ± 0.50
STZ control + 1 ml/kg DW	26.32 ± 1.00	47.59 ± 3.08	14.71 ± 0.46	0.62 ± 0.05	0.06 ± 0.01	0.03 ± 0.00	0.03 ± 0.01	13.39 ± 0.77
STZ + Glibenclamide 10 mg/kg	25.85 ± 0.46	46.81 ± 0.89	15.62 ± 1.44	0.63 ± 0.01	0.09 ± 0.02**	0.04 ± 0.01**	0.04 ± 0.01	14.29 ± 0.27
STZ + MCCRS 0.5 ml/kg	12.76 ± 0.56***	21.02 ± 0.18***	10.59 ± 0.21***	0.21 ± 0.01***	0.06 ± 0.00	0.03 ± 0.01	0.03 ± 0.01	11.72 ± 0.19***
STZ + MCCRS 1 ml/kg	29.86 ± 0.17*	60.70 ± 0.39***	17.96 ± 0.77***	0.89 ± 0.01***	0.19 ± 0.02***	0.07 ± 0.01***	0.12 ± 0.01***	14.88 ± 0.28*
STZ + MCCRS 2 ml/kg	27.44 ± 0.31***	43.71 ± 0.34	21.41 ± 0.51***	0.61 ± 0.01	0.11 ± 0.00***	0.07 ± 0.01***	0.04 ± 0.01	15.31 ± 0.32***
STZ + MCCRS 3 ml/kg	28.12 ± 0.22***	52.09 ± 0.02**	19.32 ± 0.66***	0.67 ± 0.01***	0.11 ± 0.00***	0.07 ± 0.00***	0.04 ± 0.00	15.32 ± 0.11***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water

ALT: Alanine aminotransferase; AST: Aspartate aminotransferase; ALP: Alkaline phosphate; GGT: Gamma glutamyl tranferase; TB: Total bilirubin; CB: Conjugated bilirubin; UB: Unconjugated bilirubin; TP: Total protein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.5.2 Renal Function

Tables 4.79, 4.80, 4.81, 4.82 and 4.83 show results on the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on renal function parameters of STZ-induced diabetic rats in the 28 days anti-diabetic study.

In Table 4.79, *Musanga cecropioides* aqueous leaf extract at 30 mg/kg significantly reduced sodium (at $P < 0.001$), potassium (at $P < 0.01$) and chloride concentration (at $P < 0.001$), and significantly increased bicarbonate concentration (at $P < 0.001$). The dose of 50 mg/kg significantly increased creatinine concentration at $P < 0.01$, while the dose of 100 mg/kg significantly reduced creatinine, potassium and chloride concentration at $P < 0.001$. The dose of 200 mg/kg significantly reduced creatinine, potassium and chloride concentrations at $P < 0.001$ when compared with the normal control group.

In Table 4.80, *Musanga cecropioides* methanol leaf extract at 30 mg/kg significantly increased urea concentration at $P < 0.001$ and significantly reduced potassium and chloride concentrations at $P < 0.001$. The dose of 50 mg/kg significantly increased urea and sodium concentrations and significantly reduced potassium and chloride concentrations at $P < 0.01$ and $P < 0.001$ respectively. The dose of 100 mg/kg significantly increased urea concentration and significantly reduced creatinine concentration at $P < 0.001$, while the dose of 200 mg/kg significantly reduced urea, potassium and chloride concentrations at $P < 0.001$ and $P < 0.01$ when compared to the normal control group.

In Table 4.81, *Musanga cecropioides* aqueous root extract at 30 mg/kg significantly increased urea (at $P < 0.001$) and significantly reduced creatinine (at $P < 0.001$) and

potassium (at $P < 0.05$). The dose of 50 mg/kg significantly increased urea and significantly reduced potassium (at $P < 0.05$) and chloride (at $P < 0.001$). The dose of 100 mg/kg significantly increased urea and creatinine at $P < 0.001$ and significantly reduced sodium at $P < 0.05$ while the dose of 200 mg/kg significantly reduced urea, sodium and chloride at $P < 0.01$ and $P < 0.001$, and significantly increased creatinine at $P < 0.001$ when compared to the normal control group.

In Table 4.82, *Musanga cecropioides* methanol root extract at all dose levels significantly increased urea concentration at $P < 0.001$ and significantly reduced sodium concentration at $P < 0.001$ while potassium concentration was significantly reduced only at the dose of 30 mg/kg (at $P < 0.05$) and chloride was significantly reduced at all dose levels (at $P < 0.05$, $P < 0.01$ and $P < 0.001$) when compared with the normal control group.

In Table 4.83, *Musanga cecropioides* crude root sap at 0.5 ml/kg significantly reduced urea, creatinine, sodium, potassium, chloride and bicarbonate concentrations at $P < 0.001$. The dose of 1 ml/kg significantly increased urea, creatinine, potassium and bicarbonate and significantly reduced sodium and chloride at $P < 0.001$ while the doses of 2 and 3 ml/kg significantly increased bicarbonate concentration at $P < 0.05$ when compared to the normal control group.

Table 4.79: Effect of aqueous extract of *Musanga cecropioides* leaves on the renal function parameters of STZ-induced diabetic rats

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Normal control + 1 ml/kg DW	28.72 ± 1.40	0.24 ± 0.01	105.6 ± 1.28	21.93 ± 0.74	79.75 ± 1.74	19.89 ± 1.31
STZ control + 1 ml/kg DW	24.24 ± 0.46**	0.24 ± 0.02	105.9 ± 1.62	22.47 ± 1.05	66.66 ± 3.97***	18.67 ± 1.81
STZ + Glibenclamide 10 mg/kg	27.07 ± 0.80	0.27 ± 0.01	102.5 ± 2.95	21.68 ± 1.38	67.31 ± 4.71***	20.83 ± 1.68
STZ + MCL Aq 30 mg/kg	28.33 ± 0.62	0.25 ± 0.03	93.33 ± 0.22***	19.32 ± 1.02**	59.83 ± 2.13***	27.50 ± 1.00***
STZ + MCL Aq 50 mg/kg	29.23 ± 1.26	0.29 ± 0.02**	102.7 ± 1.81	21.25 ± 0.78	72.41 ± 1.88	21.32 ± 0.61
STZ + MCL Aq 100 mg/kg	30.16 ± 0.74	0.18 ± 0.02***	106.4 ± 0.26	18.61 ± 0.03***	54.28 ± 1.23***	22.42 ± 1.38
STZ + MCL Aq 200 mg/kg	29.88 ± 0.98	0.17 ± 0.02***	106.8 ± 0.91	18.45 ± 0.06***	48.11 ± 1.00***	21.12 ± 0.81

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.80: Effect of methanol extract of *Musanga cecropioides* leaves on the renal function parameters of STZ-induced diabetic rats

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Normal control + 1 ml/kg DW	28.72 ± 1.40	0.24 ± 0.01	105.6 ± 1.28	21.93 ± 0.74	79.75 ± 1.74	19.89 ± 1.31
STZ control + 1 ml/kg DW	24.24 ± 0.46**	0.24 ± 0.02	105.9 ± 1.62	22.47 ± 1.05	66.66 ± 3.97***	18.67 ± 1.81
STZ + Glibenclamide 10 mg/kg	27.07 ± 0.80	0.27 ± 0.01	102.5 ± 2.95	21.68 ± 1.38	67.31 ± 4.71***	20.83 ± 1.68
STZ + MCL Meth 30 mg/kg	36.97 ± 2.55***	0.24 ± 0.00	107.0 ± 0.73	18.42 ± 0.52***	58.77 ± 3.24***	20.31 ± 0.71
STZ + MCL Meth 50 mg/kg	47.17 ± 1.42***	0.22 ± 0.01	112.2 ± 2.24***	19.21 ± 0.23**	68.84 ± 2.53***	22.41 ± 0.26
STZ + MCL Meth 100 mg/kg	44.67 ± 1.31***	0.17 ± 0.01***	105.3 ± 1.62	21.50 ± 0.34	72.55 ± 2.63	19.66 ± 1.00
STZ + MCL Meth 200 mg/kg	22.10 ± 0.46***	0.27 ± 0.01	104.1 ± 1.64	19.41 ± 0.75**	63.17 ± 1.02***	20.57 ± 0.87

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.81: Effect of aqueous extract of *Musanga cecropioides* root on the renal function parameters of STZ-induced diabetic rats

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Normal control + 1 ml/kg DW	28.72 ± 1.40	0.24 ± 0.01	105.6 ± 1.28	21.93 ± 0.74	79.75 ± 1.74	19.89 ± 1.31
STZ control + 1 ml/kg DW	24.24 ± 0.46**	0.24 ± 0.02	105.9 ± 1.62	22.47 ± 1.05	66.66 ± 3.97***	18.67 ± 1.81
STZ + Glibenclamide 10 mg/kg	27.07 ± 0.80	0.27 ± 0.01	102.5 ± 2.95	21.68 ± 1.38	67.31 ± 4.71***	20.83 ± 1.68
STZ + MCR Aq 30 mg/kg	43.67 ± 1.22***	0.18 ± 0.00***	104.2 ± 1.12	19.46 ± 0.62*	73.82 ± 2.81	19.43 ± 1.00
STZ + MCR Aq 50 mg/kg	45.18 ± 1.34***	0.25 ± 0.01	103.2 ± 1.22	19.82 ± 0.32*	69.41 ± 2.88***	20.11 ± 0.88
STZ + MCR Aq 100 mg/kg	50.83 ± 0.22***	0.31 ± 0.01***	100.5 ± 0.42*	21.37 ± 0.46	70.15 ± 0.60	17.41 ± 0.05
STZ + MCR Aq 200 mg/kg	24.59 ± 0.18**	0.30 ± 0.01***	98.81 ± 0.25***	20.58 ± 0.50	57.84 ± 0.25***	20.40 ± 0.14

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.82: Effect of methanol extract of *Musanga cecropioides* root on the renal function parameters of STZ-induced diabetic rats

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Normal control + 1 ml/kg DW	28.72 ± 1.40	0.24 ± 0.01	105.6 ± 1.28	21.93 ± 0.74	79.75 ± 1.74	19.89 ± 1.31
STZ control + 1 ml/kg DW	24.24 ± 0.46**	0.24 ± 0.02	105.9 ± 1.62	22.47 ± 1.05	66.66 ± 3.97***	18.67 ± 1.81
STZ + Glibenclamide 10 mg/kg	27.07 ± 0.80	0.27 ± 0.01	102.5 ± 2.95	21.68 ± 1.38	67.31 ± 4.71***	20.83 ± 1.68
STZ + MCR Meth 30 mg/kg	46.67 ± 1.00***	0.25 ± 0.01	94.21 ± 1.00***	19.48 ± 0.62*	72.33 ± 3.13*	18.47 ± 0.35
STZ + MCR Meth 50 mg/kg	43.17 ± 0.22***	0.27 ± 0.01	96.30 ± 0.82***	21.32 ± 0.82	71.00 ± 2.51**	17.51 ± 0.36
STZ + MCR Meth 100 mg/kg	42.18 ± 0.21***	0.26 ± 0.00	97.27 ± 0.81***	20.14 ± 0.62	69.42 ± 2.00***	16.89 ± 0.21
STZ + MCR Meth 200 mg/kg	42.00 ± 0.31***	0.25 ± 0.00	95.88 ± 0.36***	20.88 ± 0.28	59.21 ± 3.13***	16.21 ± 0.33

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.83: Effect of *Musanga cecropioides* crude root sap on the renal function parameters of STZ-induced diabetic rats

Parameters	Urea (mg/dl)	Creatinine (mg/dl)	Sodium (mmol/L)	Potassium (mmol/L)	Chloride (mmol/L)	Bicarbonate (mmol/L)
Normal control + 1 ml/kg DW	28.72 ± 1.40	0.24 ± 0.01	105.6 ± 1.28	21.93 ± 0.74	79.75 ± 1.74	19.89 ± 1.31
STZ control + 1 ml/kg DW	24.24 ± 0.46**	0.24 ± 0.02	105.9 ± 1.62	22.47 ± 1.05	66.66 ± 3.97***	18.67 ± 1.81
STZ + Glibenclamide 10 mg/kg	27.07 ± 0.80	0.27 ± 0.01	102.5 ± 2.95	21.68 ± 1.38	67.31 ± 4.71***	20.83 ± 1.68
STZ + MCCRS 0.5 ml/kg	18.71 ± 0.27***	0.14 ± 0.01***	89.41 ± 0.36***	13.70 ± 0.28***	44.93 ± 1.62***	11.22 ± 0.40***
STZ + MCCRS 1 ml/kg	36.64 ± 0.61***	0.40 ± 0.01***	96.57 ± 0.56***	27.90 ± 0.17***	59.59 ± 0.57***	28.73 ± 0.14***
STZ + MCCRS 2 ml/kg	28.66 ± 0.67	0.22 ± 0.01	108.4 ± 0.42	22.62 ± 0.31	81.56 ± 1.62	23.21 ± 0.14*
STZ + MCCRS 3 ml/kg	29.22 ± 0.61	0.25 ± 0.01	102.3 ± 0.38	23.33 ± 0.42	82.59 ± 1.00	23.40 ± 0.16*

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.5.3 Lipid Profile

Tables 4.84, 4.85, 4.86, 4.87 and 4.88 show results on the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on lipid profile parameters of STZ-induced diabetic rats in the 28 days anti-diabetic study.

In Table 4.84, *Musanga cecropioides* aqueous leaf extract at 50 mg/kg significantly reduced cholesterol, triacylglycerol and very low density lipoprotein and significantly increased low density lipoprotein at $P < 0.001$ when compared to the normal control group. All other dose levels did not significantly alter the lipid profile parameters.

In Table 4.85, *Musanga cecropioides* methanol leaf extract at 30 mg/kg significantly increased cholesterol, triacylglycerol and very low density lipoprotein at $P < 0.01$ while high density lipoprotein was significantly reduced at $P < 0.001$. The dose of 50 mg/kg significantly reduced high density lipoprotein at $P < 0.05$ while the dose of 100 mg/kg did not significantly alter lipid profile parameters. The dose of 200 mg/kg significantly reduced cholesterol, triacylglycerol and very low density lipoprotein and significantly increased low density lipoprotein at $P < 0.001$ when compared with the normal control group.

In Table 4.86, *Musanga cecropioides* aqueous root extract at 30 mg/kg significantly reduced cholesterol at $P < 0.001$. The dose of 50 mg/kg significantly increased Triacylglycerol and very low density lipoprotein at $P < 0.05$, while the dose of 100 mg/kg did not significantly alter lipid profile parameters. The dose of 200 mg/kg significantly reduced cholesterol, triacylglycerol and very low density lipoprotein and significantly increased low density lipoprotein at $P < 0.001$ when compared with the normal control group.

In Table 4.87, *Musanga cecropioides* methanol root extract at 30 mg/kg significantly increased triacylglycerol and very low density lipoprotein and significantly reduced high density lipoprotein values at $P < 0.001$. Other doses did not significantly alter lipid profile parameters when compared with the normal control group.

In Table 4.88, *Musanga cecropioides* crude root sap at 0.5 ml/kg significantly reduced cholesterol, triacylglycerol, high density lipoprotein and very low density lipoprotein at $P < 0.001$. The dose of 1 ml/kg significantly reduced triacylglycerol (at $P < 0.01$), high density lipoprotein (at $P < 0.05$) and very low density lipoprotein (at $P < 0.01$) and significantly increased low density lipoprotein (at $P < 0.001$). The dose of 2 ml/kg and 3 ml/kg significantly reduced cholesterol, triacylglycerol, very low density lipoprotein at $P < 0.001$, high density lipoprotein at $P < 0.01$, while low density lipoprotein was significantly increased at $P < 0.001$ when compared with the normal control group.

Table 4.84: Effect of aqueous extract of *Musanga cecropioides* leaves on the lipid profile parameters of STZ-induced diabetic rats

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Normal control + 1 ml/kg DW	75.06 ± 3.96	209.5 ± 3.46	14.74 ± 1.19	20.09 ± 4.26	41.90 ± 0.69
STZ control + 1 ml/kg DW	76.38 ± 5.18	216.1 ± 15.83	12.28 ± 0.76**	25.84 ± 3.36	43.22 ± 3.17
STZ + Glibenclamide 10 mg/kg	65.48 ± 2.43***	193.8 ± 9.25	16.67 ± 0.57	25.39 ± 5.60	38.75 ± 1.85
STZ + MCL Aq 30 mg/kg	71.42 ± 2.12	211.4 ± 8.88	14.73 ± 0.51	14.40 ± 3.13	42.29 ± 1.28
STZ + MCL Aq 50 mg/kg	56.49 ± 0.95***	150.8 ± 3.14***	16.24 ± 0.65	42.57 ± 0.77***	30.15 ± 0.63***
STZ + MCL Aq 100 mg/kg	80.55 ± 2.09	211.3 ± 6.81	14.08 ± 0.62	24.20 ± 1.39	42.27 ± 1.37
STZ + MCL Aq 200 mg/kg	77.81 ± 3.22	210.0 ± 5.88	15.21 ± 0.34	25.21 ± 0.83	41.32 ± 1.34

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.85: Effect of methanol extract of *Musanga cecropioides* leaves on the lipid profile parameters of STZ-induced diabetic rats

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Normal control + 1 ml/kg DW	75.06 ± 3.96	209.5 ± 3.46	14.74 ± 1.19	20.09 ± 4.26	41.90 ± 0.69
STZ control + 1 ml/kg DW	76.38 ± 5.18	216.1 ± 15.83	12.28 ± 0.76**	25.84 ± 3.36	43.22 ± 3.17
STZ + Glibenclamide 10 mg/kg	65.48 ± 2.43***	193.8 ± 9.25	16.67 ± 0.57	25.39 ± 5.60	38.75 ± 1.85
STZ + MCL Meth 30 mg/kg	83.57 ± 0.70**	234.4 ± 8.95**	11.54 ± 0.65***	25.15 ± 0.56	46.87 ± 1.79**
STZ + MCL Meth 50 mg/kg	77.37 ± 0.87	216.3 ± 0.01	12.73 ± 1.12*	21.38 ± 1.98	43.27 ± 0.00
STZ + MCL Meth 100 mg/kg	72.92 ± 0.67	214.0 ± 8.28	14.62 ± 0.51	15.50 ± 3.13	42.80 ± 1.21
STZ + MCL Meth 200 mg/kg	55.74 ± 0.27***	149.3 ± 1.02***	16.46 ± 0.43	42.34 ± 0.15***	29.86 ± 0.21***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.86: Effect of aqueous extract of *Musanga cecropioides* root on the lipid profile parameters of STZ-induced diabetic rats

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Normal control + 1 ml/kg DW	75.06 ± 3.96	209.5 ± 3.46	14.74 ± 1.19	20.09 ± 4.26	41.90 ± 0.69
STZ control + 1 ml/kg DW	76.38 ± 5.18	216.1 ± 15.83	12.28 ± 0.76**	25.84 ± 3.36	43.22 ± 3.17
STZ + Glibenclamide 10 mg/kg	65.48 ± 2.43***	193.8 ± 9.25	16.67 ± 0.57	25.39 ± 5.60	38.75 ± 1.85
STZ + MCR Aq 30 mg/kg	65.32 ± 0.73***	213.0 ± 5.26	16.63 ± 0.61	16.10 ± 3.34	42.60 ± 0.88
STZ + MCR Aq 50 mg/kg	81.42 ± 1.57	230.0 ± 7.13*	13.72 ± 0.88	21.70 ± 1.22	46.00 ± 0.62*
STZ + MCR Aq 100 mg/kg	73.68 ± 1.46	205.2 ± 2.52	16.40 ± 0.27	20.75 ± 0.22	41.03 ± 0.51
STZ + MCR Aq 200 mg/kg	53.07 ± 0.19***	144.1 ± 0.25***	15.03 ± 0.06	39.29 ± 0.28***	28.81 ± 0.05***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.87: Effect of methanol extract of *Musanga cecropioides* root on the lipid profile parameters of STZ-induced diabetic rats

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Normal control + 1 ml/kg DW	75.06 ± 3.96	209.5 ± 3.46	14.74 ± 1.19	20.09 ± 4.26	41.90 ± 0.69
STZ control + 1 ml/kg DW	76.38 ± 5.18	216.1 ± 15.83	12.28 ± 0.76**	25.84 ± 3.36	43.22 ± 3.17
STZ + Glibenclamide 10 mg/kg	65.48 ± 2.43***	193.8 ± 9.25	16.67 ± 0.57	25.39 ± 5.60	38.75 ± 1.85
STZ + MCR Meth 30 mg/kg	80.62 ± 0.47	238.6 ± 3.62***	11.24 ± 0.32***	21.66 ± 1.20	47.72 ± 0.32***
STZ + MCR Meth 50 mg/kg	80.39 ± 0.91	211.4 ± 4.28	13.00 ± 0.21	25.11 ± 1.82	42.28 ± 0.21
STZ + MCR Meth 100 mg/kg	81.00 ± 0.61	210.4 ± 2.81	12.99 ± 0.52	26.12 ± 1.23	42.30 ± 0.71
STZ + MCR Meth 200 mg/kg	81.21 ± 0.32	209.0 ± 4.33	13.50 ± 0.81	26.31 ± 1.00	42.51 ± 0.61

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.88: Effect of *Musanga cecropioides* crude root sap on the lipid profile parameters of STZ-induced diabetic rats

Parameters	Cholesterol (mg/dl)	TAG (mg/dl)	HDL (mg/dl)	LDL (mg/dl)	VLDL (mg/dl)
Normal control + 1 ml/kg DW	75.06 ± 3.96	209.5 ± 3.46	14.74 ± 1.19	20.09 ± 4.26	41.90 ± 0.69
STZ control + 1 ml/kg DW	76.38 ± 5.18	216.1 ± 15.83	12.28 ± 0.76**	25.84 ± 3.36	43.22 ± 3.17
STZ + Glibenclamide 10 mg/kg	65.48 ± 2.43***	193.8 ± 9.25	16.67 ± 0.57	25.39 ± 5.60	38.75 ± 1.85
STZ + MCCRS 0.5 ml/kg	27.92 ± 0.63***	97.42 ± 0.42***	10.37 ± 0.02***	18.80 ± 0.70	19.49 ± 0.09***
STZ + MCCRS 1 ml/kg	75.23 ± 0.43	183.2 ± 0.60**	12.61 ± 0.12*	51.20 ± 0.32***	36.64 ± 0.12**
STZ + MCCRS 2 ml/kg	58.43 ± 0.55***	166.1 ± 6.13***	12.26 ± 0.18**	37.46 ± 0.61***	33.23 ± 0.31***
STZ + MCCRS 3 ml/kg	55.51 ± 0.61***	167.7 ± 5.81***	12.32 ± 1.09**	36.20 ± 0.59***	32.31 ± 0.44***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; TAG: Triacylglycerol; HDL: High density lipoprotein; LDL: Low density lipoprotein; VLDL: Very low density lipoprotein; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.5.4 Total Antioxidant Capacity

Figures 4.35, 4.36, 4.37, 4.38 and 4.39 show results on the total antioxidant capacity of STZ – induced diabetic rats plasma treated with *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap respectively, after 28 days. The total antioxidant capacity was significantly higher at $P < 0.01$ in the groups treated with *Musanga cecropioides* aqueous leaf extract at 50 and 200 mg/kg, crude root sap at 2 and 3 ml/kg and was significantly higher at $P < 0.05$ in the groups treated with methanol leaf extract at 200 mg/kg, aqueous root extract at 30 and 50 mg/kg. While the total antioxidant capacity was significantly lower at $P < 0.05$ in the groups treated with *Musanga cecropioides* methanol root extract at 200 mg/kg and crude root sap at 0.5 and 1 ml/kg when compared with the normal control group.

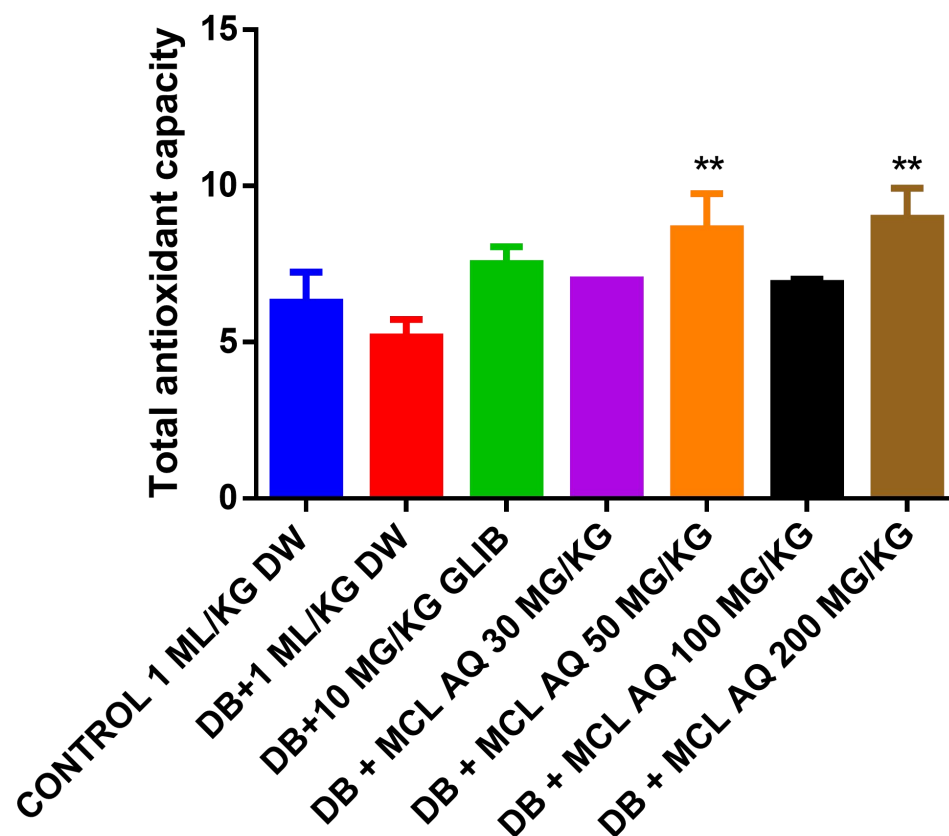


Figure 4.35: Total antioxidant capacity of STZ – induced diabetic rats plasma treated with aqueous extracts of *Musanga cecropioides* leaves after 28 days

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=6$; DB: Diabetes; GLIB: Glibenclamide; MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; ** significant values at $P < 0.01$, when compared to normal control group

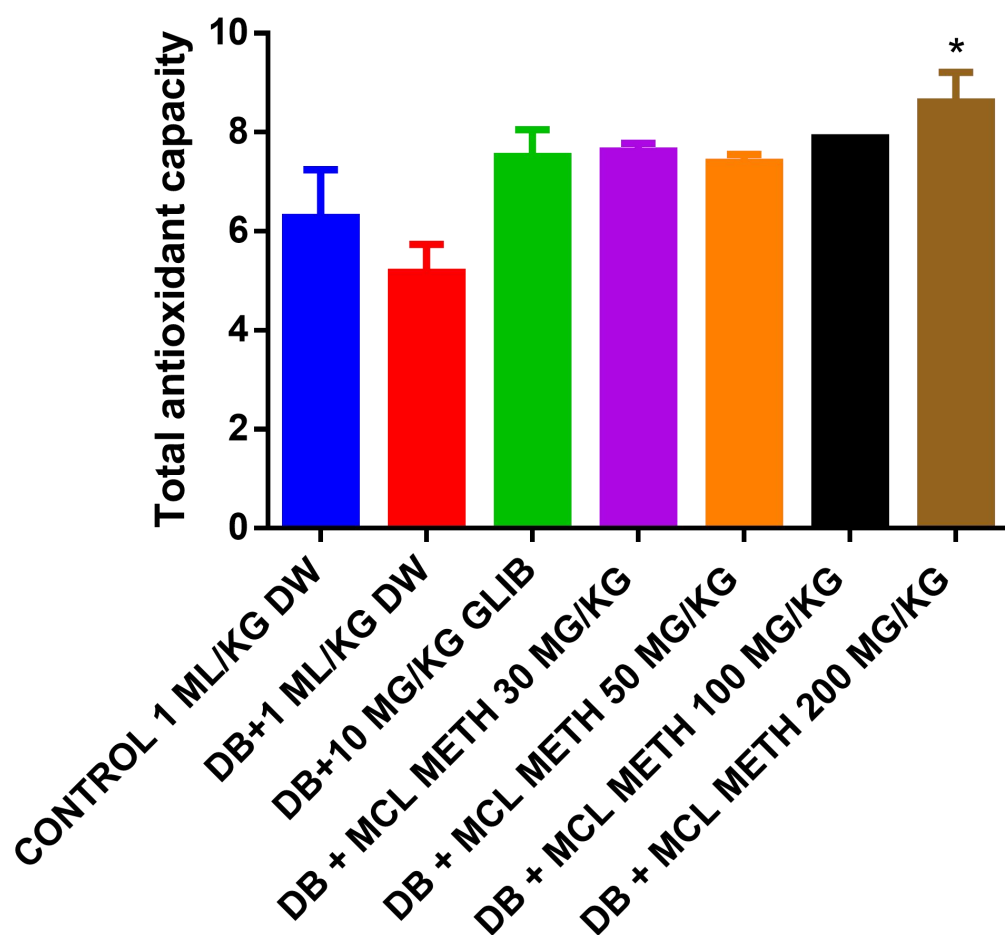


Figure 4.36: Total antioxidant capacity of STZ – induced diabetic rats plasma treated with methanol extracts of *Musanga cecropioides* leaves after 28 days

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=6$; DB: Diabetes; GLIB: Glibenclamide; MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; * Significant values at $P < 0.05$, when compared to normal control group

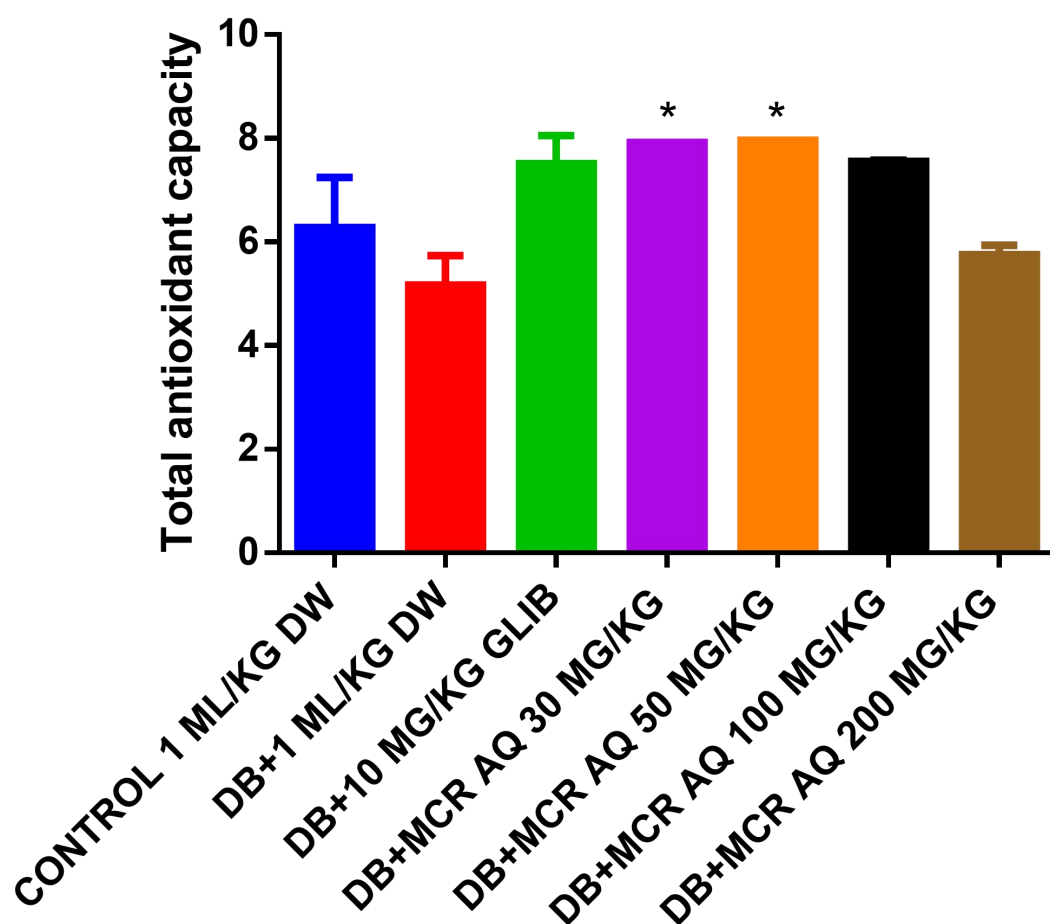


Figure 4.37: Total antioxidant capacity of STZ – induced diabetic rats plasma treated with aqueous extracts of *Musanga cecropioides* root after 28 days

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=6$; DB: Diabetes; GLIB: Glibenclamide; MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; * Significant values at $P < 0.05$, when compared to normal control group

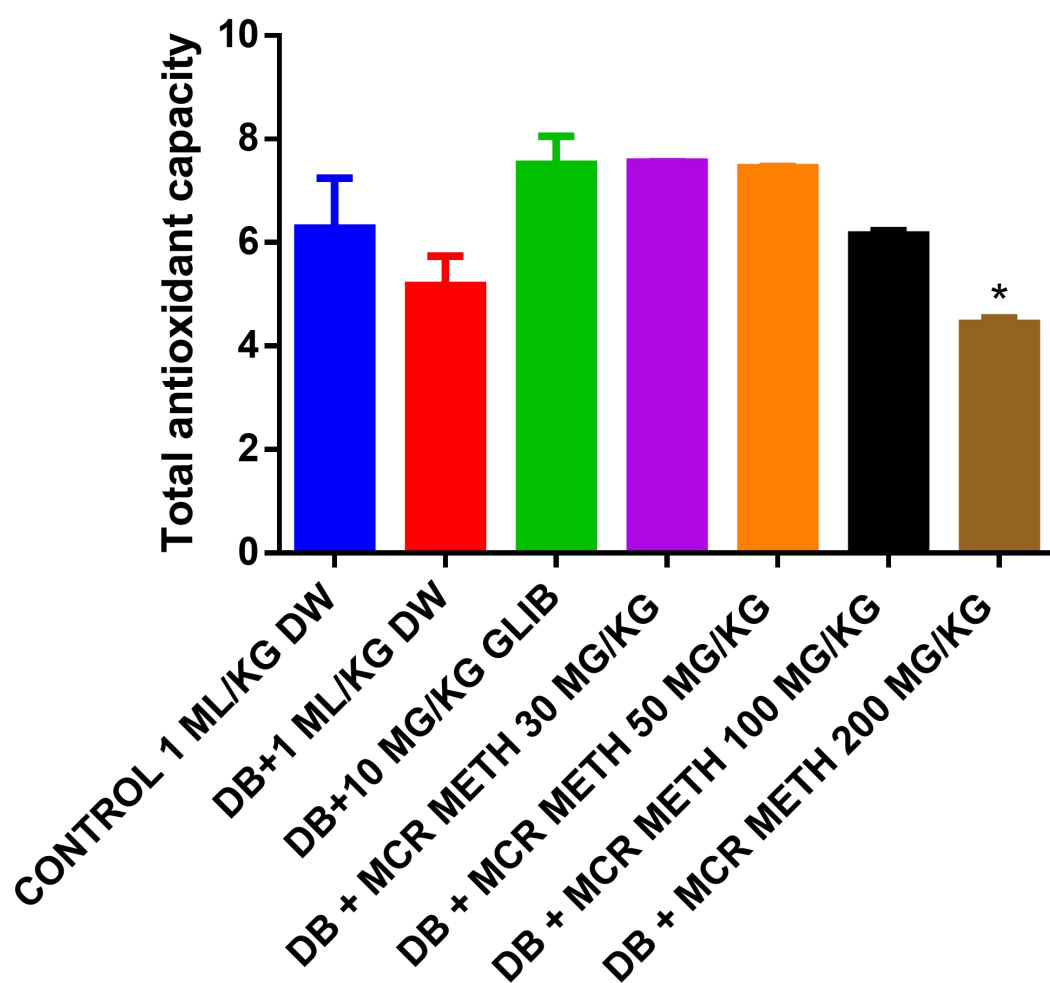


Figure 4.38: Total antioxidant capacity of STZ – induced diabetic rats plasma treated with methanol extracts of *Musanga cecropioides* root after 28 days

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=6$; DB: Diabetes; GLIB: Glibenclamide; MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; * Significant values at $P < 0.05$, when compared to normal control group

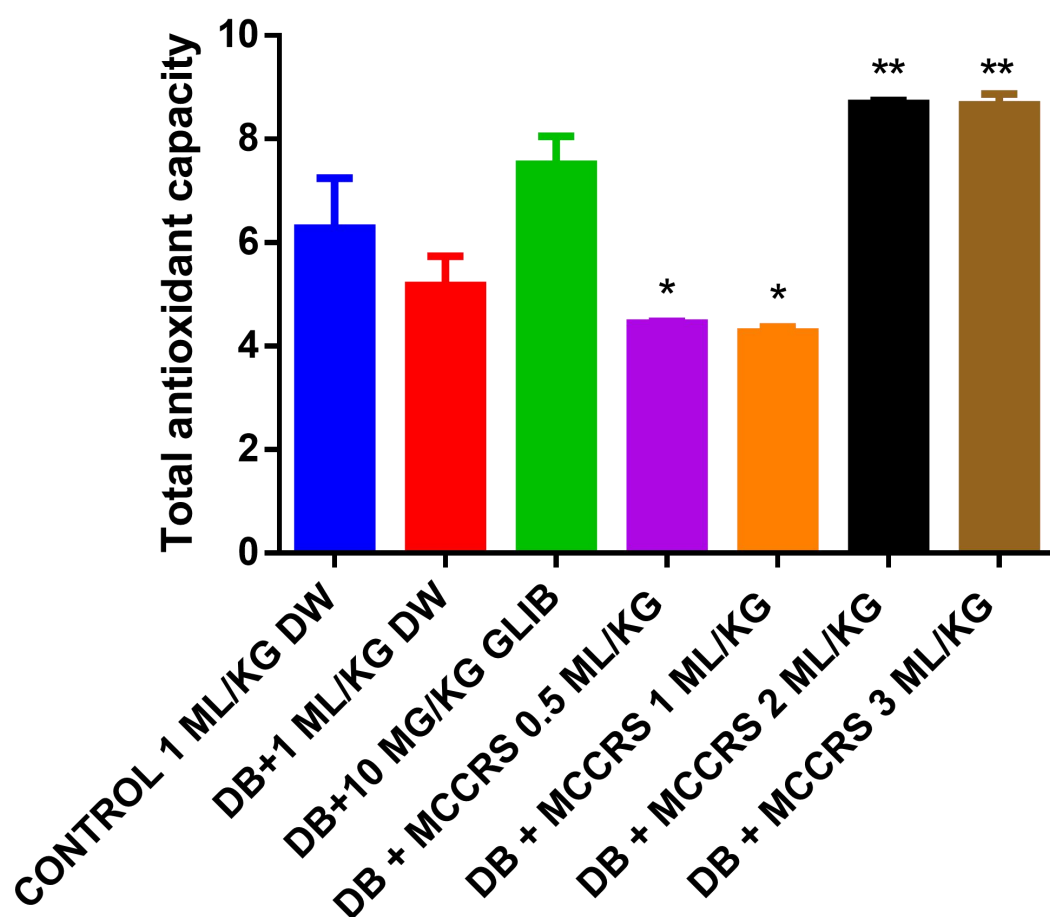


Figure 4.39: Total antioxidant capacity of STZ – induced diabetic rats plasma treated with of *Musanga cecropioides* crude root sap after 28 days

Values are expressed as Mean $\pm$ SEM, $P < 0.05$; $n=6$; DB: Diabetes; GLIB: Glibenclamide; MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$, when compared to normal control group

4.7.6 In-vivo Antioxidant of the Brain, Liver and Pancreas

4.7.6.1 Brain

Tables 4.89, 4.90, 4.91, 4.92 and 4.93 show the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the brain antioxidant parameters of STZ-induced diabetic rats.

In Table 4.89, *Musanga cecropioides* aqueous leaf extract at 30 mg/kg significantly increased malondialdehyde at $P < 0.01$. The dose of 50 mg/kg significantly increased malondialdehyde, superoxide dismutase and glutathione peroxidase at $P < 0.001$. At 100 mg/kg, malondialdehyde concentration was significantly reduced at $P < 0.05$ while at a dose of 200 mg/kg, catalase concentration was significantly reduced at $P < 0.001$ and glutathione peroxidase was significantly increased at $P < 0.05$ when compared to the normal control group.

In Table 4.90, *Musanga cecropioides* methanol leaf extract at 30 mg/kg significantly reduced malondialdehyde concentration at $P < 0.001$, catalase concentration at $P < 0.05$ and glutathione peroxidase concentration at $P < 0.01$. At 50 mg/kg, malondialdehyde and catalase activities were significantly reduced at $P < 0.01$ and $P < 0.001$ respectively, while superoxide dismutase activity was significantly increased at $P < 0.01$. At 100 mg/kg, malondialdehyde and catalase activities were significantly reduced at $P < 0.001$ while glutathione peroxidase was significantly increased at $P < 0.01$. At a dose of 200 mg/kg, glutathione peroxidase was significantly increased at $P < 0.001$ when compared to the normal control group.

In Table 4.91, *Musanga cecropioides* aqueous root extract at 30, 50 and 100 mg/kg significantly reduced malondialdehyde concentration at $P < 0.001$. Catalase concentration was also significantly reduced at 30 mg/kg, 50 mg/kg (at $P < 0.001$), 100 mg/kg (at $P < 0.01$) and 200 mg/kg (at $P < 0.001$). Glutathione peroxidase activity was significantly increased at 30 mg/kg (at $P < 0.01$), 50 mg/kg, 100 mg/kg (at $P < 0.05$) and 200 mg/kg (at $P < 0.001$) when compared to the normal control group.

In Table 4.92, *Musanga cecropioides* methanol root extract at the dose of 30 mg/kg significantly reduced malondialdehyde and catalase concentration at $P < 0.001$ and $P < 0.01$ respectively when compared to the normal control. At the dose of 50 mg/kg, malondialdehyde and catalase concentrations were significantly reduced at $P < 0.01$ while glutathione peroxidase was significantly increased at $P < 0.001$ when compared to the normal control group. At 100 mg/kg dose, glutathione peroxidase was significantly increased at $P < 0.05$ while at 200 mg/kg, malondialdehyde concentration was significantly reduced at $P < 0.05$ when compared to the normal control group.

In Table 4.93, *Musanga cecropioides* crude root sap at a dose of 0.5 ml/kg significantly increased superoxide dismutase (at $P < 0.01$), catalase (at $P < 0.001$) and glutathione peroxidase concentration (at $P < 0.01$). At the dose of 1 ml/kg, malondialdehyde was significantly increased at $P < 0.001$ while superoxide dismutase, catalase and glutathione peroxidase concentration was significantly reduced at $P < 0.001$. At the dose of 2 ml/kg, malondialdehyde was significantly increased at $P < 0.001$ while catalase concentration was significantly reduced at $P < 0.001$. At the dose of 3 ml/kg, catalase and glutathione peroxidase activity were significantly increased at $P < 0.001$.

Table 4.89: Effect of aqueous extract of *Musanga cecropioides* leaves on the brain antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	37.48 ± 4.41	5.63 ± 0.70	201.5 ± 13.57	118.6 ± 8.00	2.85 ± 0.29
STZ control + 1 ml/kg DW	44.60 ± 4.31*	4.20 ± 0.45***	181.2 ± 10.17	114.8 ± 6.80	2.80 ± 0.18
STZ + Glibenclamide 10 mg/kg	57.29 ± 2.95***	5.09 ± 0.11	180.6 ± 11.20	128.5 ± 1.57	2.19 ± 0.15
STZ + MCL Aq 30 mg/kg	46.11 ± 0.39**	5.40 ± 0.91	216.4 ± 9.20	116.3 ± 3.20	2.57 ± 0.21
STZ + MCL Aq 50 mg/kg	50.52 ± 2.27***	7.69 ± 0.18***	185.6 ± 1.50	141.1 ± 2.83***	2.69 ± 0.23
STZ + MCL Aq 100 mg/kg	30.36 ± 1.35*	6.39 ± 0.12	199.7 ± 10.24	128.3 ± 2.14	2.71 ± 0.10
STZ + MCL Aq 200 mg/kg	33.70 ± 0.93	6.73 ± 0.10*	162.6 ± 8.11***	129.3 ± 2.00*	2.33 ± 0.12

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.90: Effect of methanol extract of *Musanga cecropioides* leaves on the brain antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	37.48 ± 4.41	5.63 ± 0.70	201.5 ± 13.57	118.6 ± 8.00	2.85 ± 0.29
STZ control + 1 ml/kg DW	44.60 ± 4.31*	4.20 ± 0.45***	181.2 ± 10.17	114.8 ± 6.80	2.80 ± 0.18
STZ + Glibenclamide 10 mg/kg	57.29 ± 2.95***	5.09 ± 0.11	180.6 ± 11.20	128.5 ± 1.57	2.19 ± 0.15
STZ + MCL Meth 30 mg/kg	25.30 ± 0.40***	6.14 ± 0.18	178.5 ± 6.35*	131.0 ± 2.17**	2.02 ± 0.03
STZ + MCL Meth 50 mg/kg	28.06 ± 0.61**	6.82 ± 0.04**	165.8 ± 1.15***	128.9 ± 0.26	2.21 ± 0.04
STZ + MCL Meth 100 mg/kg	26.31 ± 0.93***	6.56 ± 0.22	166.0 ± 2.13***	131.9 ± 3.00**	2.21 ± 0.01
STZ + MCL Meth 200 mg/kg	38.76 ± 1.68	6.01 ± 0.38	187.7 ± 6.10	147.7 ± 1.88***	3.01 ± 0.18

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.91: Effect of aqueous extract of *Musanga cecropioides* root on the brain antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	37.48 ± 4.41	5.63 ± 0.70	201.5 ± 13.57	118.6 ± 8.00	2.85 ± 0.29
STZ control + 1 ml/kg DW	44.60 ± 4.31*	4.20 ± 0.45***	181.2 ± 10.17	114.8 ± 6.80	2.80 ± 0.18
STZ + Glibenclamide 10 mg/kg	57.29 ± 2.95***	5.09 ± 0.11	180.6 ± 11.20	128.5 ± 1.57	2.19 ± 0.15
STZ + MCR Aq 30 mg/kg	25.40 ± 0.99***	6.11 ± 0.31	169.6 ± 1.34***	132.2 ± 4.80**	3.11 ± 0.02
STZ + MCR Aq 50 mg/kg	23.41 ± 0.80***	5.53 ± 0.42	170.4 ± 1.82***	129.0 ± 3.12*	3.14 ± 0.03
STZ + MCR Aq 100 mg/kg	25.92 ± 0.26***	5.94 ± 0.12	171.5 ± 0.72**	129.8 ± 0.64*	3.18 ± 0.11
STZ + MCR Aq 200 mg/kg	33.81 ± 0.15	4.98 ± 0.37	170.8 ± 0.17***	139.5 ± 1.18***	3.49 ± 0.04

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.92: Effect of methanol extract of *Musanga cecropioides* root on the brain antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	37.48 ± 4.41	5.63 ± 0.70	201.5 ± 13.57	118.6 ± 8.00	2.85 ± 0.29
STZ control + 1 ml/kg DW	44.60 ± 4.31*	4.20 ± 0.45***	181.2 ± 10.17	114.8 ± 6.80	2.80 ± 0.18
STZ + Glibenclamide 10 mg/kg	57.29 ± 2.95***	5.09 ± 0.11	180.6 ± 11.20	128.5 ± 1.57	2.19 ± 0.15
STZ + MCR Meth 30 mg/kg	24.77 ± 3.59***	6.31 ± 0.10	171.2 ± 2.02**	127.8 ± 1.00	2.52 ± 0.12
STZ + MCR Meth 50 mg/kg	29.42 ± 2.03**	5.61 ± 0.34	173.3 ± 3.20**	133.6 ± 1.23***	2.30 ± 0.01
STZ + MCR Meth 100 mg/kg	31.40 ± 1.11	5.67 ± 0.13	198.5 ± 1.00	129.0 ± 1.88*	3.11 ± 0.31
STZ + MCR Meth 200 mg/kg	30.22 ± 0.40*	6.11 ± 0.12	212.2 ± 0.39	121.2 ± 0.98	2.98 ± 0.13

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.93: Effect of *Musanga cecropioides* crude root sap on the brain antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	37.48 ± 4.41	5.63 ± 0.70	201.5 ± 13.57	118.6 ± 8.00	2.85 ± 0.29
STZ control + 1 ml/kg DW	44.60 ± 4.31*	4.20 ± 0.45***	181.2 ± 10.17	114.8 ± 6.80	2.80 ± 0.18
STZ + Glibenclamide 10 mg/kg	57.29 ± 2.95***	5.09 ± 0.11	180.6 ± 11.20	128.5 ± 1.57	2.19 ± 0.15
STZ + MCCRS 0.5 ml/kg	32.63 ± 0.35	6.87 ± 0.29**	238.6 ± 0.18***	132.7 ± 0.29**	2.01 ± 0.01
STZ + MCCRS 1 ml/kg	65.37 ± 0.74***	3.62 ± 0.31***	157.0 ± 1.01***	99.33 ± 0.71***	2.76 ± 0.09
STZ + MCCRS 2 ml/kg	61.40 ± 1.21***	6.10 ± 0.22	159.5 ± 1.28***	124.6 ± 1.28	1.77 ± 0.03
STZ + MCCRS 3 ml/kg	32.56 ± 1.00	6.52 ± 0.18	241.1 ± 1.33***	136.1 ± 2.28***	1.84 ± 0.00

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.6.2 Liver

Tables 4.94, 4.95, 4.96, 4.97 and 4.98 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the liver antioxidant parameters of STZ-induced diabetic rats.

In Table 4.94, *Musanga cecropioides* aqueous leaf extract at 30 mg/kg significantly reduced superoxide dismutase at $P < 0.05$ and significantly increased glutathione reductase at $P < 0.001$. The dose of 50 mg/kg significantly increased superoxide dismutase, catalase and glutathione peroxidase at $P < 0.001$. At 100 mg/kg, superoxide dismutase concentration was significantly reduced at $P < 0.001$ while glutathione peroxidase and glutathione reductase were significantly increased at $P < 0.001$ and $P < 0.01$ respectively. The dose of 200 mg/kg significantly reduced malondialdehyde at $P < 0.05$ and superoxide dismutase at $P < 0.01$ when compared to the normal control group.

In Table 4.95, *Musanga cecropioides* methanol leaf extract at all doses significantly increased glutathione peroxidase at $P < 0.001$, while at doses of 50, 100 and 200, glutathione reductase was significantly increased (at $P < 0.001$ and $P < 0.01$) when compared to the normal control group. At the dose of 50 mg/kg, malondialdehyde level was significantly increased at $P < 0.001$. At the dose of 100 mg/kg, malondialdehyde and superoxide dismutase concentrations significantly reduced while catalase significantly increased at $P < 0.001$ when compared to the normal control group.

In Table 4.96, *Musanga cecropioides* aqueous root extract at 30 mg/kg significantly increased malondialdehyde and glutathione peroxidase concentration at $P < 0.001$, while catalase activity was significantly reduced at $P < 0.01$. At the dose of 50 mg/kg,

Superoxide dismutase was significantly reduced at $P < 0.001$ while glutathione reductase was significantly increased at $P < 0.05$ when compared to the normal control group. The dose of 100 mg/kg significantly reduced superoxide dismutase at $P < 0.001$, while the dose of 200 mg/kg significantly increased superoxide dismutase at $P < 0.01$ and significantly increased glutathione peroxidase at $P < 0.001$ when compared with the normal control group.

In Table 4.97, *Musanga cecropioides* methanol root extract at the dose of 30 mg/kg significantly increased malondialdehyde at $P < 0.001$ when compared to the normal control. At the dose of 50 mg/kg, superoxide dismutase and glutathione peroxidase concentrations were significantly reduced at $P < 0.001$ and $P < 0.05$ respectively when compared to the normal control group. At 100 mg/kg dose, superoxide dismutase was significantly reduced while glutathione peroxidase and glutathione reductase were significantly increased at $P < 0.001$. While at 200 mg/kg, superoxide dismutase concentration was significantly reduced at $P < 0.05$ and catalase concentration was significantly increased at $P < 0.001$ when compared to the normal control group.

In Table 4.98, *Musanga cecropioides* crude root sap at a dose of 0.5 ml/kg significantly reduced catalase (at $P < 0.001$) and significantly increased glutathione peroxidase concentration (at $P < 0.01$). At the dose of 1 ml/kg, malondialdehyde, catalase and glutathione reductase concentrations were significantly increased at $P < 0.001$ while superoxide dismutase was significantly reduced at $P < 0.001$. At the dose of 2 ml/kg, malondialdehyde, superoxide dismutase and glutathione peroxidase were significantly increased at $P < 0.01$ and $P < 0.001$. At the dose of 3 ml/kg, catalase activity was significantly reduced at $P < 0.01$ and glutathione peroxidase activity was significantly increased at $P < 0.001$.

Table 4.94: Effect of aqueous extracts of *Musanga cecropioides* leaves on the liver antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	46.06 ± 1.62	5.25 ± 0.43	128.5 ± 6.44	113.3 ± 1.01	1.39 ± 0.08
STZ control + 1 ml/kg DW	54.26 ± 3.27	4.87 ± 0.62	141.2 ± 5.24*	115.3 ± 2.56	1.69 ± 0.28
STZ + Glibenclamide 10 mg/kg	53.64 ± 3.97	7.65 ± 0.94***	139.4 ± 3.56	124.2 ± 1.45***	1.86 ± 0.17**
STZ + MCL Aq 30 mg/kg	44.39 ± 3.33	3.62 ± 0.61*	117.8 ± 2.81	114.1 ± 1.28	2.34 ± 0.09***
STZ + MCL Aq 50 mg/kg	55.07 ± 1.36	8.07 ± 0.77***	160.7 ± 5.78***	135.0 ± 1.02***	1.57 ± 0.06
STZ + MCL Aq 100 mg/kg	51.74 ± 2.25	2.99 ± 0.43***	134.6 ± 4.43	129.5 ± 1.41***	1.85 ± 0.10**
STZ + MCL Aq 200 mg/kg	41.62 ± 4.06*	3.46 ± 0.57**	119.3 ± 3.41	116.1 ± 0.18	1.20 ± 0.12

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.95: Effect of methanol extract of *Musanga cecropioides* leaves on the liver antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	46.06 ± 1.62	5.25 ± 0.43	128.5 ± 6.44	113.3 ± 1.01	1.39 ± 0.08
STZ control + 1 ml/kg DW	54.26 ± 3.27	4.87 ± 0.62	141.2 ± 5.24*	115.3 ± 2.56	1.69 ± 0.28
STZ + Glibenclamide 10 mg/kg	53.64 ± 3.97	7.65 ± 0.94***	139.4 ± 3.56	124.2 ± 1.45***	1.86 ± 0.17**
STZ + MCL Meth 30 mg/kg	46.40 ± 1.66	3.95 ± 0.90	127.0 ± 2.44	123.1 ± 3.89***	1.66 ± 0.18
STZ + MCL Meth 50 mg/kg	60.47 ± 0.82***	5.66 ± 0.24	138.6 ± 4.54	130.2 ± 0.35***	2.24 ± 0.03***
STZ + MCL Meth 100 mg/kg	37.57 ± 2.28***	2.33 ± 0.18***	166.3 ± 2.81***	133.3 ± 0.11***	1.88 ± 0.02**
STZ + MCL Meth 200 mg/kg	45.99 ± 2.57	4.59 ± 0.12	134.0 ± 3.22	123.7 ± 1.75***	1.87 ± 0.02**

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.96: Effect of aqueous extract of *Musanga cecropioides* root on the liver antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	46.06 ± 1.62	5.25 ± 0.43	128.5 ± 6.44	113.3 ± 1.01	1.39 ± 0.08
STZ control + 1 ml/kg DW	54.26 ± 3.27	4.87 ± 0.62	141.2 ± 5.24*	115.3 ± 2.56	1.69 ± 0.28
STZ + Glibenclamide 10 mg/kg	53.64 ± 3.97	7.65 ± 0.94***	139.4 ± 3.56	124.2 ± 1.45***	1.86 ± 0.177**
STZ + MCR Aq 30 mg/kg	66.81 ± 2.61***	4.98 ± 0.22	112.4 ± 4.88**	121.4 ± 0.93***	1.46 ± 0.11
STZ + MCR Aq 50 mg/kg	46.70 ± 2.84	2.56 ± 0.37***	118.3 ± 0.99	114.2 ± 1.21	1.76 ± 0.22*
STZ + MCR Aq 100 mg/kg	52.07 ± 2.79	3.00 ± 0.05***	121.9 ± 0.22	111.5 ± 0.86	1.36 ± 0.08
STZ + MCR Aq 200 mg/kg	44.36 ± 0.83	7.02 ± 0.10**	126.1 ± 0.29	122.9 ± 0.63***	1.29 ± 0.03

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.97: Effect of methanol extract of *Musanga cecropioides* root on the liver antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	46.06 ± 1.62	5.25 ± 0.43	128.5 ± 6.44	113.3 ± 1.01	1.39 ± 0.08
STZ control + 1 ml/kg DW	54.26 ± 3.27	4.87 ± 0.62	141.2 ± 5.24*	115.3 ± 2.56	1.69 ± 0.28
STZ + Glibenclamide 10 mg/kg	53.64 ± 3.97	7.65 ± 0.94***	139.4 ± 3.56	124.2 ± 1.45***	1.86 ± 0.17**
STZ + MCR Meth 30 mg/kg	61.43 ± 0.59***	3.87 ± 0.09	123.6 ± 0.89	114.8 ± 0.78	1.16 ± 0.03
STZ + MCR Meth 50 mg/kg	48.51 ± 1.93	2.62 ± 0.90***	120.1 ± 0.19	108.2 ± 0.63*	1.20 ± 0.04
STZ + MCR Meth 100 mg/kg	43.28 ± 1.66	3.00 ± 0.09***	117.8 ± 0.28	127.9 ± 0.18***	2.06 ± 0.02***
STZ + MCR Meth 200 mg/kg	54.11 ± 1.14	3.62 ± 0.12*	147.3 ± 0.36***	117.6 ± 0.12	1.17 ± 0.13

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.98: Effect of *Musanga cecropioides* crude root sap on the liver antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	46.06 ± 1.62	5.25 ± 0.43	128.5 ± 6.44	113.3 ± 1.01	1.39 ± 0.08
STZ control + 1 ml/kg DW	54.26 ± 3.27	4.87 ± 0.62	141.2 ± 5.24*	115.3 ± 2.56	1.69 ± 0.28
STZ + Glibenclamide 10 mg/kg	53.64 ± 3.97	7.65 ± 0.94***	139.4 ± 3.56	124.2 ± 1.45***	1.86 ± 0.17**
STZ + MCCRS 0.5 ml/kg	43.76 ± 0.47	4.90 ± 0.11	111.9 ± 0.15***	119.4 ± 0.01**	1.14 ± 0.01
STZ + MCCRS 1 ml/kg	65.44 ± 0.59***	3.11 ± 0.04***	152.3 ± 1.34***	111.7 ± 0.36	2.65 ± 0.07***
STZ + MCCRS 2 ml/kg	57.36 ± 1.28**	8.34 ± 0.13***	136.3 ± 4.21	125.4 ± 0.12***	1.64 ± 0.03
STZ + MCCRS 3 ml/kg	38.56 ± 1.34	4.85 ± 0.10	114.3 ± 2.11**	120.4 ± 0.22***	1.14 ± 0.06

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.6.3 Pancreas

Tables 4.99, 4.100, 4.101, 4.102 and 4.103 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the pancreas antioxidant parameters of STZ-induced diabetic rats.

In Table 4.99, *Musanga cecropioides* aqueous leaf extract at 30 mg/kg significantly increased malondialdehyde, catalase and glutathione peroxidase at $P < 0.001$ and $P < 0.05$ and significantly reduced superoxide dismutase at $P < 0.05$. The dose of 50 mg/kg significantly reduced superoxide dismutase at $P < 0.001$ and significantly increased glutathione peroxidase and glutathione reductase at $P < 0.001$. The dose of 100 mg/kg significantly increased malondialdehyde at $P < 0.05$, catalase at $P < 0.001$ and significantly reduced superoxide dismutase at $P < 0.001$. The dose of 200 mg/kg significantly reduced superoxide dismutase at $P < 0.001$ when compared with the normal control group.

In Table 4.100, *Musanga cecropioides* methanol leaf extract significantly reduced superoxide dismutase activity at all dose levels (30 and 50 mg/kg at $P < 0.05$, while 100 and 200 mg/kg at $P < 0.001$). Glutathione peroxidase was significantly increased in all treatment doses at $P < 0.001$. Glutathione reductase levels significantly increased in groups administered doses of 30 and 50 mg/kg at $P < 0.001$ and $P < 0.01$ respectively. While catalase activity significantly increased at 30 mg/kg ($P < 0.05$) and significantly increased at 50 ($P < 0.001$) and 200 mg/kg ($P < 0.01$) when compared to the normal control group.

In Table 4.101, *Musanga cecropioides* aqueous root extract at 30 mg/kg significantly reduced catalase concentration and significantly increased glutathione peroxidase and

glutathione reductase at $P < 0.001$. The dose of 50 mg/kg significantly reduced superoxide dismutase and significantly increased glutathione reductase at $P < 0.001$. The dose of 100 mg/kg significantly reduced superoxide dismutase (at $P < 0.001$), catalase (at $P < 0.05$) and glutathione peroxidase (at $P < 0.01$) while the dose of 200 mg/kg significantly reduced superoxide dismutase and catalase at $P < 0.001$ and significantly increased glutathione peroxidase at $P < 0.001$ when compared with the normal control group.

In Table 4.102, *Musanga cecropioides* methanol root extract at 30 mg/kg significantly reduced superoxide dismutase and significantly increased catalase at $P < 0.001$. The dose of 50 mg/kg significantly reduced superoxide dismutase at $P < 0.001$. At 100 mg/kg, superoxide dismutase was also significantly reduced while catalase, glutathione reductase and glutathione peroxidase were significantly increased at $P < 0.001$. At the dose of 200 mg/kg, malondialdehyde and glutathione reductase were significantly increased at $P < 0.001$ while superoxide dismutase was significantly reduced at $P < 0.05$ when compared with the normal control group.

In Table 4.103, *Musanga cecropioides* crude root sap at 0.5 ml/kg significantly increased malondialdehyde at $P < 0.05$ and significantly reduced catalase at $P < 0.001$. At the dose of 1 ml/kg, malondialdehyde, superoxide dismutase, glutathione peroxidase and glutathione reductase levels were significantly increased, while catalase was significantly reduced at $P < 0.001$. The administration of 2 ml/kg significantly increased malondialdehyde and glutathione peroxidase levels at $P < 0.001$, and significantly reduced superoxide dismutase and catalase levels at $P < 0.05$ and $P < 0.001$ respectively. The dose of 3 ml/kg significantly reduced superoxide dismutase, catalase and glutathione reductase (at $P < 0.001$ and $P < 0.05$) and

significantly increased glutathione peroxidase at $P < 0.01$ when compared to the normal control group.

Table 4.99: Effect of aqueous extract of *Musanga cecropioides* leaves on the pancreas antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	29.99 ± 0.54	8.63 ± 0.11	250.9 ± 4.26	127.3 ± 0.35	2.09 ± 0.19
STZ control + 1 ml/kg DW	33.37 ± 2.80***	6.25 ± 0.58***	247.4 ± 8.10	133.2 ± 3.54	2.22 ± 0.45
STZ + Glibenclamide 10 mg/kg	33.66 ± 0.47***	7.86 ± 0.30	232.5 ± 2.39**	144.2 ± 3.65***	2.41 ± 0.12
STZ + MCL Aq 30 mg/kg	32.37 ± 1.22***	7.44 ± 0.28*	291.4 ± 3.13***	134.7 ± 1.33*	2.16 ± 0.11
STZ + MCL Aq 50 mg/kg	28.48 ± 0.57	6.79 ± 0.48***	249.6 ± 2.09	139.5 ± 1.45***	2.84 ± 0.18***
STZ + MCL Aq 100 mg/kg	30.74 ± 0.80*	4.93 ± 0.55***	277.5 ± 2.04***	125.4 ± 0.90	1.89 ± 0.08
STZ + MCL Aq 200 mg/kg	27.24 ± 0.44	6.24 ± 0.34***	238.1 ± 4.22	127.3 ± 1.32	2.36 ± 0.13

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCL: *Musanga cecropioides* leaves; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.100: Effect of methanol extract of *Musanga cecropioides* leaves on the pancreas antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	29.99 ± 0.54	8.63 ± 0.11	250.9 ± 4.26	127.3 ± 0.35	2.09 ± 0.19
STZ control + 1 ml/kg DW	33.37 ± 2.80***	6.25 ± 0.58***	247.4 ± 8.10	133.2 ± 3.54	2.22 ± 0.45
STZ + Glibenclamide 10 mg/kg	33.66 ± 0.47***	7.86 ± 0.30	232.5 ± 2.39**	144.2 ± 3.65***	2.41 ± 0.12
STZ + MCL Meth 30 mg/kg	26.56 ± 1.56	7.48 ± 0.54*	264.9 ± 10.14*	144.3 ± 3.39***	3.08 ± 0.03***
STZ + MCL Meth 50 mg/kg	25.66 ± 0.97	7.38 ± 0.20*	227.3 ± 2.08***	140.6 ± 0.59***	2.79 ± 0.04**
STZ + MCL Meth 100 mg/kg	25.11 ± 0.32	3.94 ± 0.42***	246.8 ± 6.18	136.9 ± 2.08***	2.33 ± 0.13
STZ + MCL Meth 200 mg/kg	26.07 ± 1.09	6.26 ± 0.39***	233.4 ± 3.72**	142.3 ± 2.83***	2.34 ± 0.17

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.101: Effect of aqueous extract of *Musanga cecropioides* root on the pancreas antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	29.99 ± 0.54	8.63 ± 0.11	250.9 ± 4.26	127.3 ± 0.35	2.09 ± 0.19
STZ control + 1 ml/kg DW	33.37 ± 2.80***	6.25 ± 0.58***	247.4 ± 8.10	133.2 ± 3.54	2.22 ± 0.45
STZ + Glibenclamide 10 mg/kg	33.66 ± 0.47***	7.86 ± 0.30	232.5 ± 2.39**	144.2 ± 3.65***	2.41 ± 0.12
STZ + MCR Aq 30 mg/kg	26.32 ± 0.22	7.83 ± 0.28	230.9 ± 6.21***	137.2 ± 2.11***	3.43 ± 0.11***
STZ + MCR Aq 50 mg/kg	26.53 ± 0.33	6.90 ± 0.23***	253.2 ± 8.12	122.4 ± 1.82	3.56 ± 0.21***
STZ + MCR Aq 100 mg/kg	28.13 ± 0.27	6.38 ± 0.21***	265.0 ± 1.75*	135.8 ± 1.89**	2.11 ± 0.07
STZ + MCR Aq 200 mg/kg	24.01 ± 0.06	5.71 ± 0.23***	220.4 ± 0.42***	136.9 ± 0.25***	2.26 ± 0.00

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Aq: Aqueous extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.102: Effect of methanol extract of *Musanga cecropioides* root on the pancreas antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	29.99 ± 0.54	8.63 ± 0.11	250.9 ± 4.26	127.3 ± 0.35	2.09 ± 0.19
STZ control + 1 ml/kg DW	33.37 ± 2.80***	6.25 ± 0.58***	247.4 ± 8.10	133.2 ± 3.54	2.22 ± 0.45
STZ + Glibenclamide 10 mg/kg	33.66 ± 0.47***	7.86 ± 0.30	232.5 ± 2.39**	144.2 ± 3.65***	2.41 ± 0.12
STZ + MCR Meth 30 mg/kg	29.16 ± 0.43	6.19 ± 0.21***	283.4 ± 0.99***	133.6 ± 2.01	2.39 ± 0.13
STZ + MCR Meth 50 mg/kg	28.20 ± 1.28	4.93 ± 0.20***	241.3 ± 2.22	124.3 ± 1.00	1.96 ± 0.38
STZ + MCR Meth 100 mg/kg	26.88 ± 2.13	6.93 ± 0.11***	281.6 ± 6.28***	141.9 ± 1.00***	3.12 ± 0.13***
STZ + MCR Meth 200 mg/kg	32.37 ± 0.22***	7.44 ± 0.21*	240.1 ± 5.31	132.4 ± 0.53	2.90 ± 0.01***

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCR: *Musanga cecropioides* root; Meth: Methanol extract; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

Table 4.103: Effect of *Musanga cecropioides* crude root sap on the pancreas antioxidant parameters of STZ-induced diabetic rats

Parameters	MDA (mmole/ml)	SOD (U/ml)	CAT (U/ml)	GPX (U/ml)	GRX (U/ml)
Normal control + 1 ml/kg DW	29.99 ± 0.54	8.63 ± 0.11	250.9 ± 4.26	127.3 ± 0.35	2.09 ± 0.19
STZ control + 1 ml/kg DW	33.37 ± 2.80***	6.25 ± 0.58***	247.4 ± 8.10	133.2 ± 3.54	2.22 ± 0.45
STZ + Glibenclamide 10 mg/kg	33.66 ± 0.47***	7.86 ± 0.30	232.5 ± 2.39**	144.2 ± 3.65***	2.41 ± 0.12
STZ + MCCRS 0.5 ml/kg	30.77 ± 0.15*	8.83 ± 0.19	219.3 ± 0.40***	133.6 ± 0.43	1.64 ± 0.00
STZ + MCCRS 1 ml/kg	41.37 ± 0.67***	12.37 ± 0.33***	192.5 ± 2.91***	148.4 ± 0.96***	3.11 ± 0.05***
STZ + MCCRS 2 ml/kg	36.15 ± 1.21***	7.30 ± 0.19*	231.4 ± 1.31***	153.2 ± 0.38***	2.37 ± 0.12
STZ + MCCRS 3 ml/kg	25.48 ± 0.55	6.83 ± 0.22***	216.3 ± 1.81***	136.2 ± 0.19**	1.52 ± 0.11*

Values are expressed as Mean ± SEM, $P < 0.05$; n=6

MCCRS: *Musanga cecropioides* crude root sap; DW: distilled water; MDA: Malondialdehyde; SOD: Superoxide dismutase; CAT: Catalase; GPX: Glutathione peroxidase; GRX: Glutathione reductase; * Significant values at $P < 0.05$; ** significant values at $P < 0.01$; *** significant values at $P < 0.001$, when compared to normal control group

4.7.7 Histopathology

4.7.7.1 Histology of the Heart

Plates 4.16, 4.17, 4.18, 4.19 and 4.20 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the histology of the heart in STZ-induced diabetic rats. The diabetic control group showed signs of inflammation however no inflammation was observed in most of the treatment groups.

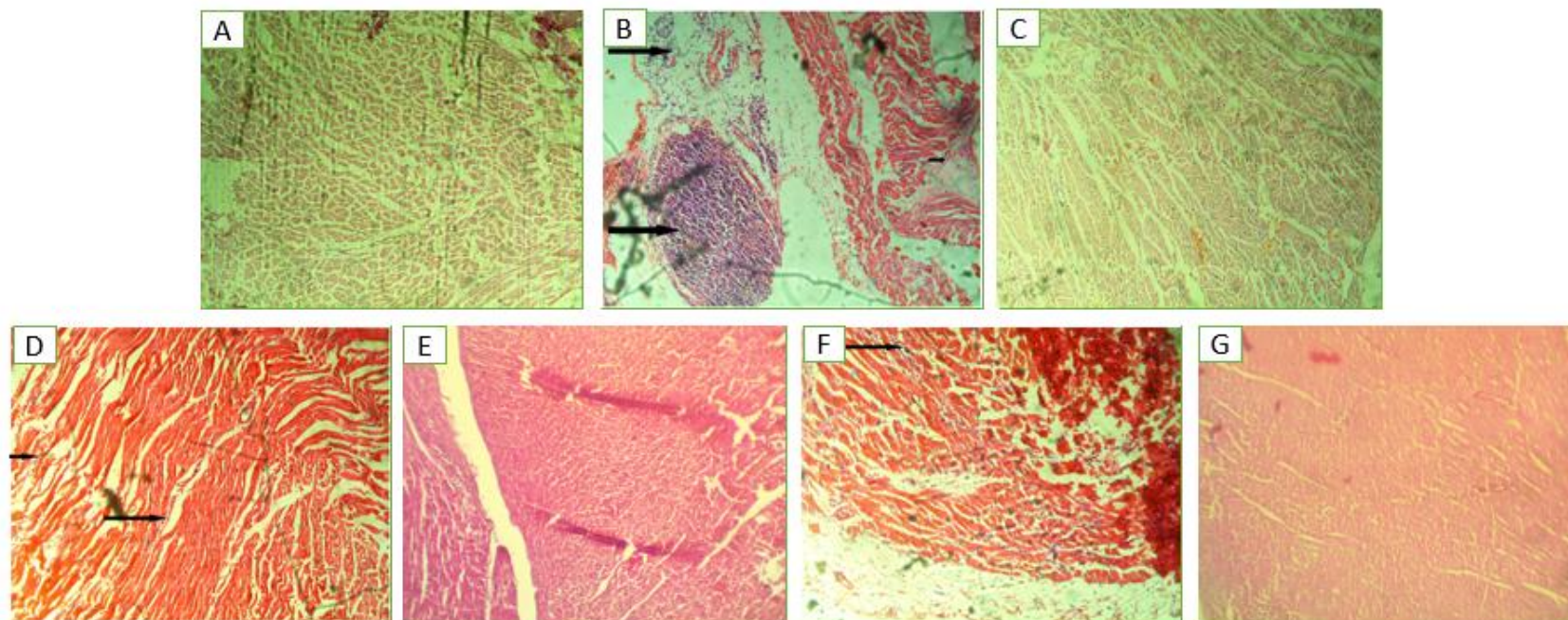


Plate 4.16: Effect of aqueous extract of *Musanga cecropioides* leaves on the histology of the heart in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pericarditis (inflammation of the pericardium) long black arrows and mild stromal inflammation (small red arrow); C: Glibenclamide (10 mg/kg) with no inflammation; D: MCL Aq (30 mg/kg) with mild stromal inflammation; E: MCL Aq (50 mg/kg) appears normal; F: MCL Aq (100 mg/kg) with mild stromal inflammation; G: MCL Aq (200 mg/kg) with normal myocytes: H and E $\times 100$

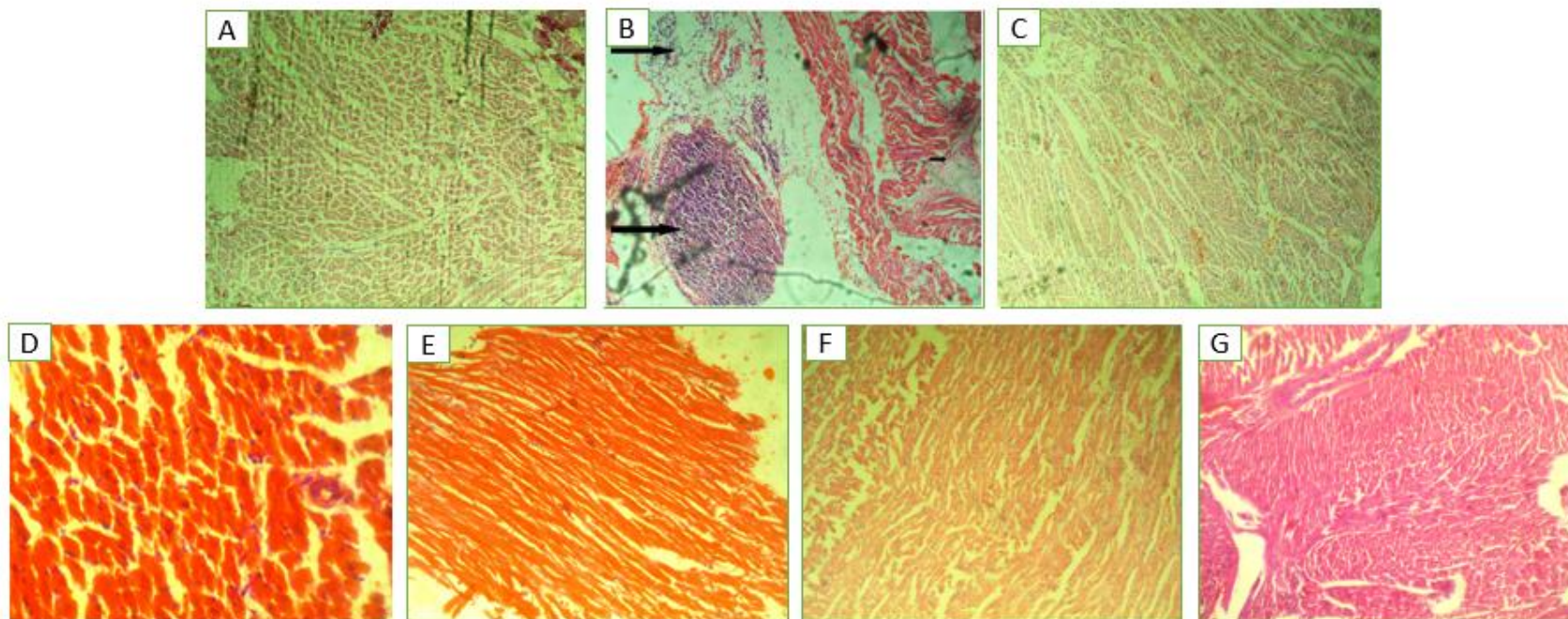


Plate 4.17: Effect of methanol extract of *Musanga cecropioides* leaves on the histology of the heart in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pericarditis (inflammation of the pericardium) long black arrows and mild stromal inflammation (small red arrow); C: Glibenclamide (10 mg/kg) with no inflammation; D: MCL Meth (30 mg/kg) with no inflammation; E: MCL Meth (50 mg/kg) with no inflammation; F: MCL Meth (100 mg/kg) with no inflammation; G: MCL Meth (200 mg/kg) appears normal: H and E $\times 100$

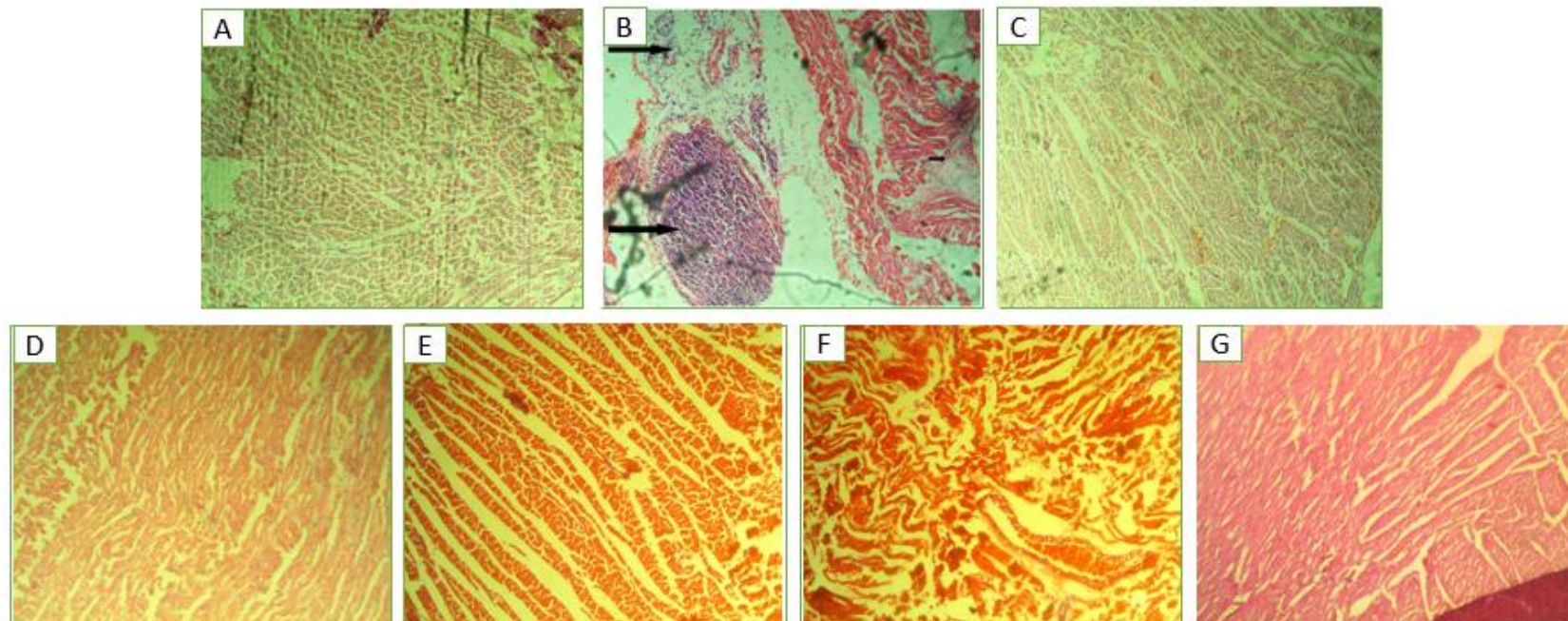


Plate 4.18: Effect of aqueous extract of *Musanga cecropioides* root on the histology of the heart in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pericarditis (inflammation of the pericardium) long black arrows and mild stromal inflammation (small red arrow); C: Glibenclamide (10 mg/kg) with no inflammation; D: MCR Aq (30 mg/kg) with no inflammation; E: MCR Aq (50 mg/kg) with no inflammation; F: MCR Aq (100 mg/kg) with no inflammation; G: MCR Aq (200 mg/kg) appears normal: H and E $\times 100$

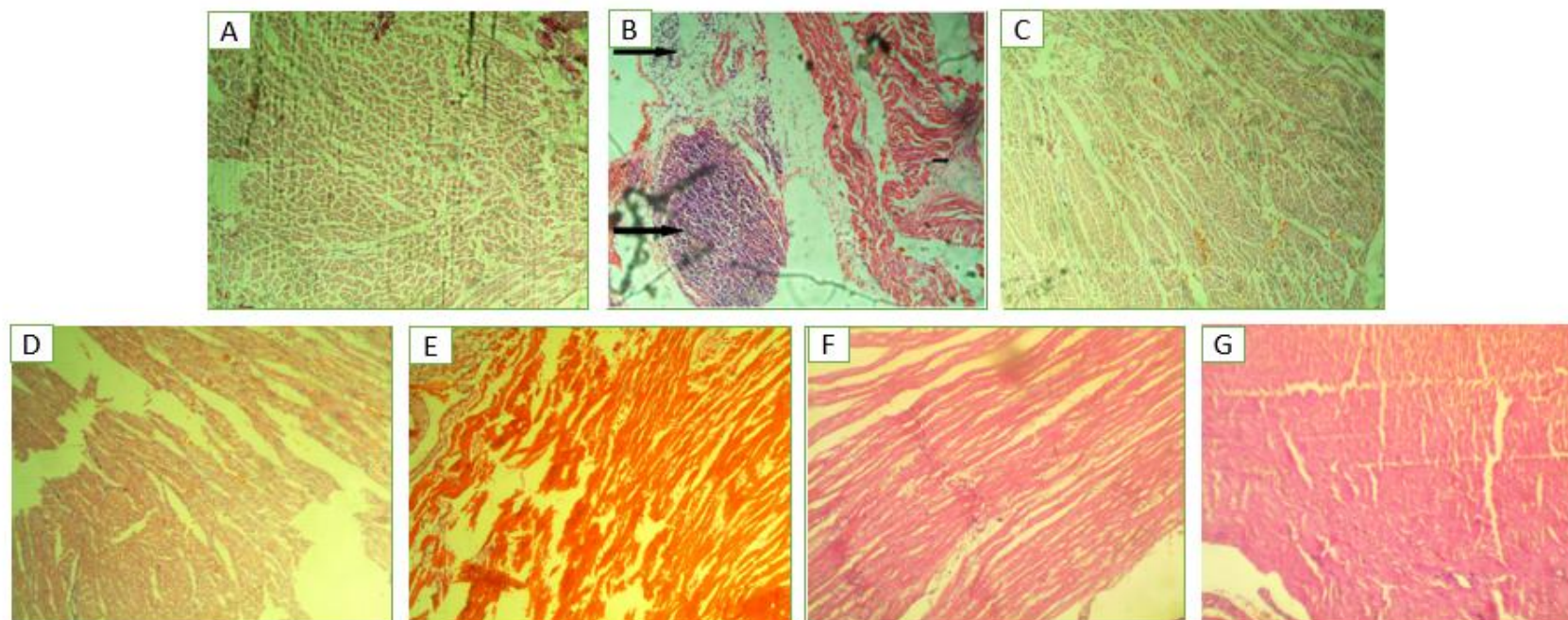


Plate 4.19: Effect of methanol extract of *Musanga cecropioides* root on the histology of the heart in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pericarditis (inflammation of the pericardium) long black arrows and mild stromal inflammation (small red arrow); C: Glibenclamide (10 mg/kg) with no inflammation; D: MCR Meth (30 mg/kg) with no inflammation; E: MCR Meth (50 mg/kg) with no inflammation; F: MCR Meth (100 mg/kg) with no inflammation; G: MCR Meth (200 mg/kg) appears normal: H and E $\times 100$

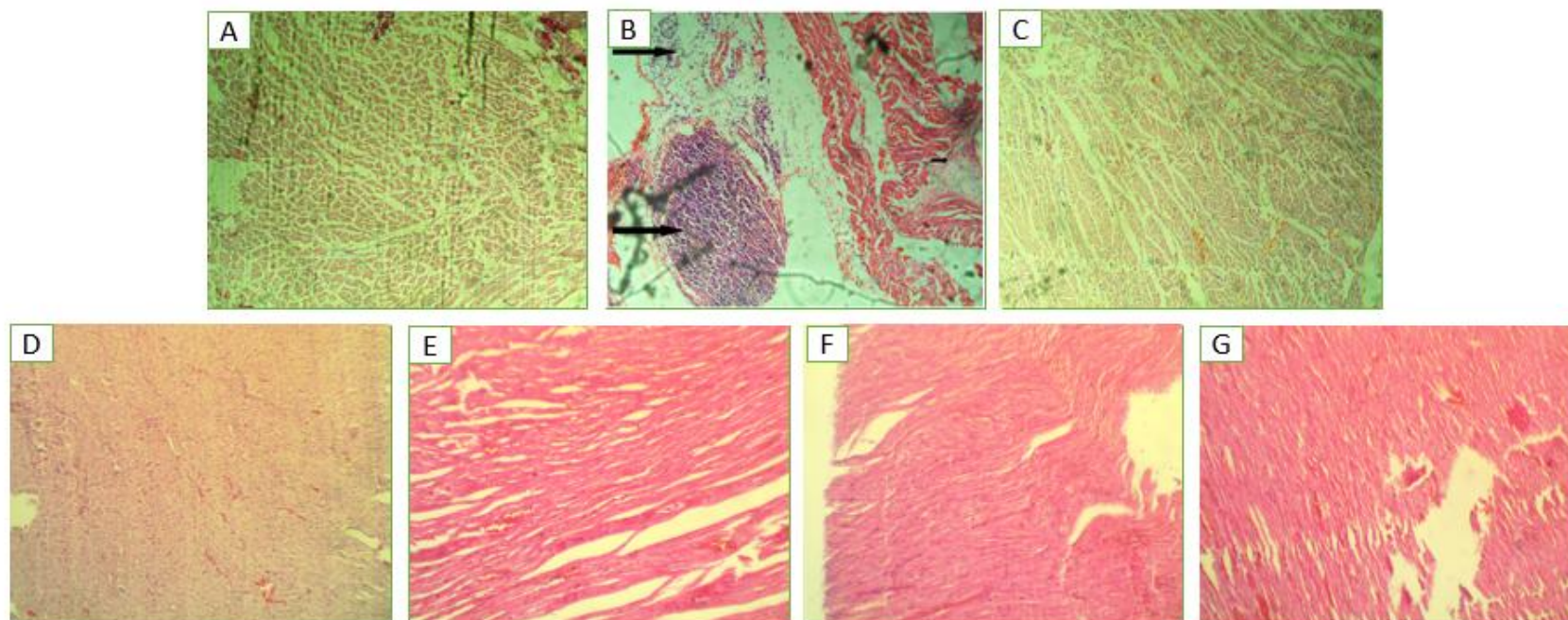


Plate 4.20: Effect of *Musanga cecropioides* crude root sap on the histology of the heart in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pericarditis (inflammation of the pericardium) long black arrows and mild stromal inflammation (small red arrow); C: Glibenclamide (10 mg/kg) with no inflammation; D: MCCRS (0.5 ml/kg) with no inflammation; E: MCCRS (1 ml/kg) with no inflammation; F: MCCRS (2 ml/kg) with no inflammation; G: MCCRS (3 ml/kg) shows normal myocyte: H and E $\times 100$

4.7.7.2 Histology of the Liver

Plates 4.21, 4.22, 4.23, 4.24 and 4.25 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the histology of the liver in STZ-induced diabetic rats. Signs of necrosis were observed in the diabetic group treated with the standard drug (glibenclamide), however all groups treated with *Musanga cecropioides* at different doses showed limited or no pathological changes.

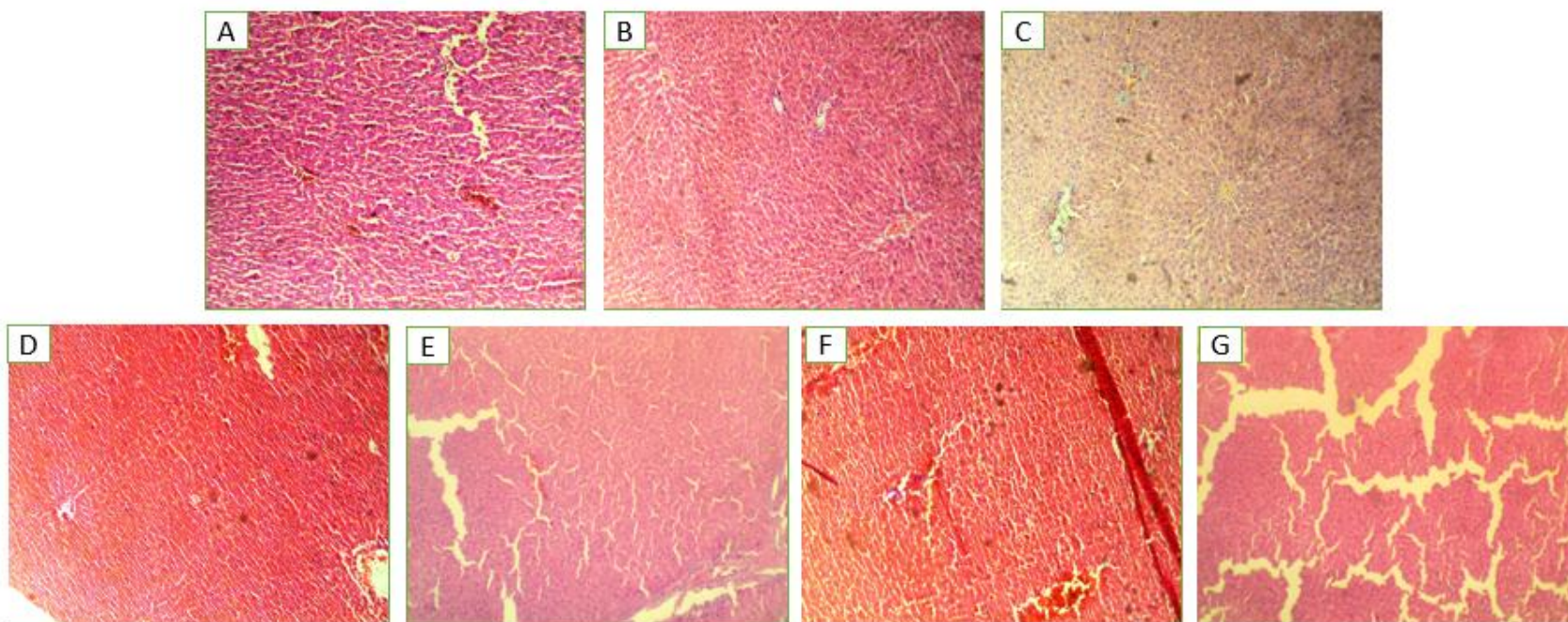


Plate 4.21: Effect of aqueous extract of *Musanga cecropioides* leaves on the histology of the liver in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) shows pyknosis of some nuclei; D: MCL Aq (30 mg/kg) appears normal; E: MCL Aq (50 mg/kg) appears normal; F: MCL Aq (100 mg/kg) appears normal; G: MCL Aq (200 mg/kg) appears normal: H and E $\times 100$

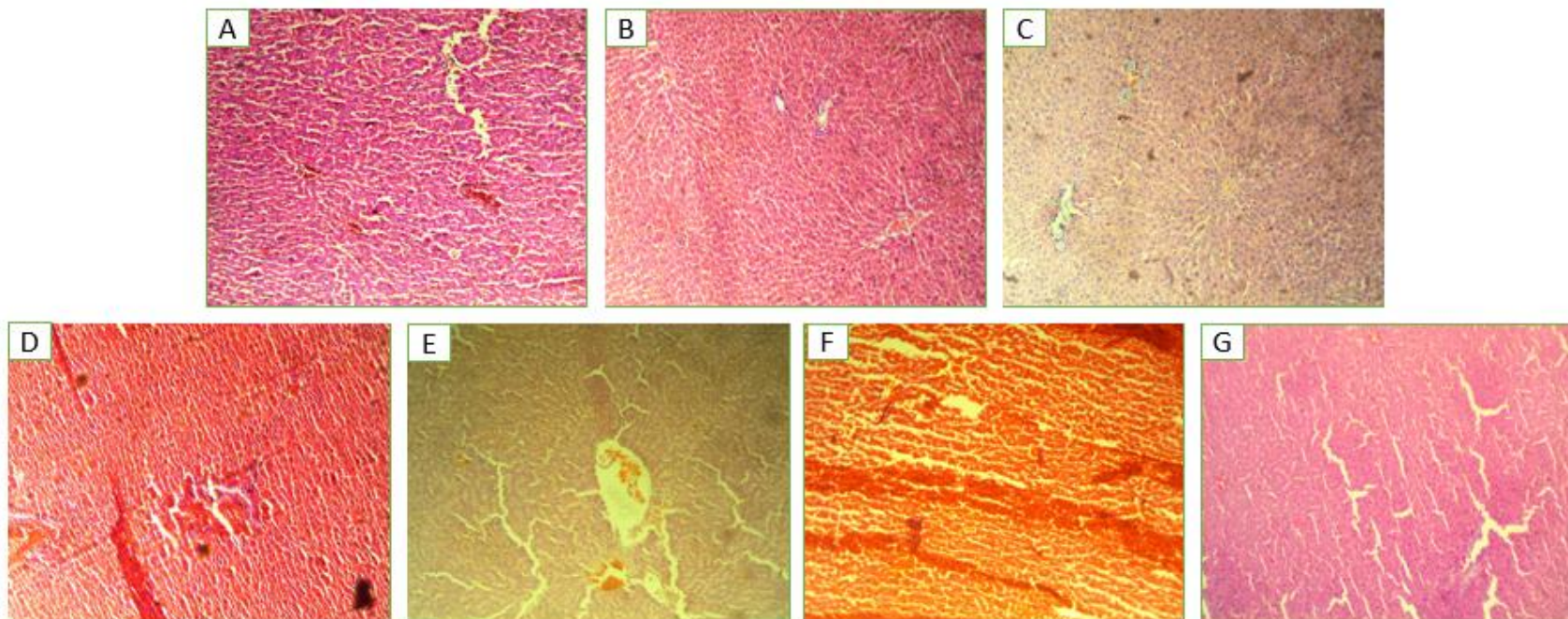


Plate 4.22: Effect of methanol extract of *Musanga cecropioides* leaves on the histology of the liver in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) shows pyknosis of some nuclei; D: MCL Meth (30 mg/kg) appears normal; E: MCL Meth (50 mg/kg) appears normal; F: MCL Meth (100 mg/kg) appears normal; G: MCL Meth (200 mg/kg) appears normal: H and E $\times 100$

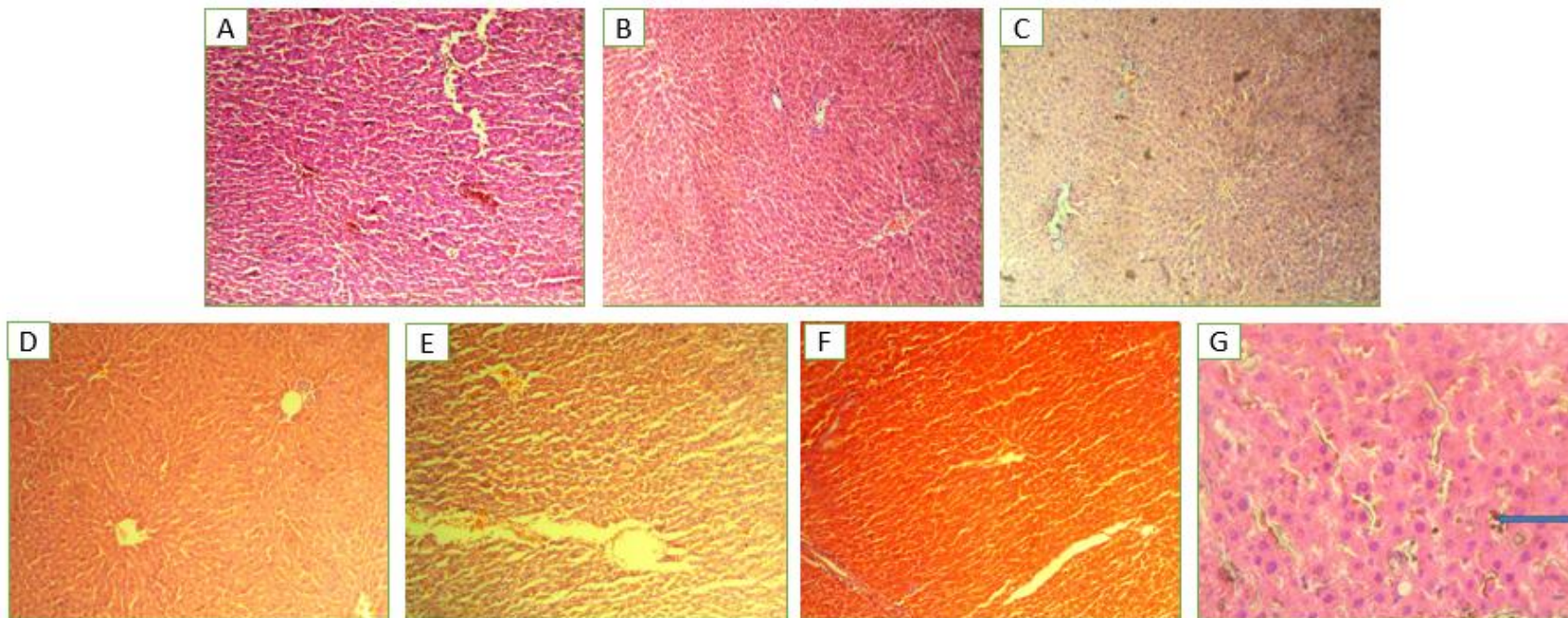


Plate 4.23: Effect of aqueous extract of *Musanga cecropioides* root on the histology of the liver in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) shows pyknosis of some nuclei; D: MCR Aq (30 mg/kg) appears normal; E: MCR Aq (50 mg/kg) appears normal; F: MCR Aq (100 mg/kg) appears normal; G: MCR Aq (200 mg/kg) normal hepatocyte with bile lake: H and E $\times 100$

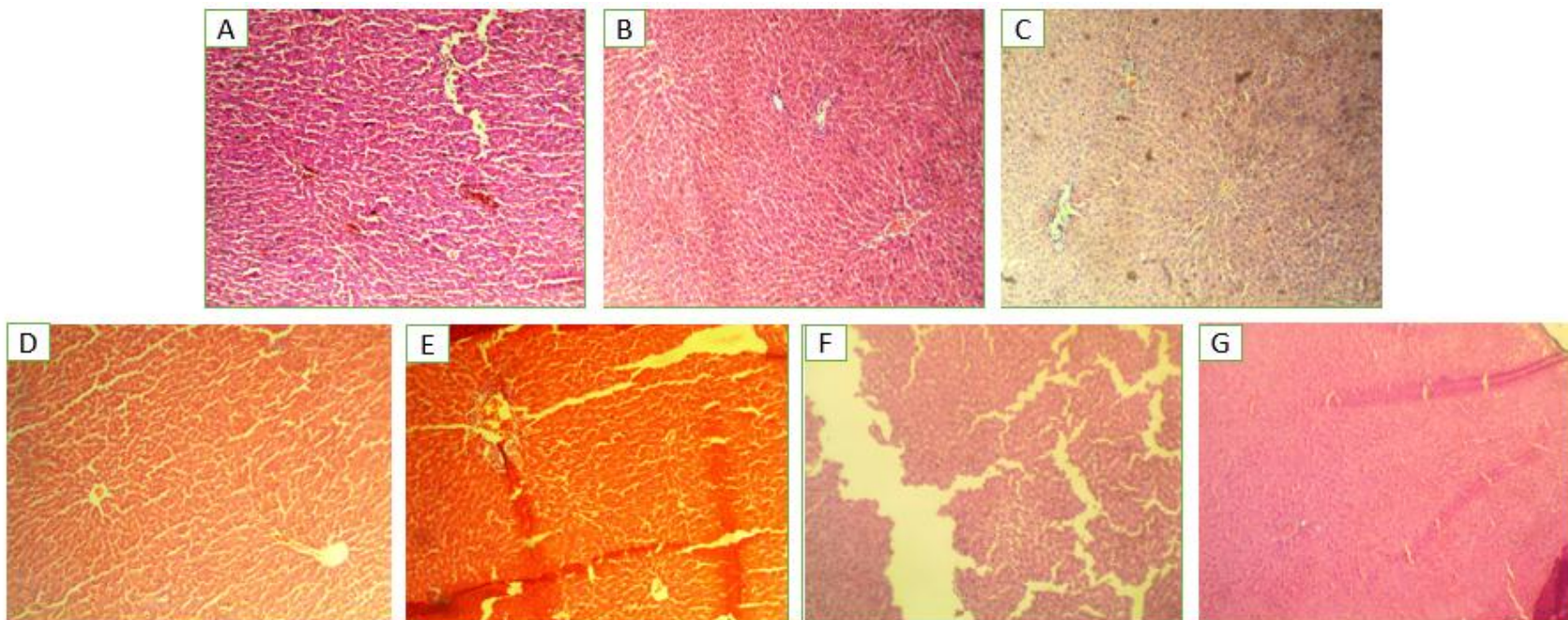


Plate 4.24: Effect of methanol extract of *Musanga cecropioides* root on the histology of the liver in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) shows pyknosis of some nuclei; D: MCR Meth (30 mg/kg) appears normal; E: MCR Meth (50 mg/kg) appears normal; F: MCR Meth (100 mg/kg) appears normal with some microvesicles; G: MCR Meth (200 mg/kg) appears normal: H and E $\times 100$

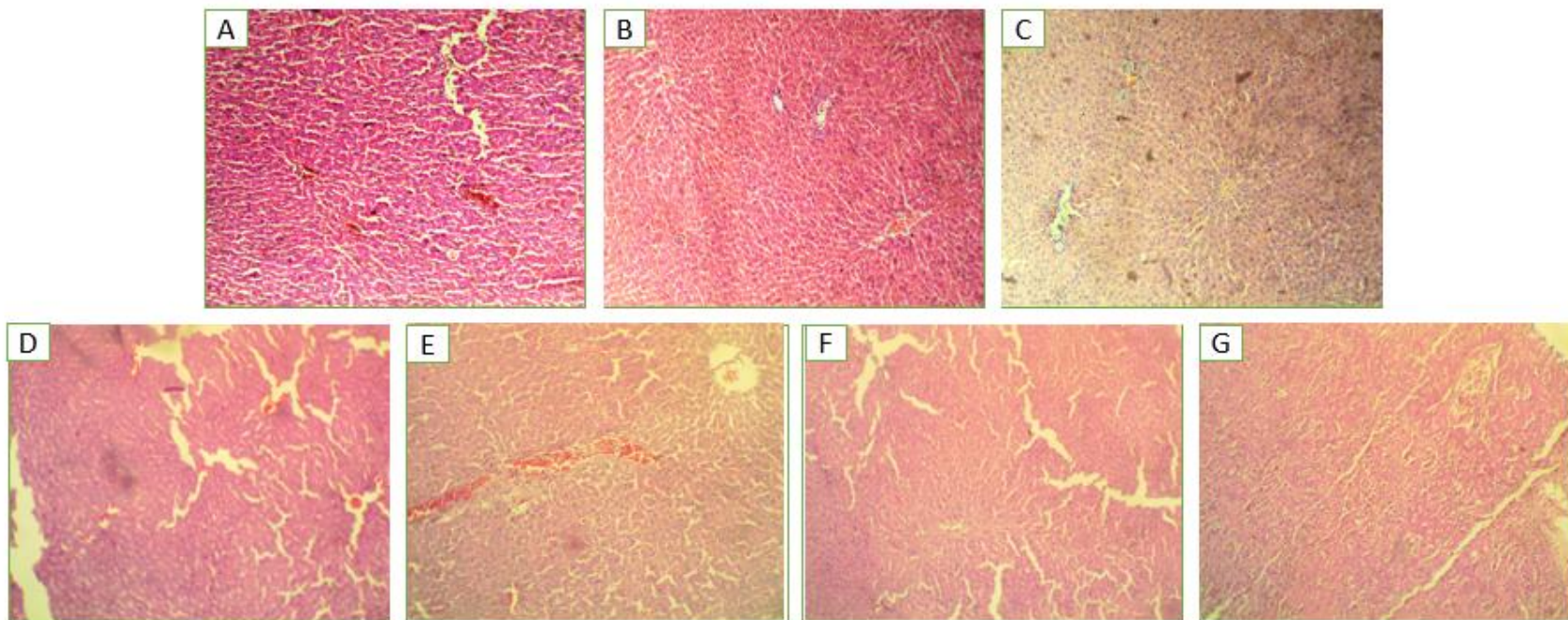


Plate 4.25: Effect of *Musanga cecropioides* crude root sap on the histology of the liver in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) shows pyknosis of some nuclei; D: MCCRS (0.5 ml/kg) shows pyknosis of some nuclei; E: MCCRS (1 ml/kg) shows pyknosis of some nuclei; F: MCCRS (2 ml/kg) shows pyknosis of some nuclei (a sign of necrosis); G: MCCRS (3 ml/kg) shows degradation of the hepatocyte: H and E $\times 100$

4.7.7.3 Histology of the Lungs

Plates 4.26, 4.27, 4.28, 4.29 and 4.30 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the histology of the lungs in STZ-induced diabetic rats. Signs of inflammation and thickening of the alveoli septae were observed in the diabetic control groups and some groups treated with *Musanga cecropioides* at different doses however most of the treatment groups showed no pathological changes.

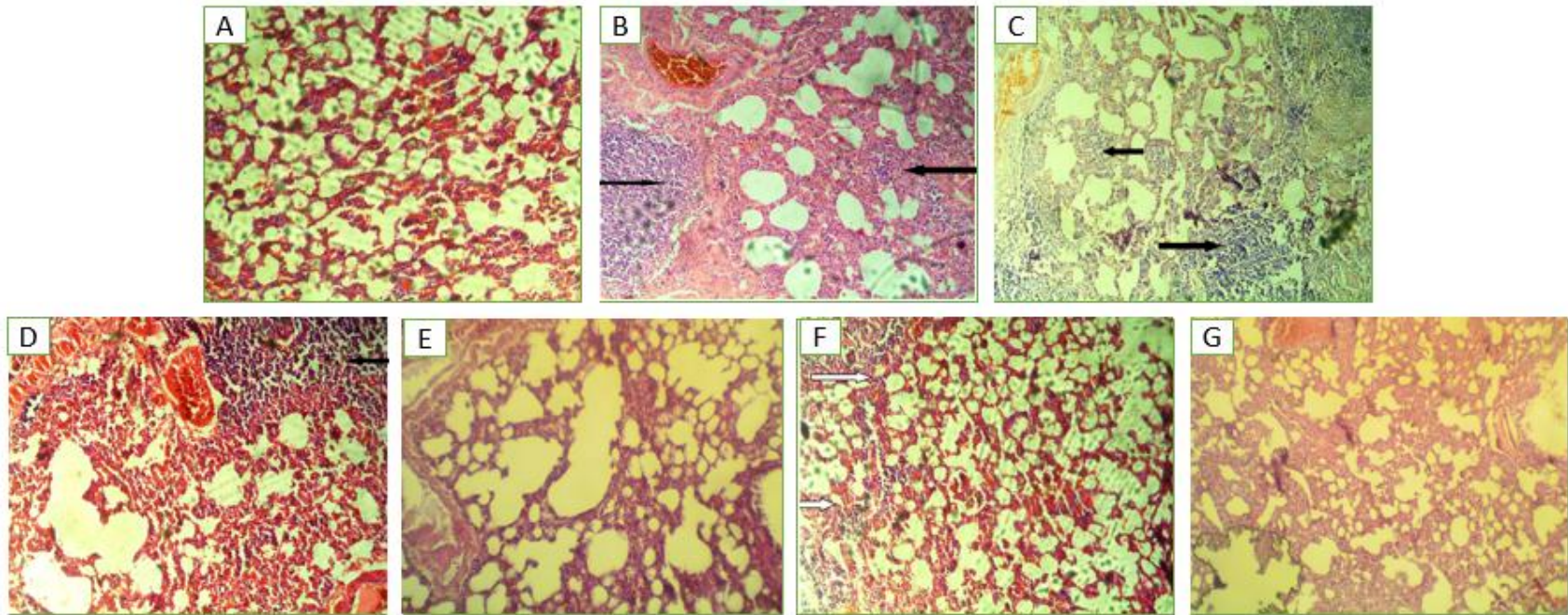


Plate 4.26: Effect of aqueous extract of *Musanga cecropioides* leave on the histology of the lung in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pneumonia (inflammation of the lung tissue); C: Glibenclamide (10 mg/kg) showing reduced inflammation; D: MCL Aq (30 mg/kg) showing mild inflammation; E: MCL Aq (50 mg/kg) appears normal; F: MCL Aq (100 mg/kg) showing minimal inflammation; G: MCL Aq (200 mg/kg) shows thickening of the alveoli: H and E $\times 100$

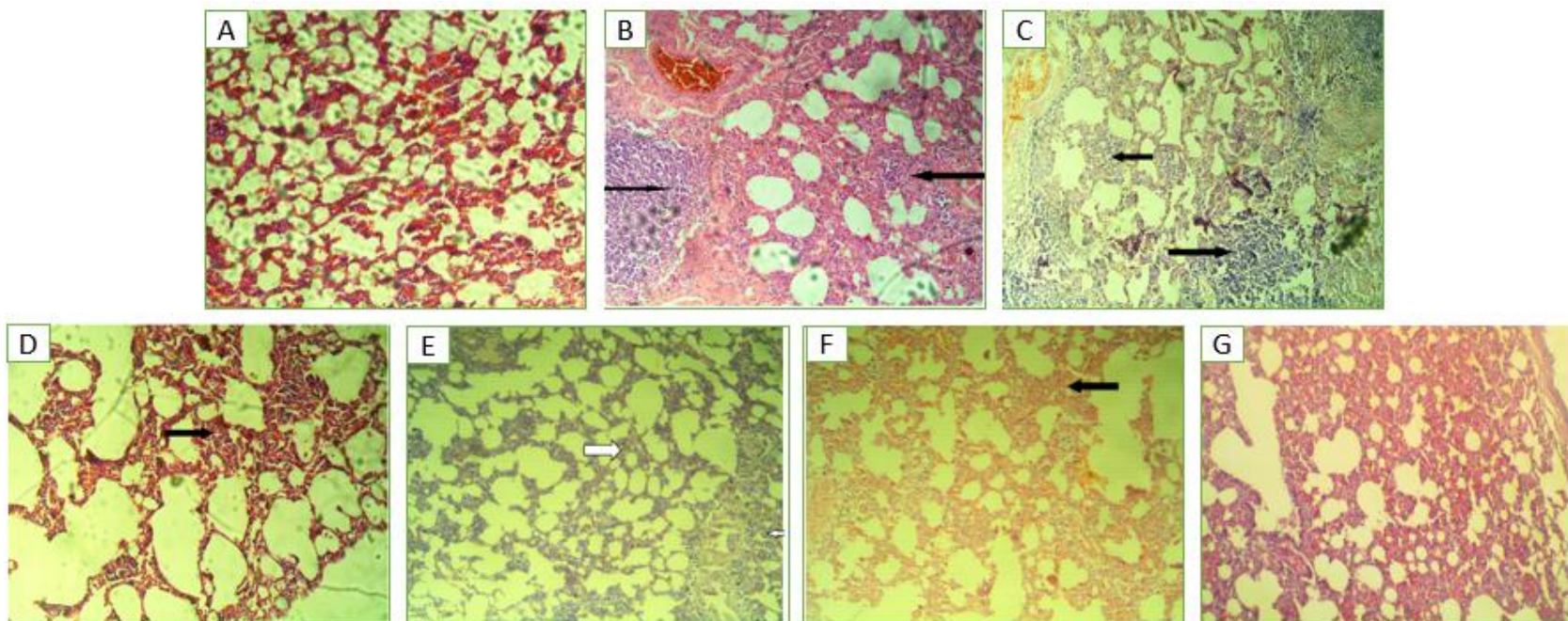


Plate 4.27: Effect of methanol extract of *Musanga cecropioides* leave on the histology of the lung in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pneumonia (inflammation of the lung tissue); C: Glibenclamide (10 mg/kg) showing reduced inflammation; D: MCL Meth (30 mg/kg) shows mild pneumonia; E: MCL Meth (50 mg/kg) shows mild pneumonia; F: MCL Meth (100 mg/kg) shows very mild pneumonia; G: MCL Meth (200 mg/kg) shows mild thickening of the alveoli septae, hemorrhage within interstitium (suggestive of diffuse alveolar damage): H and E $\times 100$

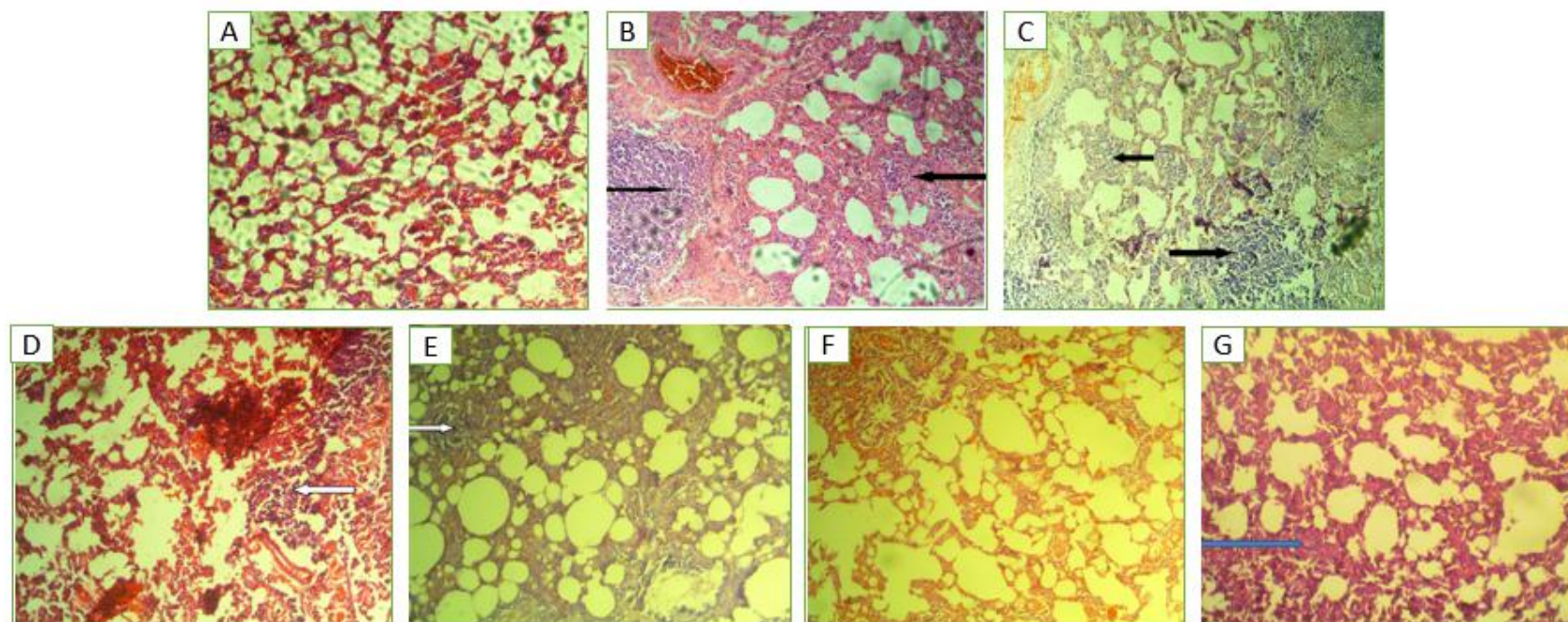


Plate 4.28: Effect of aqueous extract of *Musanga cecropioides* root on the histology of the lung in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pneumonia (inflammation of the lung tissue); C: Glibenclamide (10 mg/kg) showing reduced inflammation; D: MCR Aq (30 mg/kg) showing mild pneumonia ; E: MCR Aq (50 mg/kg) showing very mild pneumonia ; F: MCR Aq (100 mg/kg) appears normal; G: MCR Aq (200 mg/kg) with thickening of the alveoli septae: H and E $\times 100$

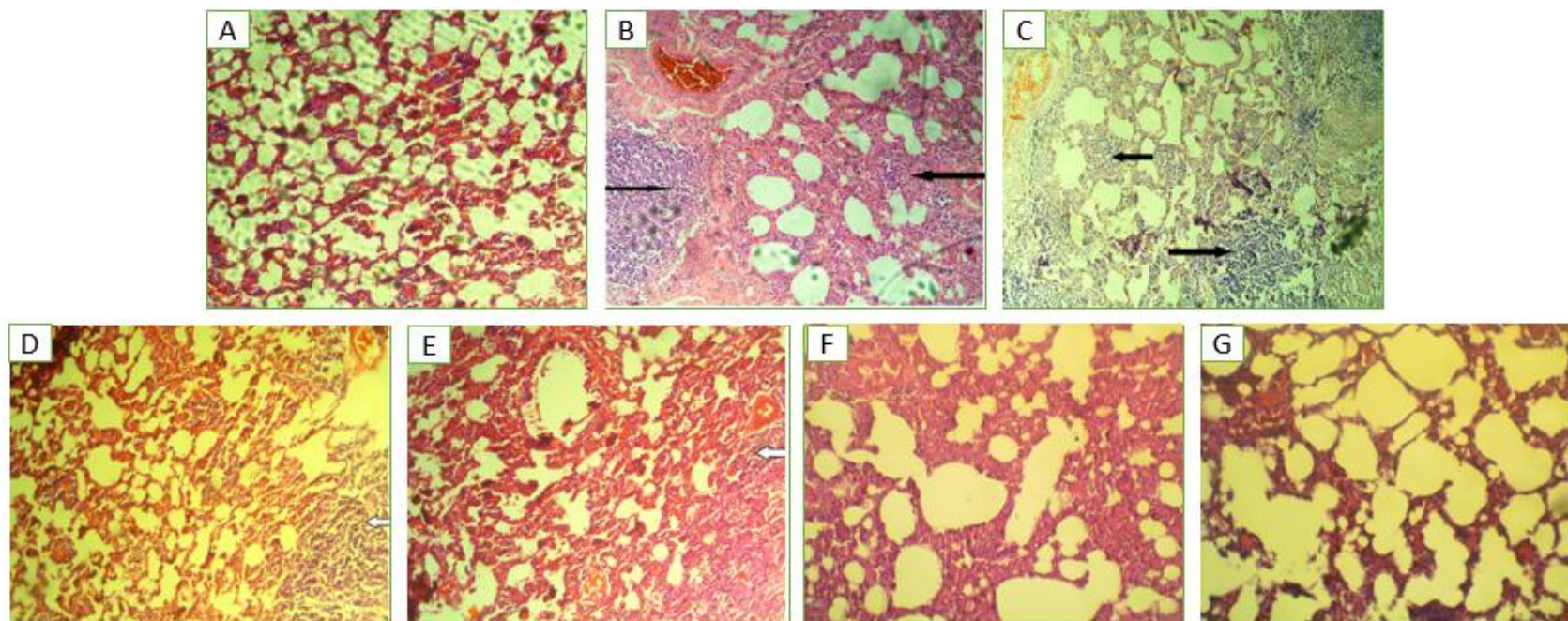


Plate 4.29: Effect of methanol extract of *Musanga cecropioides* root on the histology of the lung in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pneumonia (inflammation of the lung tissue); C: Glibenclamide (10 mg/kg) showing reduced inflammation; D: MCR Meth (30 mg/kg) with mild pneumonia ; E: MCR Meth (50 mg/kg) with mild pneumonia; F: MCR Meth (100 mg/kg) mild thickening of alveoli septae; G: MCR Meth (200 mg/kg) appears normal : H and E $\times 100$

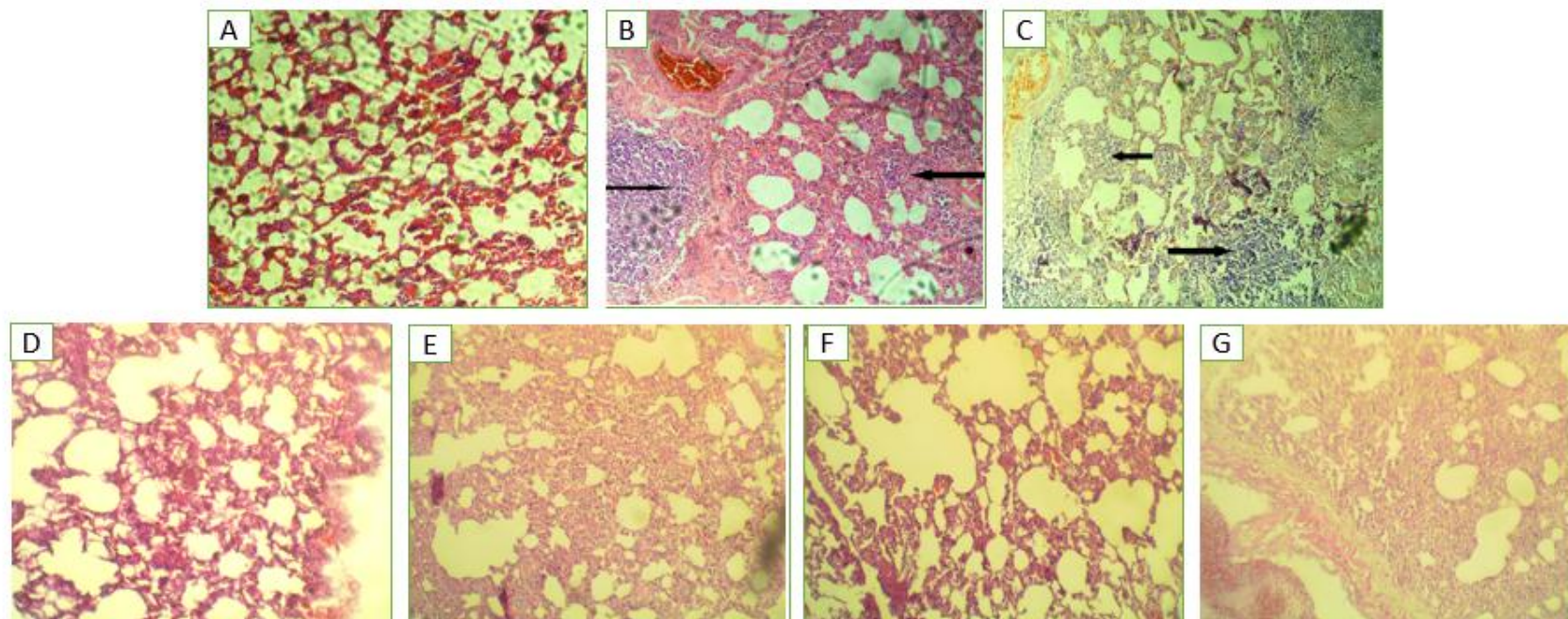


Plate 4.30: Effect of *Musanga cecropioides* crude root sap on the histology of the lung in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control with pneumonia (inflammation of the lung tissue); C: Glibenclamide (10 mg/kg) showing reduced inflammation; D: MCCRS (0.5 ml/kg) appears normal with thickening of the alveoli septae; E: MCCRS (1 ml/kg) appears normal with thickening of the alveoli septae; F: MCCRS (2 ml/kg) appears normal with mild thickening of the alveoli septae; G: MCCRS (3 ml/kg) shows thickening of the alveoli septae: H and E $\times 100$

4.7.7.4 Histology of the Pancreas

Plates 4.31, 4.32, 4.33, 4.34 and 4.35 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the histology of the pancreas in STZ-induced diabetic rats. All groups treated with *Musanga cecropioides* at different doses showed resurgent islets cells.

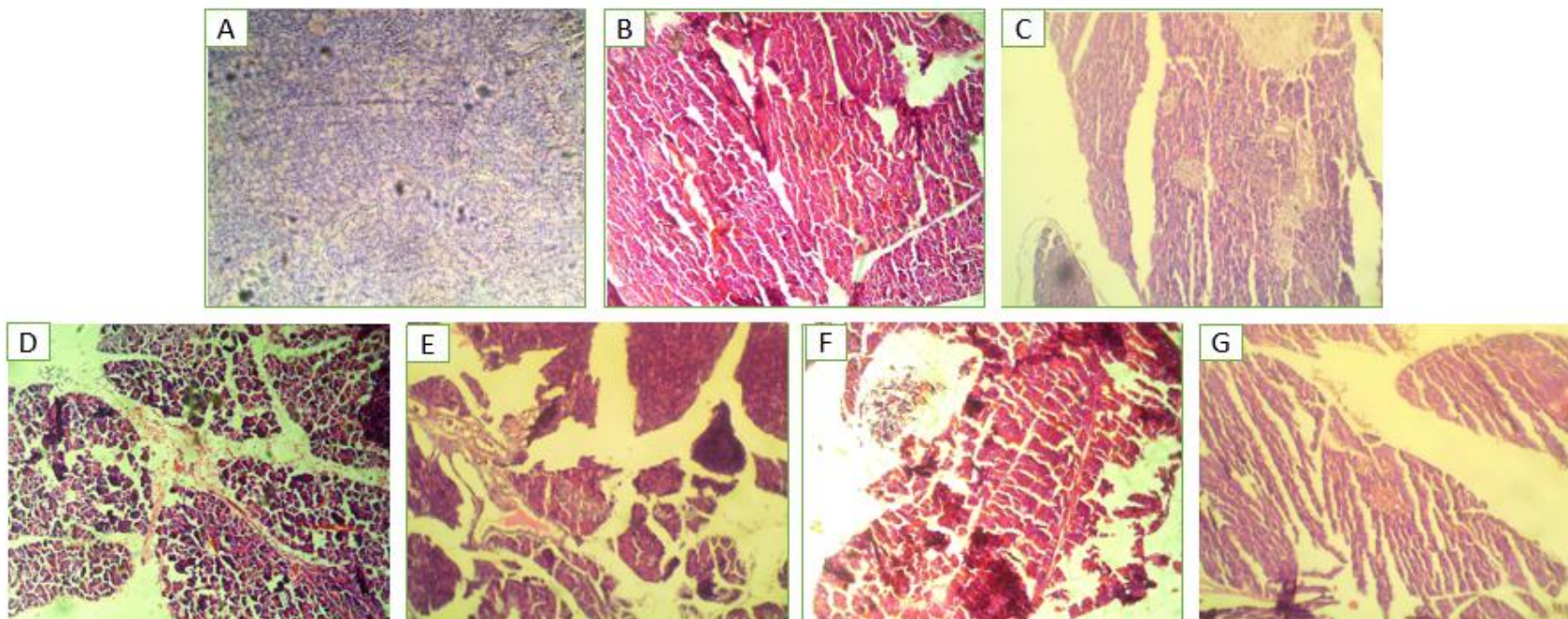


Plate 4.31: Effect of aqueous extract of *Musanga cecropioides* leaves on the histology of the pancreas in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control; C: Glibenclamide (10 mg/kg) with resurgent islets; D: MCL Aq (30 mg/kg) with resurgent islets; E: MCL Aq (50 mg/kg) with resurgent islets; F: MCL Aq (100 mg/kg) with resurgent islets; G: MCL Aq (200 mg/kg): H and E $\times 100$

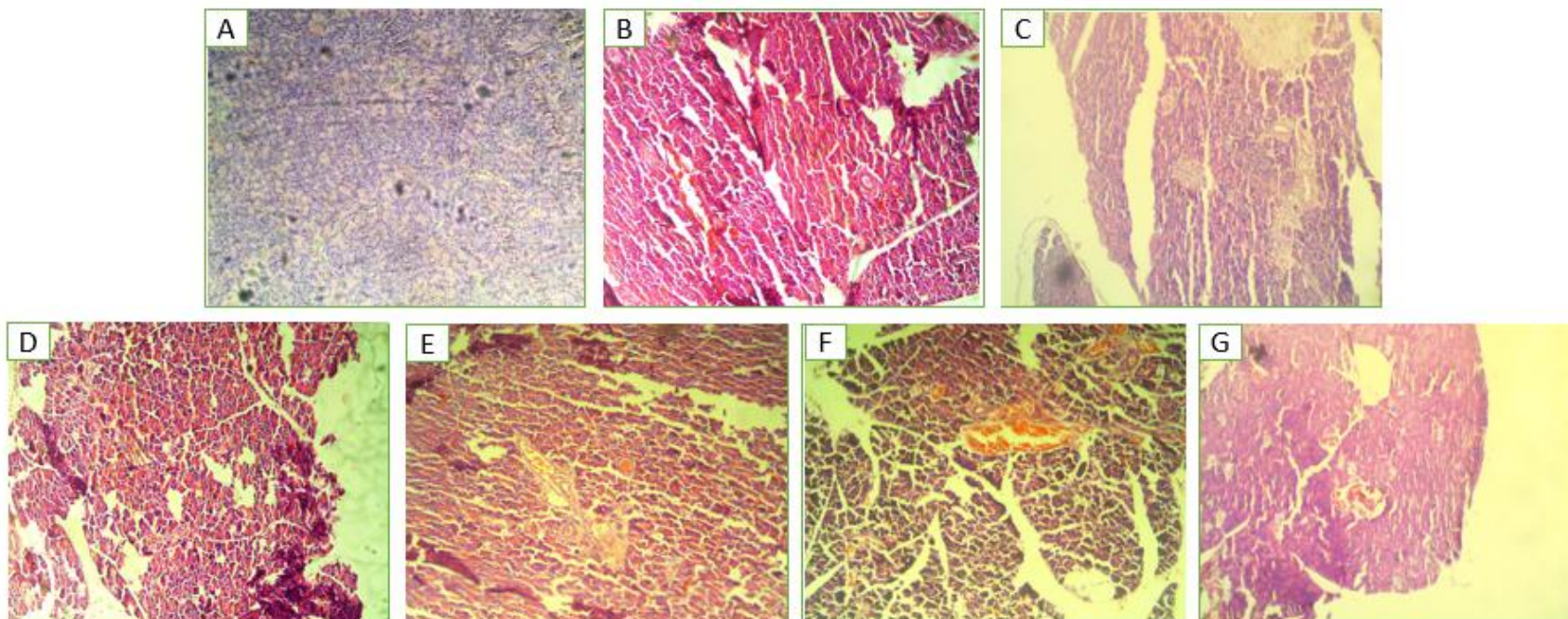


Plate 4.32: Effect of methanol extract of *Musanga cecropioides* leaves on the histology of the pancreas in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control; C: Glibenclamide (10 mg/kg) with resurgent islets; D: MCL Meth (30 mg/kg) with resurgent islets; E: MCL Meth (50 mg/kg) with resurgent islets; F: MCL Meth (100 mg/kg) with resurgent islets; G: MCL Meth (200 mg/kg) with resurgent islets: H and E $\times 100$

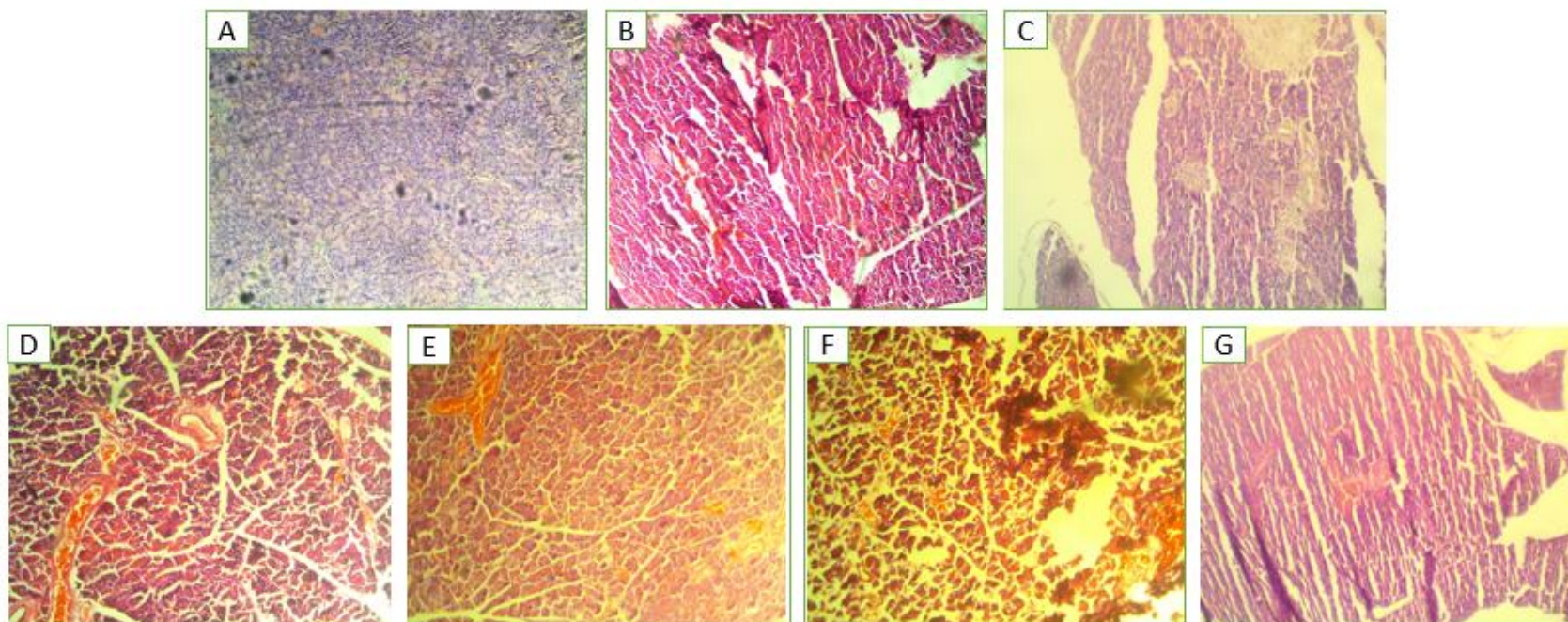


Plate 4.33: Effect of aqueous extract of *Musanga cecropioides* root on the histology of the pancreas in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control ; C: Glibenclamide (10 mg/kg) with resurgent islets; D: MCR Aq (30 mg/kg) with resurgent islets; E: MCR Aq (50 mg/kg) with resurgent islets; F: MCR Aq (100 mg/kg) with resurgent islets; G: MCR Aq (200 mg/kg) with resurgent islets : H and E $\times 100$

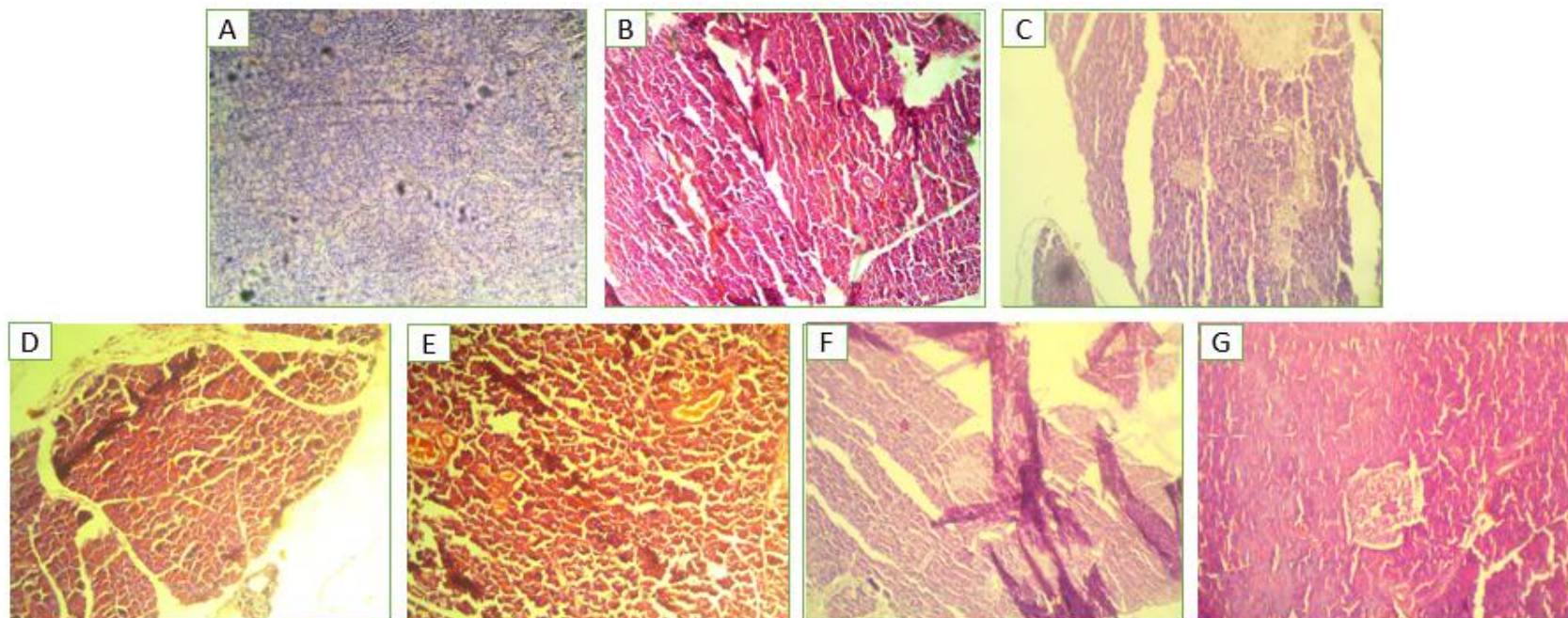


Plate 4.34: Effect of methanol extract of *Musanga cecropioides* root on the histology of the pancreas in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control; C: Glibenclamide (10 mg/kg) with resurgent islets; D: MCR Meth (30 mg/kg) with resurgent islets; E: MCR Meth (50 mg/kg) with resurgent islets; F: MCR Meth (100 mg/kg) with resurgent islets; G: MCR Meth (200 mg/kg) with resurgent islets : H and E $\times 100$

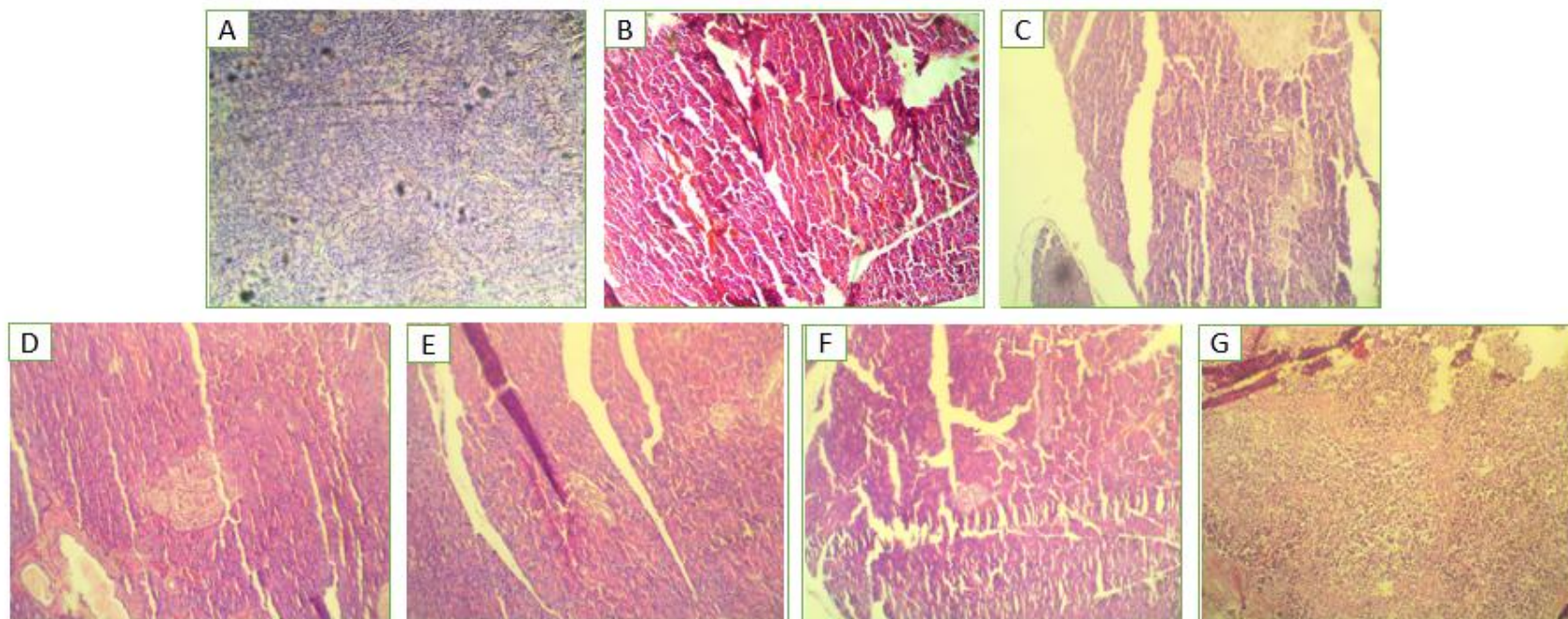


Plate 4.35: Effect of *Musanga cecropioides* crude root sap on the histology of the pancreas in STZ-induced diabetic rats.

A: Normal control; B: Diabetic control ; C: Glibenclamide (10 mg/kg) with resurgent islets; D: MCCR (0.5 ml/kg) reduced number and size of islet cells; E: MCCR (1 ml/kg)) reduced number and size of islet cells; F: MCCR (2 ml/kg) reduced number and size of islet cells; G: MCCR (3 ml/kg)) reduced number and size of islet cells : H and E $\times 100$

4.7.7.5 Histology of the Spleen

Plates 4.36, 4.37, 4.38, 4.39 and 4.40 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the histology of the spleen in STZ-induced diabetic rats. All groups treated with *Musanga cecropioides* at different doses showed normal spleen.

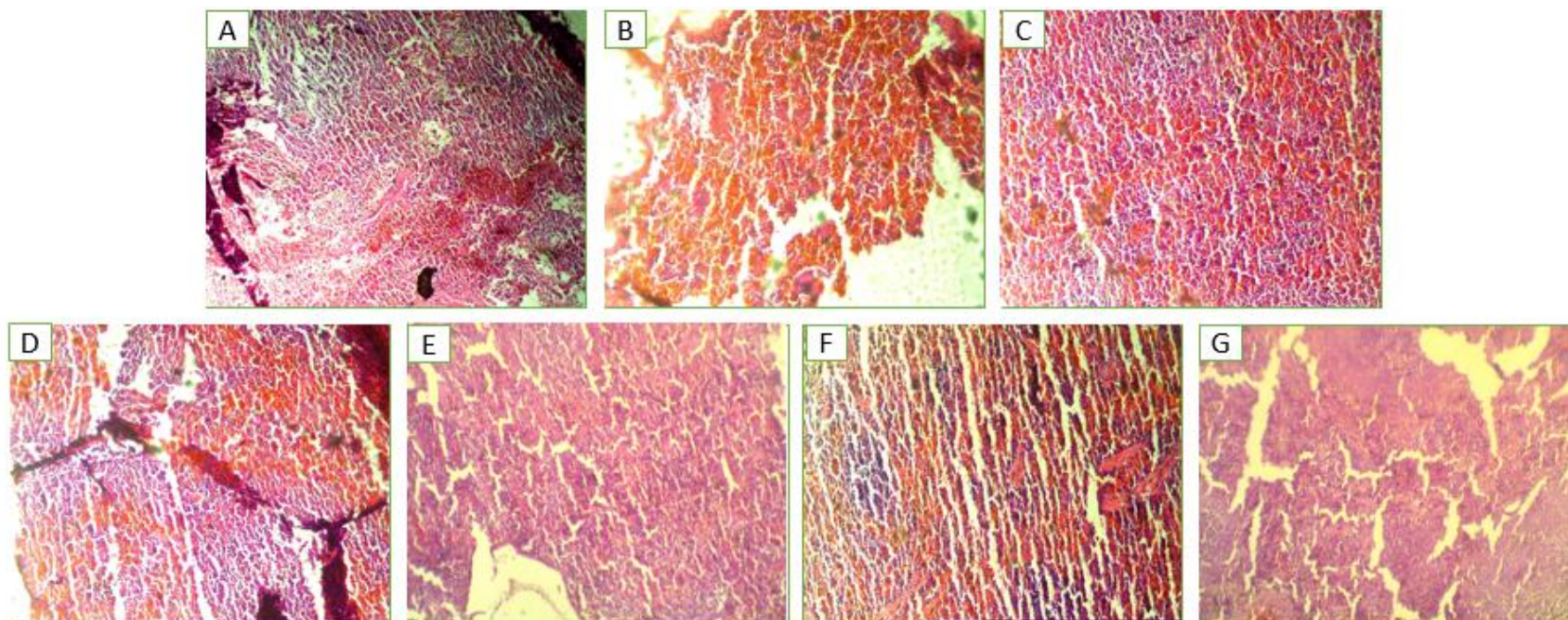


Plate 4.36: Effect of aqueous extract of *Musanga cecropioides* leaves on the histology of the spleen in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) appears normal; D: MCL Aq (30 mg/kg) appears normal; E: MCL Aq (50 mg/kg) appears normal; F: MCL Aq (100 mg/kg) appears normal; G: MCL Aq (200 mg/kg) appears normal: H and E $\times 100$

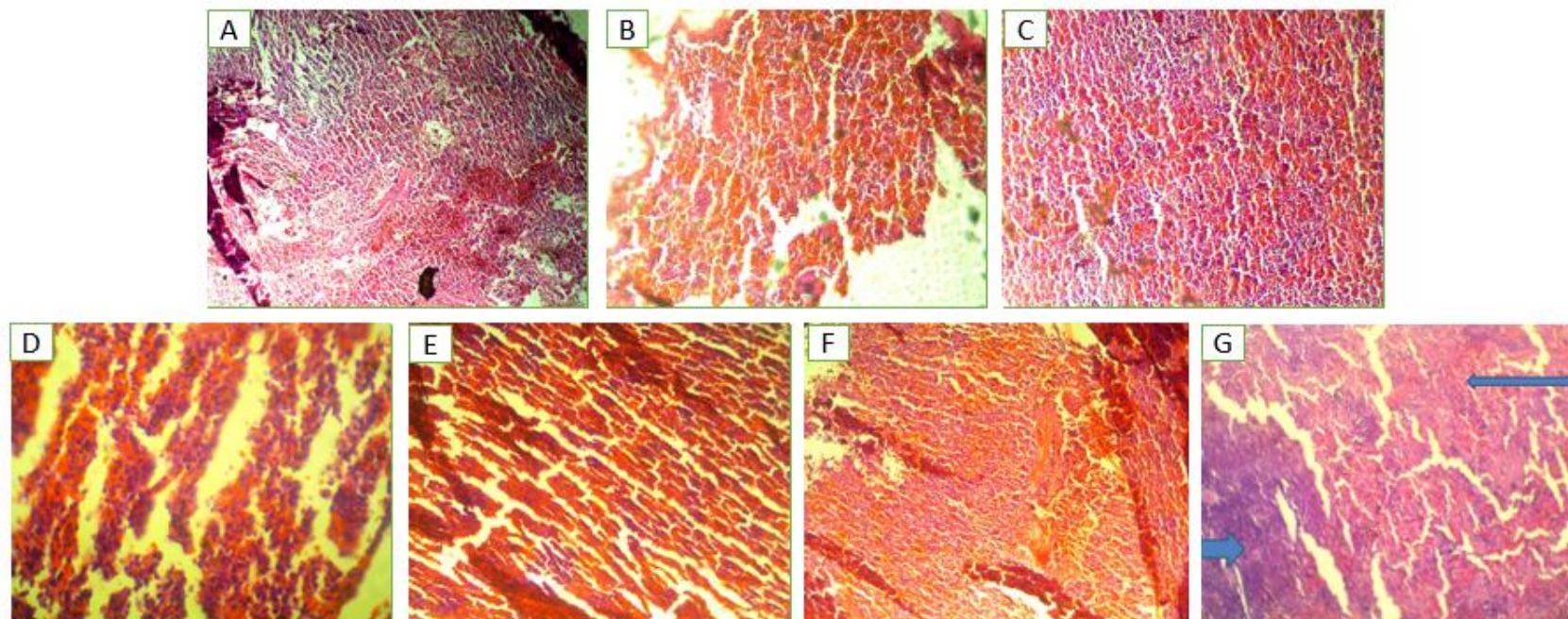


Plate 4.37: Effect of methanol extract of *Musanga cecropioides* leaves on the histology of the spleen in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) appears normal; D: MCL Meth (30 mg/kg) appears normal; E: MCL Meth (50 mg/kg) appears normal; F: MCL Meth (100 mg/kg) appears normal; G: MCL Meth (200 mg/kg) appears normal: H and E $\times 100$

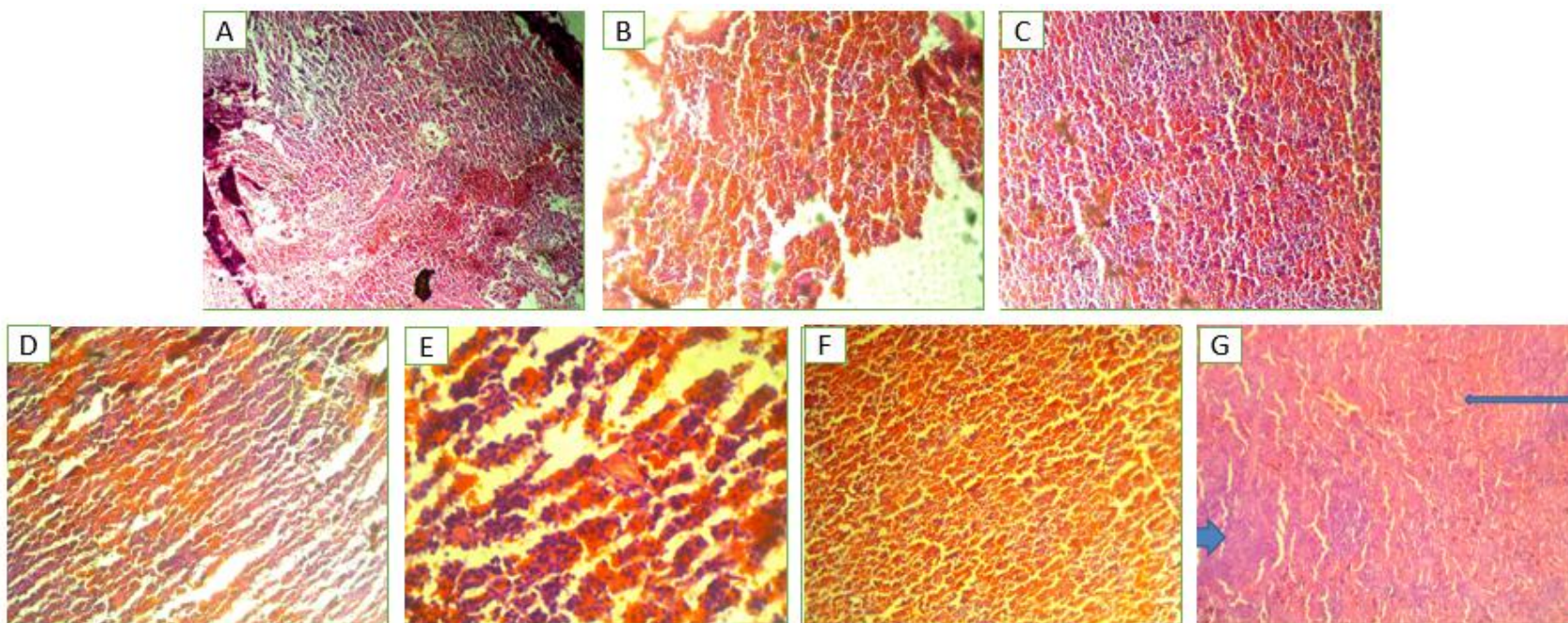


Plate 4.38: Effect of aqueous extract of *Musanga cecropioides* root on the histology of the spleen in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) appears normal; D: MCR Aq (30 mg/kg) appears normal; E: MCR Aq (50 mg/kg) appears normal; F: MCR Aq (100 mg/kg) appears normal; G: MCR Aq (200 mg/kg) appears normal : H and E $\times 100$

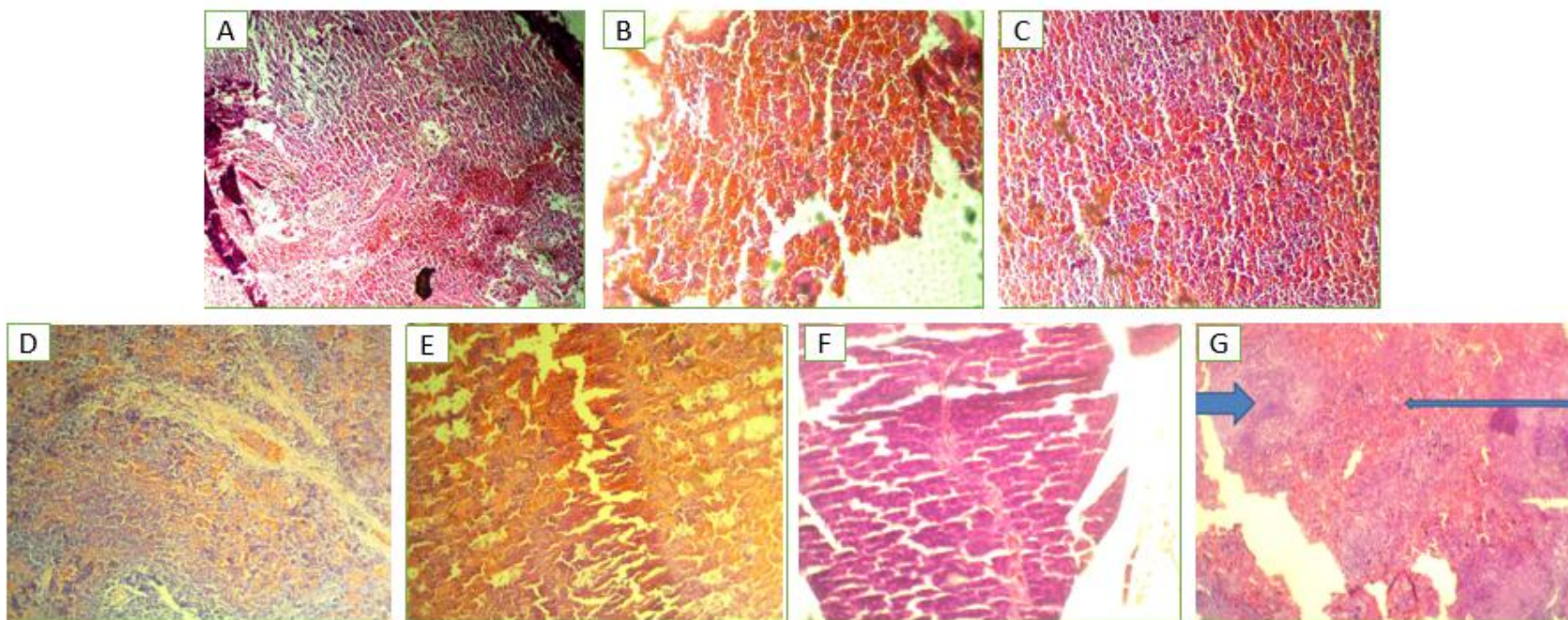


Plate 4.39: Effect of methanol extract of *Musanga cecropioides* root on the histology of the spleen in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) appears normal; D: MCR Meth (30 mg/kg) appears normal; E: MCR Meth (50 mg/kg) appears normal; F: MCR Meth (100 mg/kg) appears normal; G: MCR Meth (200 mg/kg) appears normal : H and E $\times 100$

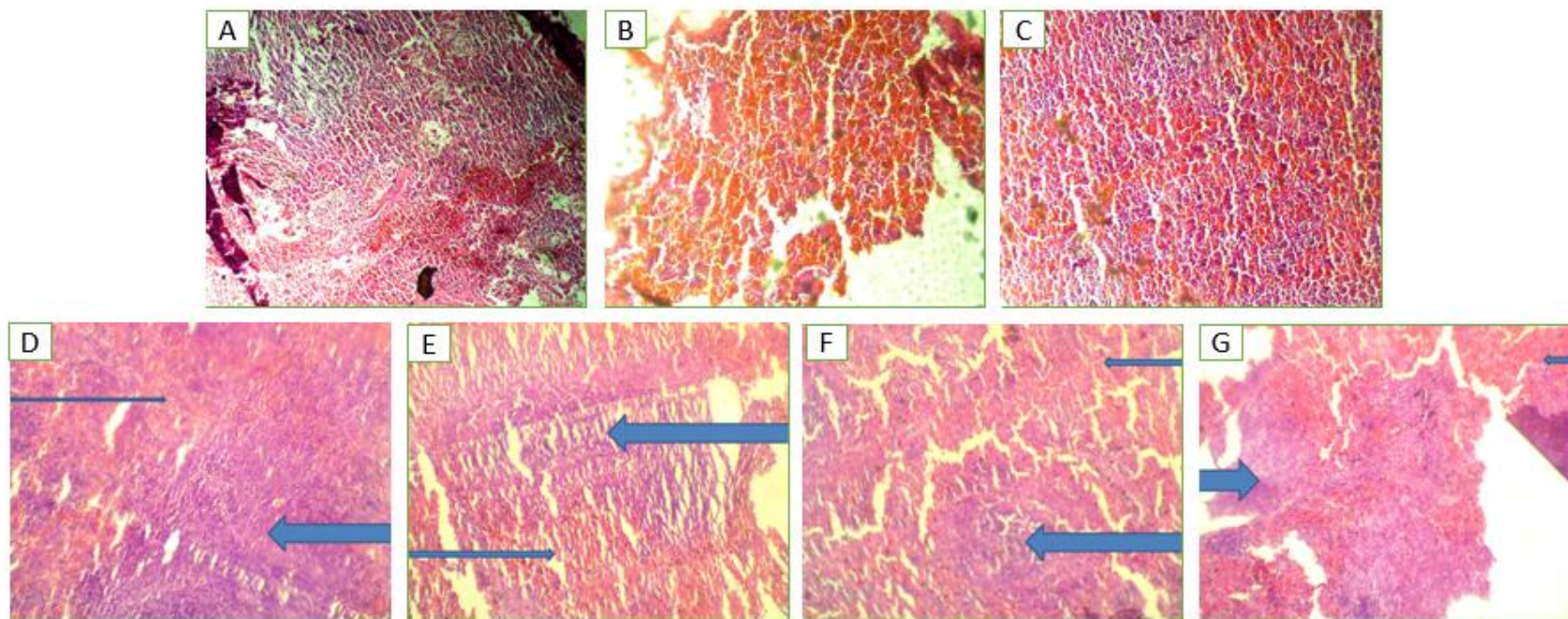


Plate 4.40: Effect of *Musanga cecropioides* crude root sap on the histology of the spleen in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control appears normal; C: Glibenclamide (10 mg/kg) appears normal; D: MCCR (0.5 ml/kg) thick arrow shows white pulp while thin arrow shows red pulp (normal); E: MCCR (1 ml/kg) thick arrow shows white pulp while thin arrow shows red pulp (normal); F: MCCR (2 ml/kg) thick arrow shows white pulp while thin arrow shows red pulp (normal); G: MCCR (3 ml/kg) thick arrow shows white pulp while thin arrow shows red pulp (normal) : H and E $\times 100$

4.7.7.6 Histology of the Kidney

Plates 4.41, 4.42, 4.43, 4.44 and 4.45 shows the effect of *Musanga cecropioides* aqueous leaf extract, methanol leaf extract, aqueous root extract, methanol root extract and crude root sap on the histology of the kidney in STZ-induced diabetic rats. Signs of inflammation and acute tubular necrosis was observed in some treatment groups while others appeared normal.

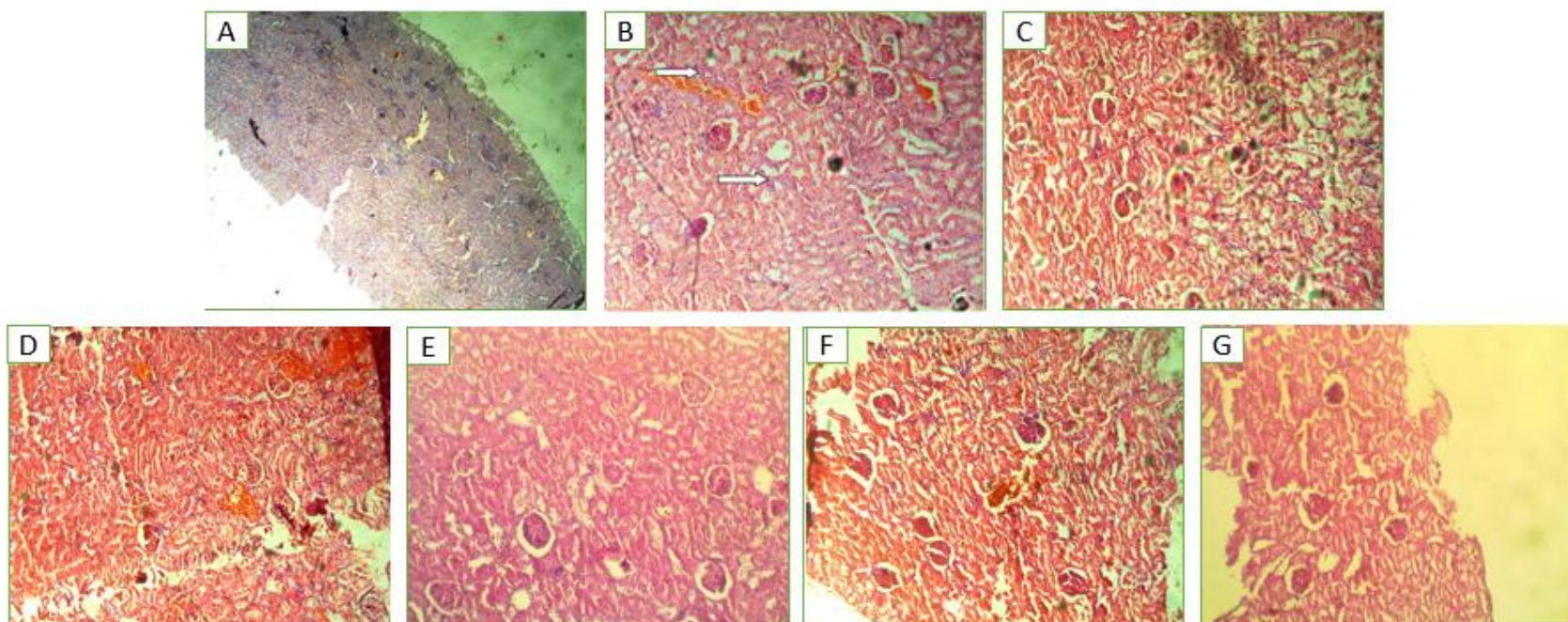


Plate 4.41: Effect of aqueous extract of *Musanga cecropioides* leaves on the histology of the kidney in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control showing moderate pyelonephritis (inflammation of the kidney); C: Glibenclamide (10 mg/kg) tubules with acute tubular necrosis ; D: MCL Aq (30 mg/kg) appears normal; E: MCL Aq (50 mg/kg) appears normal; F: MCL Aq (100 mg/kg) appears normal; G: MCL Aq (200 mg/kg) with mild tubular necrosis: H and E $\times 100$

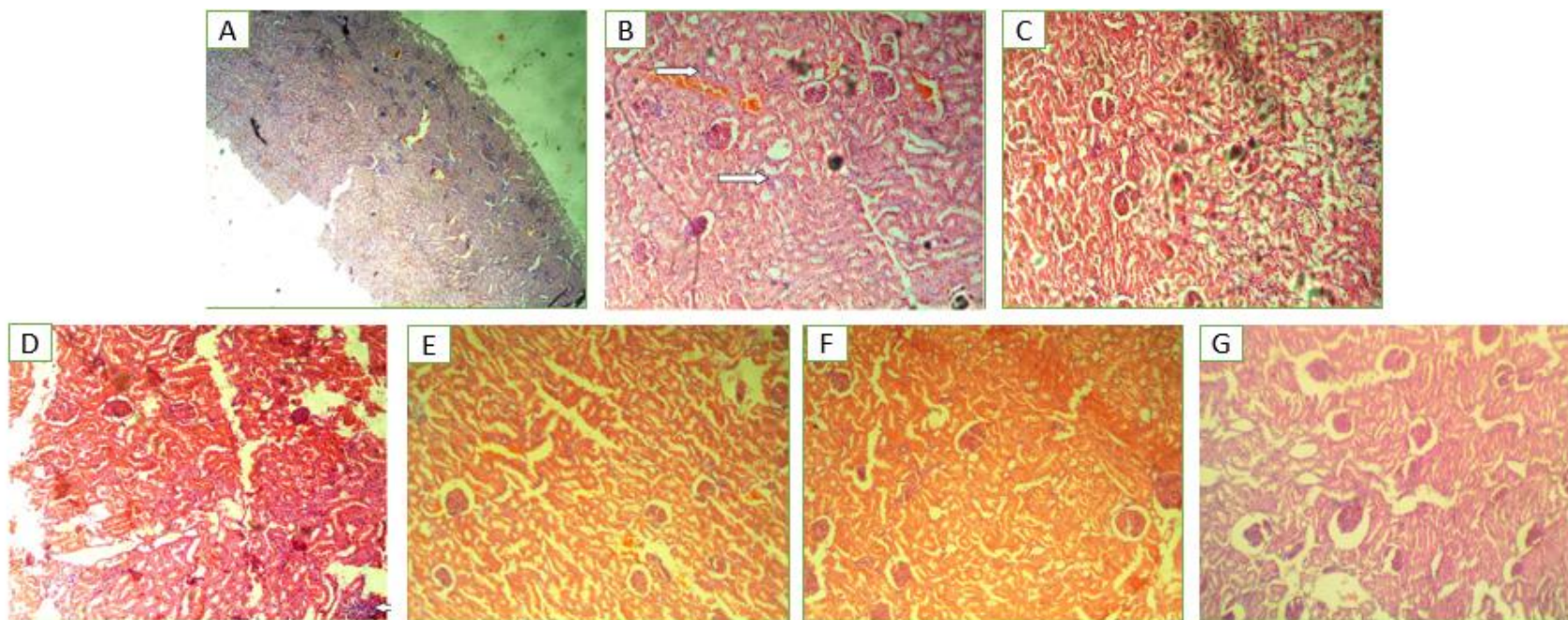


Plate 4.42: Effect of methanol extract of *Musanga cecropioides* leaves on the histology of the kidney in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control showing moderate pyelonephritis (inflammation of the kidney); C: Glibenclamide (10 mg/kg) tubules with acute tubular necrosis ; D: MCL Meth (30 mg/kg) with mild inflammation; E: MCL Meth (50 mg/kg) appears normal; F: MCL Meth (100 mg/kg) appears normal; G: MCL Meth (200 mg/kg) tubules with acute tubular necrosis : H and E $\times 100$

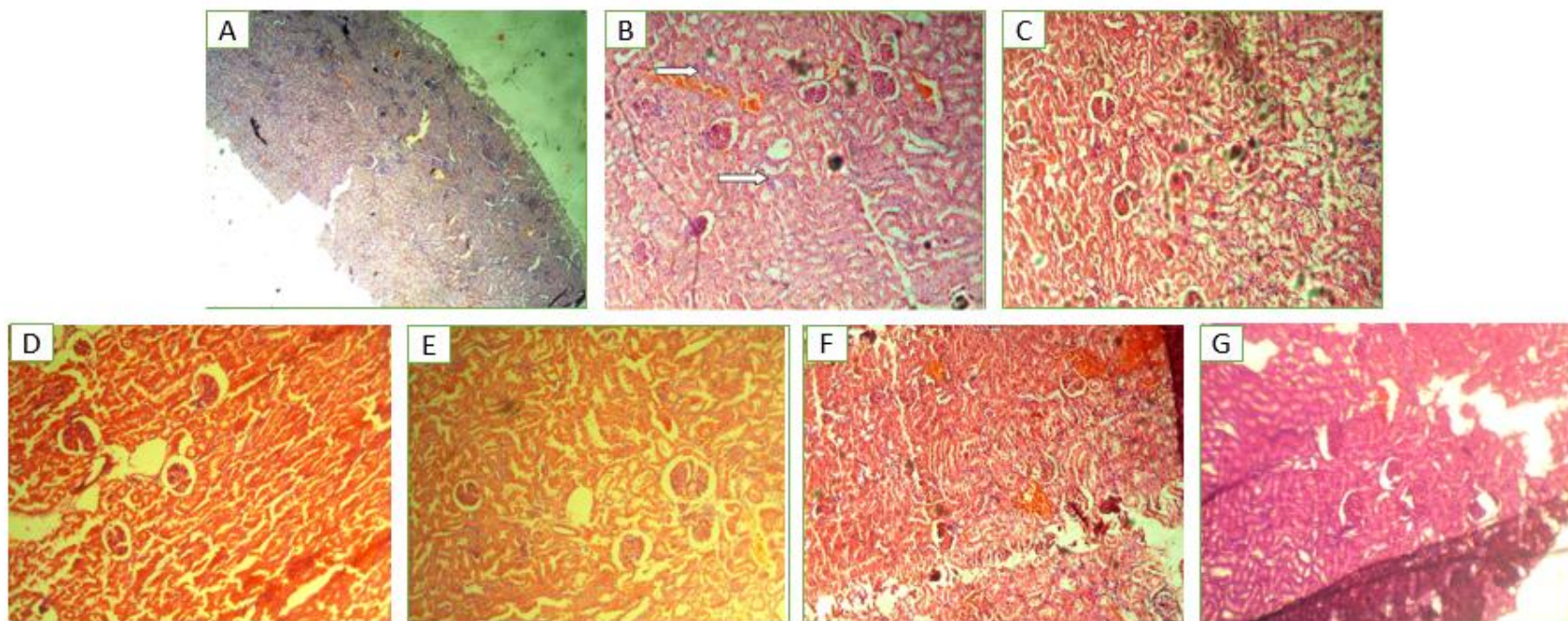


Plate 4.43: Effect of aqueous extract of *Musanga cecropioides* root on the histology of the kidney in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control showing moderate pyelonephritis (inflammation of the kidney); C: Glibenclamide (10 mg/kg) tubules with acute tubular necrosis ; D: MCR Aq (30 mg/kg) appears normal; E: MCR Aq (50 mg/kg) appears normal; F: MCR Aq (100 mg/kg) appears normal; G: MCR Aq (200 mg/kg) tubules with acute tubular necrosis: H and E $\times 100$

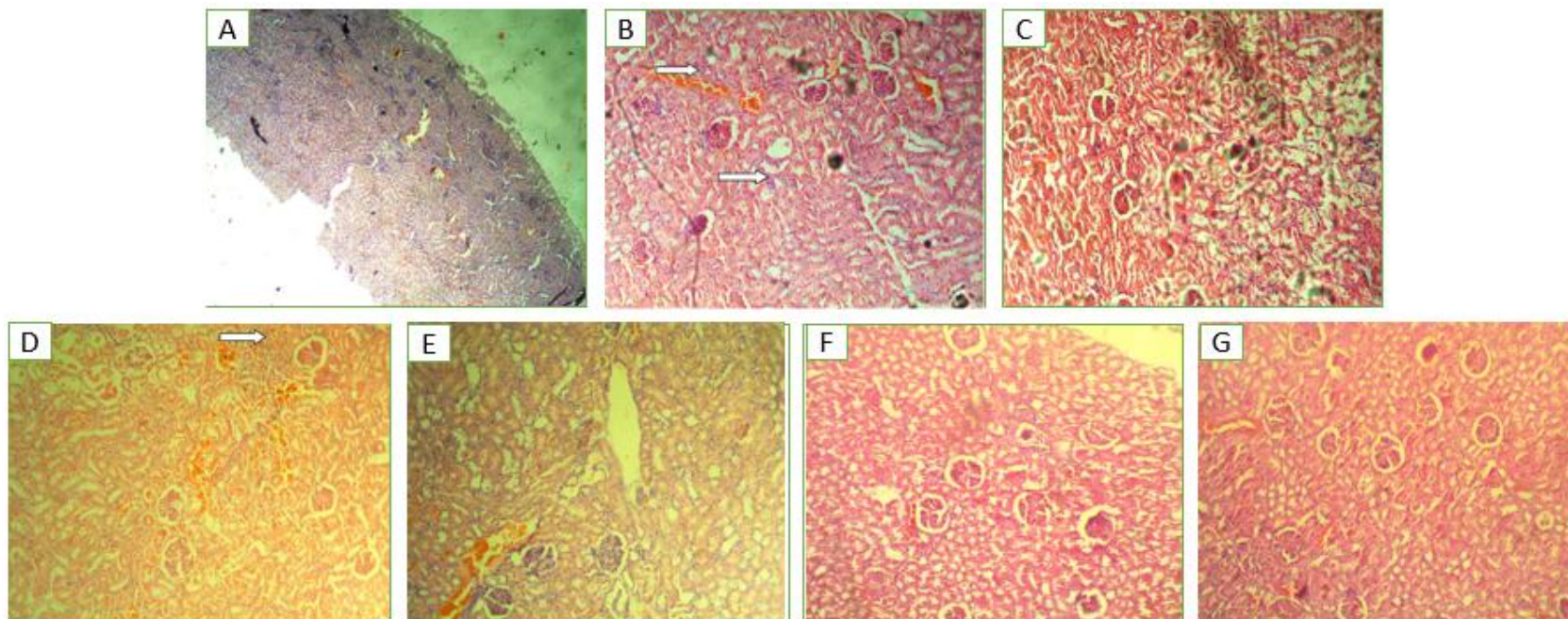


Plate 4.44: Effect of methanol extract of *Musanga cecropioides* root on the histology of the kidney in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control showing moderate pyelonephritis (inflammation of the kidney); C: Glibenclamide (10 mg/kg) tubules with acute tubular necrosis ; D: MCR Meth (30 mg/kg) showing mild inflammation ; E: MCR Meth (50 mg/kg) appears normal; F: MCR Meth (100 mg/kg) with acute tubular necrosis ; G: MCR Meth (200 mg/kg) with acute tubular necrosis : H and E $\times 100$

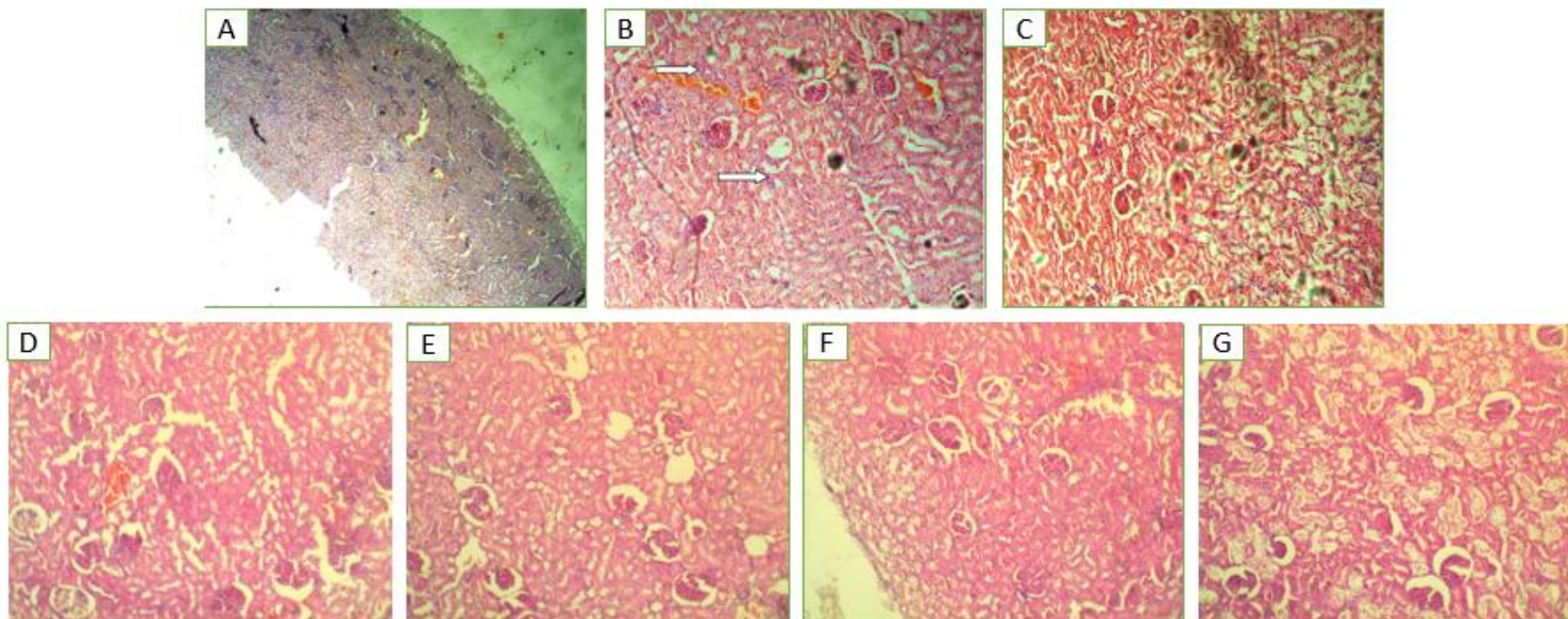


Plate 4.45: Effect of *Musanga cecropioides* crude root sap on the histology of the kidney in STZ-induced diabetic rats.

A: Normal control appears normal; B: Diabetic control showing moderate pyelonephritis (inflammation of the kidney); C: Glibenclamide (10 mg/kg) tubules with acute tubular necrosis; D: MCCRS (0.5 ml/kg) tubules with acute tubular necrosis ; E: MCCRS (1 ml/kg) tubules with acute tubular necrosis ; F: MCCRS (2 ml/kg) tubules with acute tubular necrosis ; G: MCCRS (3 ml/kg) tubules with acute tubular necrosis : H and E $\times 100$

CHAPTER FIVE: DISCUSSION AND CONCLUSION

5.1 Phytoconstituents

The study evaluated the phyto-constituents and phytomedicinal properties of *Musanga cecropioides* leaf extracts, root extracts and root sap. The presence of phytochemicals in *Musanga cecropioides* leaves and root sap is in conformity with existing literature which identified alkaloids, catechic tanins, phlobatannins, flavonoids (or bioflavonoids), triterpenes, sterols, coumarins, tannins (gallic), free and bound anthraquinone, anthocyanosides, oxalate, phenols, cyanogenic glycosides, saponin and cardiac glycosides in the leaves, stem bark, stem sap and root sap (Adeneye *et al.*, 2006a; Kadiri and Ajayi, 2009; Mabeku *et al.*, 2011; Uwah *et al.*, 2013; Tchouya and Nantia, 2015; Ajagbonna *et al.*, 2015; Nyunai *et al.*, 2016)

Also phenolic compounds, saponins and triterpene compounds including 3,4-dihydroxybenzoic acid, 3,4-dihydroxybenzaldehyde acid, kalaic acid, methyl oleanolate, methyl ursolate, 1, 2, methyl pomolate, methyl tormentate, methyl 2-acetyltormentate 28-glucosyl tormentate, methyl pomolate, methyl musangicate, euscaphate, Musancropic acids A and B and cecropiacic acid, have previously been isolated from *Musanga cecropioides* stem bark and root (Lontsi *et al.*, 1991a; Lontsi *et al.*, 1991b; Lontsi *et al.*, 1992; Lontsi *et al.*, 1998a; Lontsi *et al.*, 1998b; Ayinde *et al.*, 2007).

Proximate composition of *Musanga cecropioides* leaves, root and root sap revealed high moisture content which is in agreement with the findings of Shemishere *et al.* (2018). The high moisture content of the plant samples indicates that they may be easily susceptible to spoilage if not well preserved (Omoregie and Osagie, 2011). *Musanga cecropioides* leaves revealed higher ash, fibre, carbohydrate and protein content, making it the most

prospective option for food and energy value amongst the three parts tested. The higher ash content is indicative of its high mineral composition while the higher fibre content indicates that this plant may play a major role in digestion and prevention of constipation. The protein content indicates that the plant parts would facilitate tissue replacement and repair (Igile *et al.*, 2013).

Micronutrients are credited to having indispensable roles to play in metabolism and maintenance of tissue function, however, in excess quantities, they may be harmful, especially when administered to people who do not need them (Shenkin, 2006).

The presence of vitamins and carotene is an indication of the possible health benefits *Musanga cecropioides* leaves, root and root sap may possess. The high contents of vitamin A in the leaves, root and root sap may be due to the high carotene content as carotene is synthesized to vitamin A. All three samples tested showed high concentrations of vitamins A, C, B7 and E, which is an indication that the plant materials would possess good antioxidant and immune boosting properties (Shemishere *et al.*, 2018).

Amino acids are precursors for the synthesis of proteins and phytochemicals such as alkaloids (Croteau *et al.*, 2000). They are involved in osmolyte synthesis, cell metabolism, ammonia detoxification, antioxidant activity and alkaloid synthesis (Moran-Palacio *et al.*, 2014). Dietary supplementation of glycine has been reported effective in treating metabolic disorders in patients with cardiovascular diseases, several inflammatory diseases, obesity, cancers, and diabetes (Razak *et al.*, 2017). Similarly, aspartic acid function is essential for purine, pyrimidine, asparagine and inositol synthesis. Glutamic acid and glycine participate in the synthesis of glutathione increasing the antioxidant

capacity. Valine maintains the balance of branched chain amino acids, whereas alanine is involved on hepatic autophagy, gluconeogenesis and transamination. Leucine regulates the protein turnover and gene expression (Wu, 2009; Akram *et al.*, 2011). Glycine, lysine, threonine and glutamate help to maintain intestinal integrity and health (Rhoads and Wu, 2009; Wang *et al.*, 2009). Histidine is also important in the growth and repair of worn out tissues, maintenance of the myelin sheaths that protect nerve cells, and is needed for the production of both red and white blood cells (Vázquez-Ortiz *et al.*, 1995). In this present study, *Musanga cecropioides* leaves, root and root sap revealed the presence of both non-essential and essential amino acids in various concentrations. The essential amino acids found present are valine, methionine, phenylalanine, histidine, arginine, threonine, isoleucine, leucine, tryptophan and lysine, however the concentrations of valine, arginine and leucine were relatively high in the three samples tested. While the non-essential amino acids found present are glycine, alanine, serine, aspartate, glutamate, tyrosine, cysteine and proline, while glycine, alanine, aspartate and glutamate concentrations were relatively high. These results are in agreement with previous studies (Shemishere *et al.*, 2018). The presence of both essential and non-essential amino acids in *Musanga cecropioides* leaves, root and root sap also serves as a pointer to the possible roles of these plant materials in protein synthesis and general metabolism (Akram *et al.*, 2011; Agbadi *et al.*, 2017).

The relatively high iron content in *Musanga cecropioides* root and leaves which are comparable to recommended standards shows that they may be suitable in the management of anaemia and other iron deficiency related diseases (Idu *et al.*, 2014). Potassium, calcium, magnesium and sodium were also present in relatively high

concentrations, indicating the plant samples possess health benefits related to these mineral elements as indicated in literature (Okaka and Okaka, 2001; Weaver, 2013; Gröber *et al.*, 2015; Faraco *et al.*, 2018; Shemishere *et al.*, 2018). The low concentrations of lead and nickel also indicates that the plant may be safe for use.

5.2 Toxicity Studies

The acute toxicity study revealed that the LD₅₀ for all treatments were indeterminable since the maximum dose of 10000 mg/kg did not cause death or any other gross toxicological symptoms in the rats of the treatment groups except for the group treated with *Musanga cecropioides* aqueous root extract, with 2236 mg/kg body weight as the LD₅₀ and this value also falls within the standard range of 500 – 5000 mg/kg body weight making all the treatments practically nontoxic on the scale proposed by Lorke (1983).

Generally, reductions in body weight and internal organ weights are considered to be simple and sensitive indices of toxicity after prolonged exposure to toxic substances (Teo *et al.*, 2002). Subsequently, increase in the relative weight of the vital organs, would suggest that the extract might have caused hypertrophy of the vital organs (Yakubu *et al.*, 2018). The changes in both the body weight and organ weights of the experimental animals administered all treatments in the sub-acute toxicity study are not statistically or toxicologically significant. The fact that the various extracts of *Musanga cecropioides* administered in this study did not significantly increase the overall weights of the experimental animals agrees with the submissions of Shemishere *et al.* (2018), that *Musanga cecropioides* may be useful in a weight loss diet.

The haematopoietic system is considered a sensitive target of toxic compounds and is an important index of physiological and pathological status in man and animals (Adeneye *et al.*, 2006a). Haematology parameters tested were not significantly altered in all groups administered the various treatments when compared with the control group after the 28 days sub-acute toxicity study. The results suggests that *Musanga cecropioides* has no direct effect on the haematopoietic system of the experimental animals and is in agreement with the findings of Adeneye *et al.* (2006a).

Liver and renal function tests are vital in evaluating the toxicity of drugs and plant extracts (Olaniyan *et al.*, 2016). ALT is a better parameter for detecting liver injury because it is more specific to the liver. Serum ALP level is related to the function of hepatic cell, thus increase in serum level of ALP is due to increased synthesis of the enzyme (Nyblom *et al.*, 2006). AST is found in the cytoplasm and mitochondria of hepatocytes and few other cells. While both reversible and irreversible damage to the liver can cause release of cytoplasmic AST, only irreversible damage to the liver would cause release of mitochondrial AST. Increase in ALT may not necessarily be due to liver damage as cardiac or skeletal muscle injury and ex vivo haemolysis also leads to increased AST levels (Valentine *et al.*, 1990). In this study, aqueous extract of *Musanga cecropioides* leaves significantly reduced ALT activity in all administered doses when compared with the control group. This may be an indication of the protective effects of this extract on the liver as slightly reduced ALT levels have not been linked to pathological alterations. ALP concentration was significantly increased in the groups administered *Musanga cecropioides* aqueous root extract at 2500 mg/kg and methanol root extract at 500, 1000 and 2500 mg/kg, however ALT and AST concentrations were

reduced. The increased ALP concentration observed does not holistically describe liver injury as this did not correlate with other liver function enzymes (Boone *et al.*, 2005).

Reduced electrolyte (potassium, chloride and bicarbonate) concentrations caused by the methanol extract of *Musanga cecropioides* root was observed. Slightly elevated urea, creatinine and sodium concentrations in the groups administered aqueous extract of *Musanga cecropioides* root. Adeneye *et al.* (2006a) also observed increased creatinine concentrations after treatments with *Musanga cecropioides* bark extracts. The results of this sub-acute toxicity study suggest that *Musanga cecropioides* aqueous root extract may elicit some form of renal insult on the experimental animals however, this was not backed by histological evidence and other extracts administered did not cause any significant alteration in the liver and renal function activities.

Low density lipoprotein is a form of cholesterol that has been linked to pathological conditions like atherosclerosis and heart disease when in excess, hence the interest in toxicity studies (Akhigbemen *et al.*, 2018). While high density lipoprotein serves to mobilize excess cholesterol to the liver which is metabolized into bile salts (Akhigbemen *et al.*, 2018). Changes in cholesterol and triglyceride concentrations generally give information on the susceptibility of the heart to cardiovascular diseases (Schwarzova *et al.*, 2015). In this present study, reduced high density lipoprotein concentrations were observed in all treatment groups, this was also reported by Tom *et al.* (2018). While the groups treated with *Musanga cecropioides* aqueous and methanol root extracts also showed significantly lower low density lipoprotein and higher total cholesterol concentrations when compared to the control group. The results suggest that the leaf

extracts and crude root sap maybe incapable of interference with mechanisms associated with the development of cardiovascular diseases or they may not in any way promote the development of related diseases (Tom *et al.*, 2018).

Malondialdehyde concentration was not increased in all treatment groups except for the group treated with *Musanga cecropioides* aqueous root extract at 500 mg/kg when compared with the control group. This is an indication that lipid peroxidation was not initiated by *Musanga cecropioides* leaves, methanol root extract and root sap at the high doses administered, which is in agreement with the reports of Oduola *et al.* (2018), who reported that ingestion of high doses of *Phyllanthus amarus* leaf extract did not induce lipid peroxidation in a sub-acute toxicity study. This could further buttress the results of the acute toxicity study, where the aqueous root extract caused 100% mortality at doses of 5000, 7500 and 10000 mg/kg.

However the activities of the enzymatic antioxidants superoxide dismutase, catalase, glutathione reductase and glutathione peroxidase were not significantly increased across experimental groups, rather some of the values were significantly lower ($P < 0.05$) in the treatment groups when compared with the control group. While it may be agreed that *Musanga cecropioides* does not initiate lipid peroxidation, the extracts may not also have a direct effect on enzymatic antioxidant activities. This may also be due to the fact that exogenous toxicants or radicals were not introduced to the experimental animals (Akande *et al.*, 2014).

In the histological examinations of the vital organs, the treatments showed no visible alterations in the heart and kidney however the photomicrographs of the liver and lungs

showed signs of necrosis and thickening of the alveoli septae respectively. The pathological alterations observed in the liver at the various administered treatments were not significantly supported by the results obtained in the liver function tests, this may be a marker that these changes are not pathologically significant or they may be reversible (Boone *et al.*, 2005).

5.3 *In vitro* Antioxidant Activities

DPPH and ABTS radical scavenging assays reveals the antioxidant activity of test samples (Wu *et al.*, 2006). In this study, *Musanga cecropioides* leaves, root and root sap showed considerable radical scavenging activities, although the best activity was observed with the methanol extract of *Musanga cecropioides* leaves. The results are in agreement with the findings of Tchouya and Nantia (2015), who investigated the DPPH radical scavenging activity of *Musanga cecropioides* stem bark extracts. In the DPPH assay, the extracts showed better antioxidant potentials than the ABTS assay. This may be due to the stereo selectivity of radicals and the solubility of extracts in diverse solvent systems (Yu *et al.*, 2002). However the ability of the extracts to scavenge both radicals shows they are useful agents in reversing diverse pathological changes caused by different types of radicals. The antioxidant activity of *Musanga cecropioides* leaves, root and root sap may be due to the presence of alkaloids, tannin, saponin, flavonoid, phenols and vitamins A, C and E which are known antioxidant compounds and this is in agreement with other studies (Esua *et al.*, 2016; Adebisi *et al.*, 2017). The antioxidant activity of phytochemicals is due to their ability to act as reducing agents, hydrogen donors, metal chelators in redox reactions (Pietta, 2000).

The antioxidant potential of *Musanga cecropioides* leaves and root extracts was also assessed by assessing the DNA protective activity of the extracts using the *in vitro* DNA nicking assay. *In vitro* DNA nicking assay is regarded as a biologically relevant assay for assessing potential *in vivo* antioxidant substances as damage to DNA occurs in most diseases (Evans *et al.*, 2004; Valko *et al.*, 2006). In this study, the DNA nicking assay was carried out based on the Fenton reaction which imitates the *in vivo* biological situation (Leba *et al.*, 2014). Hydroxyl radicals (highly reactive and strong oxidizing species) generated by the Fenton reaction are known to cause oxidatively induced breaks in DNA strands to yield its fragmented forms (Leba *et al.*, 2014). Hydroxyl radicals changes the initial supercoiled configuration of plasmid DNA to open circular and nicked linear forms that present altered electrophoretic mobility properties on gel (Kitts *et al.*, 2000). DNA degradation is also induced by iron in the Fenton's reaction (Flemmig and Arnhold, 2007). While Fenton's reagent completely nicked the DNA in this study, *Musanga cecropioides* leaves and root methanol extracts both preserved the supercoiled DNA comparable to the standard quercetin. The aqueous extracts of the leaves and root however, did not completely protect the supercoiled DNA from Nicking but the open coiled form was visible. This result correlates positively with the results on the DPPH and ABTS radical scavenging assays. The high phenol content of the extracts might be responsible for the observed DNA protecting activities (Kumar *et al.*, 2017).

5.4 Anti-Diarrhoea Studies

Diarrhoea occurs as a result of increased intestinal secretion, and is considered a consequence of altered motility and fluid accumulation as a result of decreased intestinal absorption of fluid and electrolytes in the gastro-intestinal tract (Field, 2003; Rahman *et*

al., 2013). Diarrhoea was induced by castor oil through the production of ricinoleic acid which increases peristaltic activity and produces permeability changes to electrolytes and water in the intestinal mucosal membrane (Gaginella *et al.*, 1975). Castor oil also elevates the secretion and biosynthesis of prostaglandin (a known diarrhoeogenic agent) which results in irritation and inflammation of the intestinal mucosa to stimulate the motility and secretion (Venkatesan *et al.*, 2005).

In this study, all extracts showed significant reduction in the total number of diarrhoeal faeces and high percentage inhibition of diarrhoea, however the methanol leaf extract and methanol root extract at 50 mg/kg both showed the highest percentage inhibition of 71.11% and 88.89%, while the methanol root extract at 200 mg/kg was 75.56%. This result is in conformity with the findings of Uddin *et al.* (2005), where the methanol extracts of *Xylocarpus moluccensis* also showed the best anti-diarrhoeal activity in the castor-oil induced diarrhoeal model. Anti- diarrhoeal activities of plant extracts have also been linked to the presence of tannins, flavonoids, alkaloids, saponins and steroids in the plant (Nwosu *et al.*, 2012). From the results present in this study, these phytochemicals were also found in *Musanga cecropioides* parts. Enteropooling refers to the accumulation of fluid in the intestine, which is typical of a diarrhoeal episode. The plant samples used in this study also inhibited fluid accumulation in the intestine when compared to the control, a mechanism of action also exhibited by the standard drug, loperamide at 5 mg/kg. Since *Musanga cecropioides* root, leaves and root sap were able to inhibit castor oil induced diarrhoea and castor oil-induced enteropooling, the mechanism of action with which the anti-diarrhoeal effects were elicited may be linked to its ability to inhibit prostaglandin or ricinoleic acid biosynthesis and/or release, its ability to inhibit fluid

accumulation and the presence of phytochemicals (tannins, flavonoids, alkaloids, saponins and steroids), vitamin A, zinc and the electrolyte regulatory activity as seen in the results for the sub-acute toxicity study.

5.5 Antitussive and Antiasthmatic Studies

In the phenol red experiment, *Musanga cecropioides* leaves, root and root sap exhibited expectorant effects. The aqueous leaf extract at 50 mg/kg, methanol leaf extract at 100 mg/kg and aqueous root extract at 100 mg/kg significantly increased mucus expectoration in the experimental animals. However, a dose dependent reduction in the concentration of phenol red was observed in the group administered aqueous leaf extracts. Expectorants are known to increase the secretion and ease of elimination of sputum and phlegm in the respiratory tract through increased ciliary movement (Han *et al.*, 2010). Hyper secretion of mucus in the airway is a major cause of cough and phlegm build-up, and this is associated with the development of chronic airway inflammation and altered lung function (Zhang and Zhou, 2014). The observed expectorant effects in this study are comparable to previous reports and is attributable to the presence of flavonoids and the anti-inflammatory properties of *Musanga cecropioides* as earlier reported in literature (Guo *et al.*, 2016; Wu *et al.*, 2018).

The citric acid induced cough in guinea pigs is one of the easily observable and accurate model of study the antitussive effects of drugs (Mazzone, 2005). *Musanga cecropioides* leaf, root and root sap at all administered doses, significantly reduced the number of cough bouts in guinea pigs exposed to citric acid aerosol. The highest percentage reduction was observed in the group treated with the methanol root extract at 100 mg/kg.

This was correlated with the reduced phenol red output in the expectorant study and in line with the reports of Ozolua *et al.* (2016). The antitussive properties of plants have been linked to the presence of flavonoids and terpenoids (Wu *et al.*, 2018)

There are several substantive reports linking pulmonary diseases and asthma to oxidative stress and inflammation (MacNee, 2001; Caramori and Papi, 2004; Guo and Ward, 2007; Hoshino and Mishima, 2008). The high antioxidant content of *Musanga cecropioides* recorded in this study, in addition to the anti-inflammatory properties previously reported (Sowemimo *et al.*, 2015) indicates that this plant is a possible candidate for anti-asthma drug development. All extracts delayed the time before the appearance of pre-convulsive dyspnoea however, *Musanga cecropioides* aqueous leaf extract at 100 mg/kg showed the highest delay in the onset of pre-convulsive dyspnoea, thereby inhibiting bronchospasm induced by histamine aerosol (Salami *et al.*, 2013).

Anti-asthma drugs are also aimed at reducing the viscosity and volume of tracheal fluid (Ozolua *et al.*, 2016). In this study, tracheal fluid viscosity was measured by measuring the flow rate of the tracheal fluid of experimental animals. *Musanga cecropioides* leaf extracts at all doses and the aqueous root extract at 50 mg/kg significantly increased the flow rate of the tracheal fluid while the crude root sap at 1 ml/kg significantly reduced the flow rate, all other dose administrations did not significantly alter the flow rate when compared to the Ovalbumin control group. This result is in conformity with the results on the mucus expectorant study where *Musanga cecropioides* root sap inhibited mucus expectoration (Lin *et al.*, 2008). While the increased flow rate observed in the leaves and

root supports the result on the expectorant activity observed (Lin *et al.*, 2008; Wang *et al.*, 2011).

Ovalbumin administration alone significantly increased the white blood cell and lymphocyte count, however, this change was not observed in the treatment groups. This result is in agreement with existing literature (Ibulubo *et al.*, 2012).

Symptoms of asthma often include broncho-secretion and mucus plugging of the airways (Fanta, 1985; Rogers, 2007). Sensitization with ovalbumin is a model of obstructive airway disease such that the airways become hyper-responsive and inflamed (Shin *et al.*, 2009). The histology of the lungs in the different treatment groups revealed the presence of fluid blocking the airways. Also, the histology of the trachea revealed reduced trachea wall thickness across all treatment groups. This trend was also reported by Ibulubo *et al.* (2012). While the anti-asthmatic activity of *Musanga cecropioides* may not be linked to anti-secretory properties, histology of the lungs and trachea revealed that at the administered doses, the extracts exhibited Broncho-dilatory effects, thus the antitussive and anti-asthmatic activities of *Musanga cecropioides* is linked to the Broncho-dilatory effect and the anti-inflammatory activities previously reported by Sowemimo *et al.* (2015).

5.6 Anti-Diabetic Study

In this study, diabetes was induced using Streptozotocin (STZ) at a single dose of 50 mg/kg body weight. STZ is a diabetogenic, hepatotoxic, nephrotoxic compound (Piyachaturawat *et al.*, 1991), widely used to induce insulin-dependent diabetes in experimental animals because of its toxic effects on islet beta cells resulting in the loss of

capacity to secrete insulin (Gu *et al.*, 1997; Punithavathi *et al.*, 2008; Fadillioglu *et al.*, 2008). STZ has extensively been documented for the induction of diabetes via free radical generation and depletion of antioxidant defence system (Kade *et al.*, 2013). Other biological actions of STZ includes the production of acute and chronic cellular injury, carcinogenesis, teratogenesis and mutagenesis (Magee and Swann, 1969).

The characteristic feature of diabetes is elevated blood sugar or hyperglycaemia, hence prospective anti-diabetic drugs are targeted at maintaining normal blood sugar level. *Musanga cecropioides* leaves, root and root sap showed remarkable blood glucose lowering effect. The aqueous leaf extracts at 30, 50 and 100 mg/kg caused significant reduction in the blood sugar level, however the group administered 50 mg/kg showed the highest reduction. The methanol leaf extract also exhibited statistically significant glucose lowering activity at the doses of 30, 50 and 200 mg/kg however the best activity was observed at 200 mg/kg. In the groups treated with *Musanga cecropioides* aqueous root extracts, all doses showed significant anti-diabetic activities, the group administered 200 mg/kg had the best activity. In the groups treated with methanol root extracts, the groups administered 30 and 100 mg/kg showed significant anti-diabetic activities. For the groups treated with *Musanga cecropioides* crude root sap, 0.5, 1 and 2 ml/kg body weight administrations showed significant anti-diabetic activity, but the group treated with 2 ml/kg showed the best activity. These results are in conformity with earlier reports on the anti-diabetic activity of *Musanga cecropioides* stem bark (Adeneye *et al.*, 2007; Nyunaï *et al.*, 2016). However, the anti-diabetic activity observed in this study cannot be said to be dose dependent, which is in contrast with the findings of Adeneye *et al.* (2007). This may be due to the choice of dose levels used in this study. The anti-diabetic activity of

Musanga cecropioides samples used in this study can be attributed to the presence of phytochemicals especially flavonoids and phenols, and micronutrients reported.

STZ administration led to observed weight loss in all diabetic animals, which is in agreement with the report of Zafar and Naqvi (2010) and Eleazu *et al.* (2013), however the administration of *Musanga cecropioides* leaf extracts, root extracts and root sap did not cause any significant weight gain in all treatment groups when compared with the diabetic control group. This result further confirms the findings in the sub-acute toxicity study that *Musanga cecropioides* had no direct effect on weight of experimental animals.

The diabetic control group showed increased liver, kidney and brain to body weight ratio. STZ has been reported to induce hypertrophy of vital organs which may also be linked to cellular damage, accumulation of fatty tissues and lipids in such organs as a result of low rate of excretion and utilization of lipoproteins (Merzouk *et al.*, 2000; Ohno *et al.*, 2000; Habibuddin *et al.*, 2008; Lee *et al.*, 2008). During diabetes, the liver has also been reported to decrease in weight due to enhanced catabolic processes such as glycogenolysis, lipolysis and proteolysis, which is the outcome of lack of insulin in the liver cells while the kidney has been reported to increase in weight due to glucose over-utilization and subsequent enhancement in glycogen synthesis, lipogenesis and protein synthesis (Meyer *et al.*, 1998; Eleazu *et al.*, 2013). The various treatments showed inconsistent trend in the organ to body weight ratio. In some cases, the ratio was higher while in other cases, the value was significantly lower when compared to the normal control group. The condition of increased organ weight was not completely reversed in the treatment groups, however, the groups administered *Musanga cecropioides* aqueous

leaf extract at 50 and 100 mg/kg, methanol leaf extract at 50 mg/kg, methanol root extract at 100 ml/kg and crude root sap at 2 ml/kg showed normal organ to body weight ratios in most organs assessed.

Hyperglycaemia has been linked to haematological alterations such as reduced red blood cell count, haemoglobin concentration and haematocrit levels through the increased production of reactive oxygen species (Baloyi *et al.*, 2019). Reactive oxygen species cause destruction and inactivation of the red blood cell membrane proteins and antioxidant enzymes respectively, thereby decreasing the oxygen-carrying capacity of the cells, leading to diabetic anaemia (Jain, 1989; De Jong *et al.*, 2001; Pandey and Rizvi, 2011; Varashree and Bhat, 2011; Kang *et al.*, 2015; Shola and Olatunde, 2015). In this present study, the diabetic control group showed significantly lower red blood cell count, and lower haemoglobin concentration when compared with the normal control group, which was also reported by Baloyi *et al.* (2019). However, the administration of *Musanga cecropioides* significantly increased red blood cell count, haemoglobin concentration and haematocrit count in the group administered aqueous leaf extract at 30, 50 and 100 mg/kg body weight. The administration of *Musanga cecropioides* aqueous root extract at 200 mg/kg body weight and crude root sap at all doses significantly increased the haematocrit count also. This result suggests that while *Musanga cecropioides* may not alter haematological parameters when administered alone to normal animals, as observed in the sub-acute toxicity study, the leaf, root and root sap may protect against damage caused by exogenous conditions to the hematopoietic system.

The induction of diabetes with STZ causes the lysis hepatocytes cells which release transaminases indicating impaired liver function and subsequently hepatic damage (Sepici-Dincel *et al.*, 2007). Piyachaturawat *et al.* (1991) also reported that STZ is known to cause renal assaults in experimental animals, which is a similar occurrence in diabetic patients. In this study, STZ caused increased levels of all liver function enzymes tested in the diabetic control group which is in conformity with the report of Demirbolat *et al.* (2019). While the administration of *Musanga cecropioides* extracts caused no marked increase in liver function parameters, rather reduced enzyme activities were observed. Also, in the group treated with aqueous leaf extract at different doses, renal function parameters were relatively low, while the administration of methanol leaf extract, aqueous and methanol root extracts and crude root sap increased the urea concentration at selected doses leaving electrolyte concentrations low or unaltered. These inconsistencies observed are not farfetched in anti-diabetic studies.

Increased cholesterol and triglyceride concentrations have been reported in STZ diabetic rats (Kumarappan and Mandal, 2014). Reduction in the concentrations of the lipids would subsequently reduce the effects of diabetic complications (Yin *et al.*, 2011). The improvement of lipid profile might be directly or indirectly related to the reduction of blood glucose levels. Lowering of serum lipid levels through dietary or drug therapy seems to be associated with a decrease in the risk of vascular disease and related complications (Yin *et al.*, 2011). *Musanga cecropioides* aqueous leaf extract at 50 mg/kg, methanol leaf extract at 200 mg/kg, aqueous root extract at 200 mg/kg and the different administered doses of the crude root sap significantly reduced total cholesterol and triglyceride levels.

Total antioxidant capacity is the measure of the amount of free radicals scavenged by a test solution (Ghiselli *et al.*, 2000), and is used to evaluate the antioxidant capacity of biological samples (Bartosz, 2010; Pinchuk *et al.*, 2012; Marques *et al.*, 2014). In this study, the blood plasma of the experimental animals in the STZ-induced diabetic study were tested for the total antioxidant capacity of *Musanga cecropioides* leaves, root and root sap. STZ is known to cause oxidative damage which also occurs in diabetic patients, and a drug with high total antioxidant capacity in an anti-diabetic study would hold some prospects in combating the disease. In this study, *Musanga cecropioides* aqueous leaf extract at 50 and 200 mg/kg, methanol leaf extract at 200 mg/kg, aqueous root extract at 30 and 50 mg/kg and crude root sap at 2 and 3 ml/kg showed significantly higher total antioxidant capacity. This result is in conformity with the findings of Malekiyan *et al.* (2019), and further suggests that the anti-diabetic activity observed in these extracts and doses are linked to the antioxidant activities.

The results of the antioxidant activities of *Musanga cecropioides* leaves, root and root sap in the brain, pancreas and liver of STZ-induced diabetic rats revealed mixed trends in the activities of the enzymatic antioxidants and malondialdehyde. The elevated levels of oxidative stress in diabetic animals have been linked to autooxidation of glucose, protein glycation, lipid peroxidation, and low activities of antioxidant enzymes (Giugliano *et al.*, 1996). In the study carried out by Sheweita *et al.* (2016), STZ increased malondialdehyde level, and decreased the activities of antioxidant enzymes.

In this present study, *Musanga cecropioides* leaves, root and root sap was able to reverse lipid peroxidation caused by STZ in the brain, liver and pancreas at several dose levels

with few exceptions. In the brain, significantly reduced malondialdehyde levels were observed in all treatment groups except the groups treated with *Musanga cecropioides* aqueous leaf extract at 30 and 50 mg/kg and the groups treated with *Musanga cecropioides* crude root sap at 1 and 2 ml/kg. While in the liver, either normal or significantly lower malondialdehyde values were observed except in the groups treated with *Musanga cecropioides* aqueous and methanol root extracts both at 30 mg/kg, methanol leaf extract at 50 mg/kg and crude root sap at 1 and 2 ml/kg. In the pancreas as well, the same trend observed in the liver and brain was seen, malondialdehyde values were only increased in the groups treated with *Musanga cecropioides* aqueous leaf extract at 30 and 100 mg/kg, the methanol root extract at 200 mg/kg and crude root sap at 0.5, 1 and 2 ml/kg. Glibenclamide which is the standard drug, did not significantly reduce the malondialdehyde values in any of the organs studied. These results are in agreement with the results observed in the sub-acute toxicity where malondialdehyde was reduced in most treatment groups however the group treated with the crude root sap did not significantly reduce the malondialdehyde values at any dose. Based on these results, the antioxidant activities observed in *Musanga cecropioides* leaves and root may be as a result of their ability to limit lipid peroxidation.

Furthermore, the results on the enzymatic antioxidant activities revealed increased activities in several treatments. Remarkably, for the brain, at 50 mg/kg, *Musanga cecropioides* aqueous leaf extract showed significantly ($P < 0.001$) increased SOD and GPx activities. Increased enzymatic antioxidant activity was also observed in the liver and pancreas at this treatment. *Musanga cecropioides* methanol leaf extract and aqueous root extract at 200 mg/kg and crude root sap at 2 ml/kg also showed remarkable increase

in enzymatic antioxidant activities in the three organs studied. This result may be a marker as to the increased anti-diabetic activity observed with these treatments. These results are comparable to the results obtained by Ononamadu *et al.* (2019) and Okechukwu *et al.* (2019).

The inflammation of the pericardium in the photomicrograph of the heart observed in the diabetic control group was ameliorated in all the treatment groups. This is further establishes the anti-inflammatory properties of *Musanga cecropioides* as reported by Sowemimo *et al.* (2015). Signs of necrosis were observed in the liver of the diabetic control group which was however ameliorated by the various treatments. The diabetic control group also showed inflammation in the lungs and thickening of the alveoli septae, which was however ameliorated to various degrees by the treatments. This result indicates that *Musanga cecropioides* extracts reverses or prevents the inflammatory conditions in the lungs at doses lower than 500 mg/kg body weight. Also suggesting its suitability as a therapeutic agent in the management of asthma. The degradation of the islet cells in the pancreas caused by STZ was also ameliorated by the various treatments as resurgent islet cells were observed across the groups. The spleen across groups appeared normal showing that the administration of STZ may not have caused pathological changes to the spleen while the photomicrographs of the kidney showed signs of inflammation and necrosis which was ameliorated in some treatment groups. Generally, the histological changes caused by STZ were reversed to near normal in most cases which is supported by the results in biochemical tests and changes in blood glucose level. This is supported by the reports of Ahmed *et al.* (2015).

5.7 Conclusion and Recommendation

This study gives comprehensive reports on the phytomedicinal properties of *Musanga cecropioides* leaves, root and root sap. The presence of therapeutically and nutraceutically important phyto-constituents has been established and this lends credence to the use of this plant ethnomedicinally in various parts of Africa. Toxicity studies carried out also suggests that the administration of this plant parts at controlled doses pose no adverse effect. The antioxidant properties of this plant parts have also been established in the different assays, and this is mainly due to the presence of selected phyto-constituents. Furthermore, *Musanga cecropioides* parts are confirmed relevant and effective therapy in the management of diarrhoea, cough, asthma and diabetes and these biological activities can be linked to the abundant phyto-constituents reported and the antioxidant properties of this plant. It is therefore recommended that chronic toxicity studies may be carried out on the plants using the therapeutically active dose ranges used in this study, to further ascertain the role of the plant in metabolic processes after prolonged usage. However, the plant's potentials should be utilized in the development of drugs and supplements.

5.8 Contribution to Knowledge

The contribution to knowledge includes:

1. This study reports the vitamin, amino acid, and quantitative phytochemical content of *Musanga cecropioides* leaf and root extracts and root sap for the first time.
2. Toxicity studies and antioxidant activities of the root extracts and root sap are reported for the first time.

3. The DNA protective effect of *Musanga cecropioides* leaf and root extracts are reported for the first time.
4. The antitussive and anti-asthmatic activities of *Musanga cecropioides* leaf extracts and root extracts and root sap are reported for the first time.
5. The anti-diarrhoea activities of *Musanga cecropioides* leaf extracts, root extracts and root sap are reported for the first time.
6. The anti-diabetic activities of *Musanga cecropioides* leaf extracts, root extracts and root sap are reported for the first time.

References

- Abbaspour N**, Hurrell R and Kelishadi R (2014). Review on iron and its importance for human health. *Journal of Research in Medical Sciences*, 19(2): 164 – 174.
- Abdullah KM**, Alam M, Iqbal Z and Naseem I (2018). Therapeutic effect of vitamin B3 on hyperglycemia, oxidative stress and DNA damage in alloxan induced diabetic rat model. *Biomedicine and Pharmacotherapy*, 105: 1223 – 1231.
- Adebiyi OE**, Olayemi FO, Ning-Hua T and Guang-Zhi Z (2017). In vitro antioxidant activity, total phenolic and flavonoid contents of ethanol extract of stem and leaf of *Grewia carpinifolia*. *Beni-Suef University Journal of Basic and Applied Sciences*, 6: 10 – 14.
- Adeneye AA** (2009). Protective activity of the stem bark aqueous extract of *Musanga cecropioides* in carbon tetrachloride- and acetaminophen induced acute hepatotoxicity in

rats. *African Journal of Traditional, Complementary and Alternative Medicines*, 6(2): 131 – 138.

Adeneye AA, Ajagbonna OP and Ayodele OW (2007). The hypoglycemic and antidiabetic activities of the stem bark aqueous and alcohol extracts of *Musanga cecropioides* in normal and alloxan-induced diabetic rats. *Fitoterapia*, 78: 502 – 505.

Adeneye AA, Ajagbonna OP, Adeleke TI and Bello SO (2006a). Preliminary toxicity and phytochemical studies of the stem bark aqueous extract of *Musanga cecropioides* in rats. *Journal of Ethnopharmacology*, 105(3): 374 – 379.

Adeneye AA, Ajagbonna OP, Mojiminiyi FBO, Odigie IP, Etarrh RR, Ojobor PD and Adeneye AK (2006b). The hypotensive mechanisms for the aqueous extract of *Musanga cecropioides* stem bark in rats. *Journal of Ethnopharmacology*, 106(2): 203 – 207.

Agbadi RK, Kaukhova IE, Terninko II and Sirichenko TI (2017). Quantitative and Qualitative Analyses of Amino Acids in *Morinda citrifolia* (Rubiaceae). *International Journal of Pharmacognosy and Phytochemical Research*, 9(7): 980 – 984.

Ahmed D, Kumar V, Verma A, Shukla GS and Sharma M (2015). Antidiabetic, antioxidant, antihyperlipidemic effect of extract of *Euryale ferox* salisb. with enhanced histopathology of pancreas, liver and kidney in streptozotocin induced diabetic rats. *Springer Plus*, 4: 315. Doi: 10.1186/s40064-015-1059-7

Ajagbonna OP, Adeniran LA and Idowu OO (2015). Diuretic effects of aqueous crude extract of *Musanga cecropioides* in normotensive Sprague dawley rat. *Journal of Biology, Agriculture and Healthcare*, 5(13): 47 – 53.

Akande G, Aliu YO, Ambali SF and Ayo JO (2014). Co-treatment of chlorpyrifos and lead induce serum lipid disorders in rats: alleviation by taurine. *Toxicology and Industrial Health*, 32: 1328 – 1334.

Akhigbemen AM, Ozolua RI, Bafor EE and Okwuofu EO (2018). Subacute toxicological profile of *Caladium bicolor* Aiton (Araceae) methanolic leaf extract in rat. *Journal of Pharmacy and Pharmacognosy Research*, 6(6): 503 – 516.

Akram M, Asif M, Uzair M, Naveed A, Madni MA, Ali SS, Hasan Z and Khan A (2011). Amino acids: A review article. *Journal of Medicinal Plants Research*, 5: 3997 – 4000.

Allen LH, Miller JW, de Groot L, Rosenberg IH, Smith AD, Refsum H and Raiten DJ (2018). Biomarkers of Nutrition for Development (BOND): Vitamin B-12 Review. *The Journal of Nutrition*, 148(4): 1995 – 2027.

Amiebenomo CS and Osaghae DO (2017). The management of acute diarrhoea in children. *Annals of Medical and Surgical Practice*, 2(2): 114 – 119.

Anderson BB, Fulford-Jones CE, Child JA, Beard M and Bateman CJ (1971). Conversion of vitamin B 6 compounds to active forms in the red blood cell. *The Journal of Clinical Investigation*, 50(9): 1901 – 1909.

Anke M, Trübschuch A and Gunstheimer G (2002). *Trace Elements in Man and Animals*. 10th Edition, Roussel, A. M., Anderson, R. A. and Favrier, A. E. (Eds), Kluwer Academic. pp. 685 – 686.

Anonymous (2002). *Toxicology and Exposure Guidelines*. UNL Environmental Health and Safety. University of Nebraska, Lincoln. 28p. [Online] [Available at: https://ehs.unl.edu/documents/tox_exposure_guidelines.pdf] [Accessed: 22/09/2017].

AOAC (2016). *Official Methods of Analysis*. 20th Edition, Association of Official Analytical Chemists Inc. Volume 1, George W. and Latimer, Jr. (Eds) Washington, D. C., USA. pp. 89 – 101.

Aranow C (2011). Vitamin D and the immune system. *Journal of Investigative Medicine*, 59(6): 881 – 886.

Astaras C, Muhlenberg M and Waltert M (2008). Note on Drill (*Mandrillus Leucophaeus*) Ecology and Conservation Status in Korup National Park, Southwest Cameroon. *American Journal of Primatology*, 70: 306 – 310.

Atmani D, Nassima C, Dina A, Meriem B, Nadjat D and Hania B (2009). Flavonoids in Human Health: From Structure to Biological Activity. *Current Nutrition and Food Science*, 5: 225 – 237.

Au A, Ha J, Hernandez M, Polotsky A, Hungerford DS and Frondoza CG (2006). Nickel and vanadium metal ions induce apoptosis of T-lymphocyte Jurkat cells. *Journal of Biomedical Material Research A*, 79: 512 – 521.

Avila DS, Puntel RL and Aschner M (2013). Manganese in Health and Disease. In: Sigel A, Sigel H and Sigel RKO (Eds.), *Interrelations between Essential Metal Ions and Human Diseases, Metal Ions in Life Sciences* 13. Springer Science, Dordrecht. pp 199 – 227.

Ayeni KE and Yahaya SA (2010). Phytochemical screening of three medicinal plants Neem leaf (*Azadirachta indica*), Hibiscus leaf (*Hibiscus rosa-sinensis*) and spear grass leaf (*Imperata cylindrica*). *Continental Journal of Pharmaceutical Sciences*, 4: 47 – 50.

Ayinde BA, Omogbai EKI and Onwukaeme DN (2003). Pharmacognostic Characteristics and Hypotensive Effect of the Stem Bark of *Musanga cecropioides* R. Br. (Moraceae). *West African Journal of Pharmacology and Drug Research*, 19(1&2): 37 – 41.

Ayinde BA, Onwukaeme DN and Nworgu ZAM (2006). Oxytotic effects of the water extract of *Musanga cecropioides* R. Brown (Moraceae) stem bark. *African Journal of Biotechnology*, 5(14): 1350 – 1354.

Ayinde BA, Onwukaemea DN and Omogbai EK (2007). Isolation and characterization of two phenolic compounds from the stem bark of *Musanga cecropioides* R. Brown (Moraceae). *Acta Poloniae Pharmaceutica -Drug Research*, 64(2): 183 – 185.

Ayitey-Smith E (1989). *Prospects and scope of plant medicine in health care*. Ghana Universities Press P. O. Box 4219 Accra, Ghana. pp. 5 – 6.

Azad S (2018). Amino acids: Its types and uses. *International Journal of Clinical and Diagnostic Pathology*, 1(1): 13 – 16.

Aziba PI (2005). Inhibitory effects of *Musanga cecropioides* on noradrenaline and potassium-induced contractions in rat thoracic aorta. *African Journal of Biomedical Research*, 8: 59 – 61.

Aziba PI and Gbile ZO (2000). Pharmacological screening of the aqueous extract of *Musanga cecropioides*. *Fitoterapia*, 71: 143 – 146.

Bailey RL, Fulgoni VL, Keast DR and Dwyer JT (2011). Dietary supplement use is associated with higher intakes of minerals from food sources. *American Journal of Clinical Nutrition*, 94: 1376 – 1381.

Balekari U and Veeresham C (2015). *In vivo* and *in vitro* evaluation of anti-diabetic and insulin secretagogue activities of *Capparis zeylanica*. *Pharmacology and Pharmacy*, 6: 311 – 320.

Baloyi CM, Khathi A, Sibiya NH and Ngubane PS (2019). The Haematological Effects of Oleanolic Acid in Streptozotocin Induced Diabetic Rats: Effects on Selected Markers. *Journal of Diabetes Research*, 2019: 1 – 9. Doi: <https://doi.org/10.1155/2019/6753541>

Banu KS and Cathrine L (2015). General techniques involved in phytochemical analysis. *International Journal of Advanced Research in Chemical Science*, 2(4): 25 – 32.

Bartosz G (2010). Non-enzymatic antioxidant capacity assays: Limitations of use in biomedicine. *Free Radical Research*, 44: 711 – 720.

Benavente-Garcia O, Castillo J, Marin FR, Ortuño A and Del-Rio JA (1997). Uses and properties of Citrus flavonoids. *Journal of Agriculture and Food Chemistry*, 45: 4505 – 4515.

Boone L, Meyer D, Cusick P, Ennulat D, Bolliger AP, Everds N, Meador V, Elliott G, Honor D, Bounous D and Jordan H (2005). Selection and interpretation of clinical

pathology indicators of hepatic injury in preclinical studies. *Veterinary Clinical Pathology*, 34: 182 – 188.

Bouquet A (1969) *Feticheurs et Medicine Traditionnelles du Congo*. Orstrom, Brazaviile. pp. 1 – 150.

Bramley AM, Langlands JM, Jones AK, Burgoyne DL, Li Y, Andersen RJ and Salari H (1995). Effects of IZP-94005 (contignasterol) on antigen-induced bronchial responsiveness in ovalbumin-sensitized guinea-pigs. *British Journal of Pharmacology*, 115(8): 1433 – 1438.

Brewer MS (2011). Natural Antioxidants: Sources, Compounds, Mechanisms of Action, and Potential Applications. *Comprehensive Reviews in Food Science and Food Safety*, 10: 221 – 247.

Burkill HM (1985). *The useful plants of West Tropical Africa*. 2nd Edition. Volume 1, Families A-D. Royal Botanic Gardens, Kew, Richmond, United Kingdom. 960 pp.

Caramori G and Papi A (2004). Oxidants and asthma. Review. *Thorax*, 59: 170 – 173.

Carr AC and Maggini S (2017). Vitamin C and Immune Function. *Nutrients*, 9(1211): 1 – 25.

Chambial S, Dwivedi S, Shukla KK, John PJ and Sharma P (2013). Vitamin C in Disease Prevention and Cure: An Overview. *Indian Journal of Clinical Biochemistry*, 28(4): 314 – 328.

Chang C, Yang M, Wen H and Chern J (2002). Estimation of total flavonoid content in propolis by two complementary colorimetric methods. *Journal of Food and Drug Analysis*, 10: 178 – 182.

Chikezie PC, Ojiako OA and Nwifo KC (2015). Overview of anti-diabetic medicinal plants: The Nigerian research experience. *Journal of Diabetes and Metabolism*, 6(6): 546 – 553.

Chung KF (2002a). Assessment and measurement of cough: the value of new tools. *Pulmonary Pharmacology and Therapeutics*, 15: 267 – 272.

Chung KF (2002b). Cough: potential pharmacological developments. *Expert Opinion on Investigational Drugs*, 11: 955 – 963.

Claude B and Paule S (1979). *The Manual of Natural Living*. 1st Edition. Biddles Ltd., Guildford, Surrey. pp. 98 – 101.

Cohen D, Dembiec D and Marcus J (1970). Measurement of catalase activity in tissue extracts. *Annals of Clinical Biochemistry*, 34: 30 – 38.

Crider KS, Bailey LB and Berry RJ (2011). Folic acid food fortification -its history, effect, concerns, and future directions. *Nutrients*, 3: 370 – 384.

Croteau R, Kutchan TM and Lewis NG (2000). Natural products (secondary metabolites). *Biochemistry and Molecular Biology of Plants*, 1250 – 1318.

Danks DM (1995). Disorders of copper transport. In: Scriver, C. L., Beaudet, A. L., Sly, W. S. and Valle, D. (Eds). *The Metabolic and Molecular Bases of Inherited Disease*. McGraw-Hill, New York. pp 2211 – 2235.

De Bruyne T, Pieters L, Deelstra H and Vlietinck A (1999). Condensed vegetables tannins: biodiversity in structure and biological activities. *Biochemical System Ecology*, 27: 445 – 59.

De Jong K, Emerson RK, Butler J, Bastacky J, Mohandas N and Kuypers FA (2001). Short survival of phosphatidyl serine exposing red blood cells in murine sickle cell anemia. *Blood*, 98(5): 1577 – 1584.

Demirbolat I, Ekinçi C, Nuhog˘lu F, Kartal M, Yıldız P and Geer MÖ (2019). Effects of Orally Consumed *Rosa damascena* Mill. Hydrosol on Hematology, Clinical Chemistry, Lens Enzymatic Activity, and Lens Pathology in Streptozotocin-Induced Diabetic Rats. *Molecules*, 24: 4069. doi:10.3390/molecules24224069

Denny KH and Stewart CW (2013). Acute, sub-acute, sub-chronic and chronic general toxicity testing for preclinical drug development. In: *A Comprehensive Guide to Toxicology in Preclinical Drug Development*. Elsevier Inc., London. pp 87 – 105.

Dey L, Attele AS and Yuan CS (2002). Alternative therapies for type 2 diabetes. *Alternative Medicine Review*, 7: 45 – 58.

Dike IP, Obembe OO and Adebisi FE (2012). Ethnobotanical survey for potential anti-malarial plants in south-western Nigeria. *Journal of Ethnopharmacology*, 144(3): 618 – 626.

Dolara P, Luceri C, De Filippo C, Femia AP, Giovannelli L, Carderni G, Cecchini C, Silvi S, Orpianesi C and Cresci A (2005). Red wine polyphenols influence carcinogenesis, intestinal microflora, oxidative damage and gene expression profiles of colonic mucosa in F344 rats. *Mutation Research*, 591: 237 – 246.

- Dongmo AB**, Kamanyi A and Bopelet M (1996). Saponins from the leaves of *Musanga cecropioides* (Cecropiaceae) constitute a possible source of potent hypotensive principles. *Phytotherapy Research*, 10: 23 – 27.
- Doumas BT**, Bayse DD, Carter RJ, Peters T and Schaffer R (1981). A candidate reference method for determination of total protein in serum: I Development and validation. *Clinical Chemistry*, 27(10): 1642 – 1650.
- Dudareva N**, Pichersky E and Gershenzon J (2004). Biochemistry of plant volatiles. *Plant Physiology*, 135: 1893 – 1902.
- Eleazu CO**, Iroaganachi M, Okafor PN, Ijeh II and Eleazu KC (2013). Ameliorative Potentials of Ginger (*Z. officinale* Roscoe) on Relative Organ Weights in Streptozotocin induced Diabetic Rats. *International Journal of Biomedical Science*, 9(2): 82 – 90.
- Engler H** and Szelenyi I (1984). Tracheal Phenol Red Secretion, a New Method for Screening Mucosecretolytic Compounds. *Journal of Pharmacological Methods*, 11: 151 – 157.
- Essien AI**, Udoinim MM, Akpan GD, Effiong JO and Ofor CO (2012) Aquatic Macrophytes and Limnological Implications on Fisheries Resources: A Case Study of Obio Akpa Stream in Akwa Ibom State, Nigeria. *International Journal of Water and Soil Resources Research*, 3(1): 15 – 21.
- Esua OJ**, Makinde OO, Arueya GL and Chin NL (2016). Antioxidant potential, phytochemical and nutrient compositions of Nigerian hog plum (*Spondias mombin*) seed kernel as a new food source. *International Food Research Journal*, 23: 179 – 185.

Evans MD, Dizdaroglu M and Cooke MS (2004). Oxidative DNA damage and disease: Induction, repair and significance. *Mutation Research*, 567: 1 – 61.

Ezenwa KC, Igbe I and Idu M (2015). Antidiabetic activity of methanol extract of *Stachytarpheta jamaicensis* in streptozotocin-induced diabetic rats. *Nigerian Journal of Pharmaceutical Sciences*, 14(1): 09 – 18.

Fadillioglu E, Kurcer Z, Parlakpinar H, Iraz M and Gursul C (2008). Melatonin treatment against remote open injury induced by renal ischemia reperfusion injury in diabetes mellitus. *Archives of Pharmacal Research*, 31(6): 705 – 712.

Fanta CH (1985). Clinical aspects of mucus and mucous plugging in asthma. *Journal of Asthma*, 22: 295 – 301.

Faraco G, Brea D, Garcia-Bonilla L, Wang G, Racchumi G, Chang H, Buendia I, Santisteban MM, Segarra SG, Koizumi K and Sugiyama Y (2018). Dietary salt promotes neurovascular and cognitive dysfunction through a gut-initiated TH17 response. *Nature Neuroscience*, 21(2): 240 – 249.

Farquhar WB, Edwards DG, Jurkowitz CT and Weintraub WS (2015). Dietary sodium and health: more than just blood pressure. *Journal of the American College of Cardiology*, 65(10): 1042 – 1050.

Fattal-Valevski A (2010). Thiamine (Vitamin B1). *Journal of Evidence-Based Complementary and Alternative Medicine*, 16(1): 12 – 20.

Field M (2003). Intestinal ion transport and the pathophysiology of diarrhea. *Journal of Clinical Investigations*, 111(7): 931 – 943.

Flemmig J and Arnhold J (2007). Ferrous ion-induced strand breaks in the DNA plasmid pBR322 are not mediated by hydrogen peroxide. *European Biophysics Journal*, 36: 377 – 384.

Flohé L and Günzler WA (1984). Assays of glutathione peroxidase. *Methods in Enzymology*, 105: 114 – 120.

Folin O and Ciocalteau V (1927). On tyrosine and tryptophane determination in proteins. *Journal of Biological Chemistry*, 27: 627 – 650.

Freitas M, Barcellos-de-Souza P, Barja-Fidalgo C and Fernandes E (2013). Nickel induces apoptosis in human neutrophils. *BioMetals*, 26: 13 – 21.

Friedewald WT, Levi RI and Fredrickson DS (1972). Estimation of the concentration of low density lipoproteins cholesterol in plasma without use of the ultracentrifuge. *Clinical Chemistry*, 18(6): 499 – 502.

Gaginella TS, Stewart JJ, Olsen WA and Bass P (1975). Action of recinoleic acid and structurally related fatty acid on the gastrointestinal tract. II. Effect on water and electrolyte absorption in-vitro. *Journal of Pharmacology and Experimental Therapeutic*, 195: 355 – 356.

Gasperi V, Sibilano M, Savini I and Catani MV (2019). Niacin in the Central Nervous System: An Update of Biological Aspects and Clinical Applications. *International Journal of Molecular Sciences*, 20(4): 974. doi:10.3390/ijms20040974

GBIF (2017). *Musanga cecropioides* Tedlie in Global Biodiversity Information Facility (GBIF) Backbone Taxonomy. Checklist Dataset. [Online] [Available at: <https://doi.org/10.15468/39omei>] [Accessed: 10/11/2017].

Ghasemzadeh A, Jaafar HZE and Rahmat A (2010). Antioxidant activities, total phenolics and flavonoids content in two varieties of Malaysia Young Ginger (*Zingiber officinale* Roscoe). *Molecules*, 15: 4324 – 4333.

Ghiselli A, Serafini M, Natella F and Scaccini C (2000). Total antioxidant capacity as a tool to assess redox status: critical view and experimental data. *Free Radical Biology and Medicine*, 29: 1106–1114.

Gibson GE, Hirsch JA, Fonzetti P, Jordan BD, Cirio RT and Elder J (2016). Vitamin B1 (thiamine) and dementia. *Annals of the New York Academy of Sciences*, 1367(1): 21 – 30.

Gill LS (1992). *Ethnomedicinal Uses of Plants in Nigeria*. UNIBEN Press, Benin City, Nigeria. 276p.

Giugliano D, Ceriello A and Paolisso G (1996). Oxidative stress and diabetic vascular complications. *Diabetes Care*, 19(3): 257 – 267.

Gröber U, Schmidt J and Kisters K (2015). Magnesium in Prevention and Therapy. *Nutrients*, 7: 8199 – 8226.

Gryglewski RJ, Korbut R and Robak J (1987). On the mechanism of antithrombotic action of flavonoids. *Biochemical Pharmacology*, 36: 317 – 321.

Gu D, Arnush M and Sarvetnic N (1997). Endocrine/exocrine intermediate cells in Streptozotocin treated Ins-IFN-gamma transgenic mice. *Pancreas*, 15(3): 246 – 250.

- Guo RF** and Ward PA (2007). Role of oxidants in lung injury during sepsis. *Antioxidant and Redox Signalling*, 9: 1991 – 2002.
- Guo T**, Wei JQ and Ma JP (2016). Antitussive and expectorant activities of *Potentilla anserine*. *Pharmaceutical Biology*, 54(5): 807 – 811.
- Gupta VK** and Sharma SK (2006). Plants as natural antioxidants. *Natural Products Radiance*, 5(4): 326 – 334.
- Habibuddin M**, Daghriri HA, Humaira T, Al-Qahtani MS and Hefzi AA (2008). Antidiabetic effect of alcoholic extract of *Caralluma sinaica* L. on streptozotocin-induced diabetic rabbits. *Journal of Ethnopharmacology*, 117(2): 215 – 220.
- Halliwell B** (2007). Biochemistry of oxidative stress. *Biochemical Society Transactions*, 35: 1147 – 1150.
- Han N**, Chang C, Wang Y, Huang T, Liu Z and Yin J (2010). The in vivo expectorant and antitussive activity of extract and fractions from *Reineckia carnea*. *Journal of Ethnopharmacology*, 131(1): 220 – 223.
- Harbone JB** (1973). *Phytochemical methods*. London: Chapman and Hall Ltd. 279p.
- Hayes J**, Flanagan J and Jowsey I (2005): Glutathione transferases. *Annual Review of Pharmacology and Toxicology*, 45: 51 – 88.
- Herxheimer A** (1987). Basic information that prescribers are not getting about drugs. *Lancet*, 329(8523): 31 – 33.

Hilary P (2003). Riboflavin (vitamin B2) health. *The American Journal of Clinical Nutrition*, 77: 1352 – 1360.

Hill MS (1997). *Understanding Environmental Pollution*. 3rd Edition. Cambridge University Press, Cambridge. 316p.

Ho YS, Xiong Y, Ma W, Spector A and Ho DS (2004): Mice lacking catalase develop normally but show differential sensitivity to oxidant tissue injury. *Journal of Biological Chemistry*, 279: 32804 – 32812.

Hoshino Y and Mishima M (2008). Antioxidants and redox signalling redox-based therapeutics for lung diseases. *Antioxidant and Redox Signalling*, 10: 701 – 704.

Howe A, Fung LH, Lalor G, Rattray R and Vutchkov M (2005). Elemental composition of Jamaican foods 1: A survey of five food crop categories. *Environmental Geochemistry and Health*, 27: 19 – 30.

Ibulubo MT, Eze GI, Ozolua RI, Baxter-Grillo D and Uwaya DO (2012). Evaluation of the protective and ameliorative properties of *Garcinia kola* on histamine-induced bronchoconstriction in guinea pigs. *Pharmacognosy Research*, 4: 203 – 207.

Idu M (2010). Phytomedicine in Nigeria-Past, Present and Future. 7th Professor James Ogonor Memorial lecture. Women's Health and Action Research Centre, Benin City, Nigeria, 67p.

Idu M (2011). *The Plant Called Medicine*. UNIBEN Press, Benin City, Edo State. 234p.

Idu M and Timothy O (2012). Plant extracts and biodiversity testing. In: Okhuoya, J. A., Okungbowa, F. I. and Shittu, H. O. (Eds). *Biological Techniques and Applications*, UNIBEN Press, Benin City, Nigeria. pp 157 – 179.

Idu M, Igbape GE and Erhabor J (2014). Anti-anaemic activity of *Jatropha tanjorensis* Ellis & Saroja in Rabbits. *Journal of Medicinal Plants Studies*, 2(1): 64 – 72.

Idu M, Obaruyi GO and Erhabor JO (2009). Ethnobotanical uses of plants among the Binis in the treatment of ophthalmic and ENT (Ear, Nose and Throat) ailments. *Ethnobotanical Leaflets*, 13: 480 – 496.

Idu M, Ovuakporie-Uvo O, Omoregie ES and Omosigho M (2018). Physicochemical properties, antioxidant activity and phyto-nutritional composition of cold and hot pressed coconut oils. *GSC Biological and Pharmaceutical Sciences*, 5(1): 56 – 66.

Ifemeje JC, Egbuna C, Eziokwudiaso JO and Ezebuo FC (2014). Determination of the Anti-nutrient Composition of *Ocimum gratissimum*, *Corchorus olitorius*, *Murraya koenigii* Spreng and *Cucurbita maxima*. *International Journal of Innovation and Scientific Research*, 3(2): 127 – 133.

Igile GO, Iwara IA, Mgbeje BI, Uboh FE and Ebong PE (2013). Phytochemical, Proximate and Nutrient composition of *Vernonia calvaona* Hook (Asteraceae): A Green-leafy vegetable in Nigeria. *Journal of Food Research*, 2(6): 111 – 122.

Irwin RS and Madison JM (2000). The diagnosis and treatment of cough. *The New England Journal of Medicine*, 343: 1715 – 1721.

Isaac UE (2012). Physicochemical and microbial studies of water obtained from *Musanga cecropioides* (African cork wood or umbrella or “Uno” tree). *World Applied Sciences Journal*, 19(2): 287 – 294.

Jain SK (1989). Hyperglycemia can cause membrane lipid peroxidation and osmotic fragility in human red blood cells. *The Journal of Biological Chemistry*, 264(35): 21340 – 21345.

Jaishankar M, Tseten T, Anbalagan N, Mathew BB and Beeregowda KN (2014). Toxicity, mechanism and health effects of some heavy metals. *Interdisciplinary Toxicology*, 7(2): 60 – 72.

James AL, Bai TR, Mauad T, Abramson MJ, Dolhnikoff M, McKay KO, Maxwell PS, Elliot JG and Green FH (2009). Airway smooth muscle thickness in asthma is related to severity but not duration of asthma. *European Respiratory Journal*, 34(5): 1040 – 1045.

Jendrassik L and Grof P (1938). Colorimetric method of determination of bilirubin. *Biochemische Zeitschrift*, 297: 81 – 82.

Kabel AM (2014). Free Radicals and Antioxidants: Role of Enzymes and Nutrition. *World Journal of Nutrition and Health*, 2(3): 35 – 38.

Kade IJ, Ogunbolude Y, Kamdem JP and Rocha JB (2013). Influence of gallic acid on oxidative stress-linked streptozotocin-induced pancreatic dysfunction in diabetic rats. *Journal of Basic and Clinical Physiology and Pharmacology*, 26: 1 – 11.

- Kadiri AB** and Ajayi GO (2009). Phyto-anatomical characteristics of the West African {umbrella tree} *Musanga cercropioides* M. Smithii R. Br. (Moraceae). *Indian Journal of Science and Technology*, 2(7): 1 – 5.
- Kamanyi A**, Bopelet M, Aloamaka CP, Obiefuna CPM and Ebeigbe AB (1991). Endothelium-dependent rat aortic relaxation to the aqueous leaf extract of *Musanga cecropioides*. *Journal of Ethnopharmacology*, 34: 283 – 286.
- Kamanyi A**, Bopelet M, Lontsi D and Noamesi BK (1996). Hypotensive effects of some extracts of the leaves of *Musanga cecropioides* (Cecropiaceae). Studies in the cat and the rat. *Phytomedicine*, 2(3): 209 – 212.
- Kang BPS**, Frencher S, Reddy V, Kessler A, Malhotra A and Meggs LG (2015). High glucose promotes mesangial cell apoptosis by oxidant-dependent mechanism. *American Journal of Physiology-Renal Physiology*, 284(3): F455 – F466.
- Keen CL** and Zidenberg-Cherr S (1994). Manganese Toxicity in Humans and Experimental Animals. In: Klimis-Tavantzis, D. J. (Ed). *Manganese in Health and Disease*, CRC Press, Boca Raton. pp. 193 – 205.
- Kennedy DO** (2016). B Vitamins and the Brain: Mechanisms, Dose and Efficacy—A Review. *Nutrients*, 8(2): 68. doi: [10.3390/nu8020068](https://doi.org/10.3390/nu8020068)
- Kitts DD**, Wijewickreme AN and Hu C (2000). Antioxidant properties of a North American ginseng extract. *Molecular and Cellular Biochemistry*, 203: 1 – 10.

Komlaga G, Agyare C, Dickson RA, Mensah MLK, Annan K, Loiseau PM and Champy P (2015). Medicinal plants and finished marketed herbal products used in the treatment of malaria in the Ashanti region, Ghana. *Journal of Ethnopharmacology*, 172: 333 – 346.

Korpas J and Tomori Z (1978). Cough and other respiratory reflexes. In: Karger, S. (Ed) *Progress in Respiratory Research*, Volume 12. Basel. 368p.

Krishnan R, Chandravada MV, Ramachander PR and Bharathkumar H (1983). Inter-relationships between growth and alkaloid production in *Catharanthus roseus* G. Don. *Herba Hungarica*, 22: 47 – 54.

Kuete V (2014). *Toxicological Survey of African Medicinal Plants*. 1st Edition. Elsevier Inc, London. 742p.

Kumar R, Arora R, Mahajan J, Mahey S and Arora S (2017). Polyphenols from cutch tree (*Acacia catechu* Willd.): normalize in vitro oxidative stress and exerts antiproliferative activity. *Brazilian Archives of Biology and Technology* 60: e17160728. Doi: <http://dx.doi.org/10.1590/1678-4324-2017160728>

Kumaran MS, Sivaselvi P, Brinda P and Vimala T (2014). Molecular docking studies of *Abelmoschus esculentus* for anti-diabetics and anti-inflammatory. *World Journal of Pharmaceutical Sciences*, 2(3): 253 – 258.

Kumarappan C and Mandal SC (2014). Polyphenol extract of *Ichnocarpus frutescens* leaves modifies hyperglycemia in dexamethasone (dex) treated rats. *Indian Journal of Physiology and Pharmacology*, 58(4): 441 – 445.

Langenheim JH (1994). Higher plant terpenoids: A phytocentric overview of their ecological roles. *Journal of Chemical Ecology*, 20: 1223 – 1280.

Larsen K (1972). Creatinine assay by reaction kinetic principle. *Clinica Chimica Acta* 41: 209 – 217.

Leba LJ, Brunschwig C, Saout M, Martial K, Vulcain E, Bereau D and Robinson JC (2014). Optimization of a DNA Nicking Assay to Evaluate *Oenocarpus bataua* and *Camellia sinensis* Antioxidant Capacity. *International Journal of Molecular Sciences*, 15: 18023 – 18039.

Lee JC, Kim HR, Kim J and Jang YS (2002). Antioxidant property of an ethanol extract of the stem of *Opuntia ficus-indica* var. saboten. *Journal of Agriculture and Food Chemistry*, 50: 6490 – 6496.

Lee SI, Kim JS, Oh SH, Park KY, Lee HG and Kim SD (2008). Antihyperglycemic effect of *Fomitopsis pinicola* extracts in streptozotocin-induced diabetic rats. *Journal of Medicinal Food*, 11(3): 518 – 524.

Legbosi NL and Ellis TR (2018). Sub-Chronic Toxicity of Hydromethanolic Stem Bark Extract of *Musanga cecropioides* (Urticaceae) in Rat. *EC Pharmacology and Toxicology*, 6(3): 76 – 95.

Lin BQ, Li PB, Wang YG, Peng W, Wu Z, Su WW and Ji H (2008). The expectorant activity of naringenin. *Pulmonary Pharmacology and Therapeutics*, 21: 259 – 263.

Lobo V, Patil A, Phatak A and Chandra N (2010). Free radicals, antioxidants and functional foods: Impact on human health. *Pharmacognosy Reviews*, 4(8): 118 – 126.

Lone AA, Ganai SA, Ahanger RA, Bhat HA, Bhat TA and Wani IA (2013). Free radicals and antioxidants: Myths, facts and mysteries. *African Journal of Pure and Applied Chemistry*, 7(3): 91 – 113.

Lontsi D, Sondengam BL and Martin MI (1998b). Cecropioic acid, a pentacyclic triterpene from *Musanga cecropioides*. *Phytochemistry*, 48(1): 171 – 174.

Lontsi D, Sondengam BL, Bodo B and Martin MT (1998a). Kalaic Acid, A New Ursane-Type Saponin from *Musanga cecropioides*. *Planta Medica Letters*, 64: 189 – 191.

Lontsi D, Sondengam BL, Martin MT and Bodo B (1991a). Musancropic acids A and B: a-ring contracted triterpenes from *Musanga cecropioides*. *Phytochemistry*, 30(7): 2361 – 2364.

Lontsi D, Sondengam BL, Martin MT and Bodo B (1991b). Seco-ring-a-triterpenoids from the rootwood of *Musanga cecropioides*. *Phytochemistry*, 30(5): 1621 – 1624.

Lontsi D, Sondengam BL, Martin MT and Bodo B (1992). Musangicic acid, a triterpenoid constituent of *Musanga cecropioides*. *Phytochemistry*, 31(12): 4285 – 4288.

Lorke D (1983). A New Approach to Tropical Acute Toxicity Testing. *Archives of Toxicology*, 53: 275 – 287.

Lorraine B and Katrin B (2006). Amino Acid Metabolism, β -Cell Function, and Diabetes. *Diabetes*, 55(2): 39 – 47.

Mabeku LBK, Roger KJ and Louis OEJ (2011). Screening of some plants used in the Cameroonian folk medicine for the treatment of infectious diseases. *International Journal of Biology*, 3(4): 13 – 21.

MacNee W (2001). Oxidative stress and lung inflammation in airways disease. *European Journal of Pharmacology*, 429: 195 – 207.

Magee PN and Swann PF (1969). Nitroso compounds. *British Medical Bulletin*, 25: 240 – 244.

Malekiyan R, Abdanipour A, Sohrabi D and Jafari AI (2019). Antioxidant and neuroprotective effects of lycopene and insulin in the hippocampus of streptozotocin-induced diabetic rats. *Biomedical Reports*, 10(1): 47 – 54.

Marques SS, Magalhães LM, Tóth IV and Segundo MA (2014). Insights on antioxidant assays for biological samples based on the reduction of copper complexes-the importance of analytical conditions. *International Journal of Molecular Sciences*, 15: 11387 – 11402.

Mazzone SB (2005). An overview of the sensory receptors regulating cough. *Cough*, 1: 11 – 19.

Melaku U, Clive EW and Habtamon F (2005). Content of zinc, Iron, Calcium and Their Absorption Inhibitors in Ethiopia. *Journal of Food Composition and Analysis*, 18: 803 – 817.

Mensah MLK, Komlaga G, Forkuo AD, Firempong C, Anning AK and Dickson RA (2019). Toxicity and Safety Implications of Herbal Medicines Used in Africa. In: Builders, P. F. (Ed) *Herbal Medicine*. [Online] [Available at: DOI: 10.5772/intechopen.72437] [Accessed: 15/01/2020]

Merzouk H, Madani S, Chabane SD, Prost J, Bouchenak M and Belleville J (2000). Time course of changes in serum glucose, insulin, lipids and tissue lipase activities in

macrosomic offspring of rats with Streptozotocin induced diabetes. *Clinical Science*, 98(1): 21 – 30.

Meyer C, Stumvoll M, Nadkarni V, Dostou J, Mitrakou A and Gerich J (1998). Abnormal renal and hepatic glucose metabolism in type 2 diabetes mellitus. *Journal of Clinical Investigation*, 102: 619 – 624.

Michael F (2011). Folate (vitamin B9) and Vitamin B12 and their function in the maintenance of nuclear and mitochondrial genome integrity. *Mutation Research*, 733: 21 – 33.

Misra HP and Fridovich I (1972). The role of superoxide anion in the autoxidation of epinephrine and a simple assay for superoxide dismutase. *Journal of Biological Chemistry*, 247(10): 3170 – 3175.

Moran-Palacio EF, Tortoledo-Ortiz O, Yañez-Farias GA, Zamora-Álvarez LA, Stephens-Camacho NA, Soñanez-Organis JG, Ochoa-López LM and Rosas-Rodríguez JA (2014). Determination of Amino Acids in Medicinal Plants from Southern Sonora, Mexico. *Tropical Journal of Pharmaceutical Research*, 13(4): 601 – 606.

Morrissey JP and Osbourn AE (1999). Fungal resistance to plant antibiotics as a mechanism of pathogenesis. *Microbiological and Molecular Biological Reviews*, 63: 708 – 724.

Nadig P and Laxmi S (2005). Study of anti-tussive activity of *Ocimum sanctum* Linn in guinea pigs. *Indian Journal of Physiology and Pharmacology*, 49: 243 – 245.

Najeeb U, Ahmad W, Zia MH, Malik Z and Zhou W (2017). Enhancing the lead phytostabilization in wetland plant *Juncus effusus* L. through somaclonal manipulation and EDTA enrichment. *Arabian Journal of Chemistry*, 10(2): 3310 – 3317.

Nasri H and Shirzad H (2013). Toxicity and safety of medicinal plants. *Journal of Herbmed Pharmacology*, 2(2): 21 – 22.

NIH (2002). *Public Health Service Policy on Humane Care and Use of Laboratory Animals*. National Institute of Health. Office of the laboratory animal welfare, USA. pp 1 – 19.

Nwosu CU, Hassan SW, Abubakar MG and Ebbo AA (2012). Anti-diarrhoeal and Toxicological Studies of Leaf Extracts of *Khaya senegalensis*. *Journal of Pharmacology and Toxicology*, 7(1): 1 – 10.

Nyblom H, Björnsson E, Simrén M, Aldenborg F, Almer S and Olsson R (2006). The AST/ALT ratio as an indicator of cirrhosis in patients with PBC. *Liver International*, 26(7): 840 – 845.

Nyunaï N, Yaya AJG, Tabi TGN, Tchamgoue AD, Ngondé MC and Minka CSM (2016). Anti-hyperglycemic and antioxidant potential of water-ethanol extract of *Musanga cecropioides* stem bark. *International Journal of Pharmaceutical Sciences and Drug Research*; 8(1): 43 – 49.

Odebiyi OO and Sofowora EA (1978). Phytochemical screening of Nigerian medicinal plants II. *Lloydia*, 41(3): 234 – 246.

- Oduola T**, Kakako SL, Tajudeen M, Aiyelabegan F, Olayinka OS and Isah LO (2018). Effect of intake of *Phyllanthus amarus* aqueous leaf extract on lipid peroxidation and some antioxidant factors in wistar rats. *Journal of Pharmacognosy and Phytochemistry*, 7(4): 2660 – 2666.
- Ohno T**, Horio F, Tanaka S, Terada M, Namikawa T and Kitch J (2000). Fatty liver and hyperlipidemia in IDDM (insulin dependent diabetes mellitus) of Streptozotocin treated shrews. *Life Sciences*, 66(2): 125 – 131.
- Ojiako AO** and Chikezie PC (2014). Comparative proximate composition and hypoglycemic properties of three medicinal plants (*Verononia amygdalina*, *Azadirachta indica* and *Moringa oleifera*). *Pharmacognosy Communication*, 4: 40 – 48.
- Okaka JC** and Okaka ANO (2001). *Food Composition, Spoilage and Shelf Life Extension*. Ocjarco Academic Publishers, Enugu, Nigeria. pp 54 – 56.
- Okechukwu PN**, Ekeuku SO, Sharma M, Nee CP, Chan HK, Mohamed N and Froemming GRA (2019). *In vivo* and *in vitro* antidiabetic and antioxidant activity of spirulina. *Pharmacognosy Magazine*, 15(1): 17 – 29.
- Okwu DE** and Okwu ME (2004). Chemical composition of *Spondias mombin* (Linn.) plant parts. *Journal of Sustainable Agriculture and Environment*, 6(2): 140 – 147.
- Olaniyan JM**, Muhammad HL, Makun HA, Busari MB and Abdullah AS (2016). Acute and sub-acute toxicity studies of aqueous and methanol extracts of *Nelsonia campestris* in rats. *Journal of Acute Disease*, 5(1): 62 – 70.

Omorieg ES and Osagie AU (2011). Effect of *Jatropha tanjorensis* leaves supplement on the activities of some antioxidant enzymes, vitamins and lipid peroxidation in rats. *Journal of Food Biochemistry*, 35(2): 409 – 424.

Omoruyi SI and Enogieru AB (2018). *Musanga cecropioides* (Cecropiaceae) Attenuates Carbon Tetrachloride-Induced Non-Alcoholic Fatty Liver Disease in Wistar Rats. *Tropical Journal of Natural Products Research*, 2(11): 482 – 488.

Ononamadu CJ, Alhassan AJ, Imam AA, Ibrahim A, Ihegboro GO, Owolarafe AT and Sule MS (2019). In vitro and in vivo anti-diabetic and anti-oxidant activities of methanolic leaf extracts of *Ocimum canum*. *Caspian Journal of Internal Medicine*, 10(2): 162 – 175.

Orwa C, Mutua A, Kindt R, Jamnadass R and Anthony S (2009). Agroforestry Database: A Tree Reference and Selection Guide Version 4.0 [Online] [Available at: <http://www.worldagroforestry.org/sites/treedbs/treedatabases.asp>] [Accessed: 10/01/2017]

Oshomoh EO, Idu M and Uwaya OD (2013). Acute and sub-acute toxicity of the aqueous extract of the stem of *Masularia acuminata* (G. Don) Bullock ex Hoyle on albino rats and mice. *Pharmacologia*, 4: 606 – 616.

Osman LM, McKenzie L, Cairns J, Friend JA, Godden DJ, Legge JS and Douglas JG (2001). Patient weighting of importance of asthma symptoms. *Thorax*, 56: 138 – 142.

Ovuakporie-Uvo O and Idu M (2016). Phytochemistry, anti-asthmatic and antioxidant activities of *Anchomanes difformis* (Blume) Engl. leaf extract. *Asian Pacific Journal of Tropical Biomedicine*, 6(3): 225 – 231.

- Ozolua RI**, Umuso DI, Uwaya DO, Modugu AA, Oghuvwu SO and Olomu JM (2016). Evaluation of the anti-asthmatic and antitussive effects of aqueous leaf extract of *Ocimum gratissimum* in rodents. *Medicinal and Aromatic Plants*, 5: 235. Doi:10.4172/21670412.1000235
- Pandey KB** and Rizvi SI (2011). Biomarkers of oxidative stress in red blood cells. *Biomedical Papers of the Medical Faculty of Palacky University in Olomouc*, 155(2): 131 – 136.
- Pandey M**, Debnath M, Gupta S and Chikara SK (2011). Phytomedicine: An ancient approach turning into future potential source of therapeutics. *Journal of Pharmacognosy and Phytotherapy*, 3(1): 113 – 117.
- Pari L** and Latha M (2004). Protective role of *Scoparia dulcis* plant extract on brain antioxidant status and lipid peroxidation in STZ diabetic male Wistar rats. *BMC Complementary and Alternative Medicine*, 4: 16. Doi:10.1186/1472—6882-4-16
- Parra M**, Stahl S and Hellmann H (2018). Vitamin B₆ and Its Role in Cell Metabolism and Physiology. *Cells*, 7(7): 84. Doi:10.3390/cells7070084
- Persijn JP** and van der Slik W (1976). A new method for the determination of gamma-glutamyl transferase in serum. *Journal of Clinical Chemistry and Biochemistry*, 14(9): 421 – 427.
- Pietta PG** (2000). Flavonoids as antioxidants. *Journal of Natural Products*, 63: 1035 – 1042.

Pinchuk I, Shoval H, Dotan Y and Lichtenberg D (2012). Evaluation of antioxidants: scope, limitations and relevance of assays. *Chemistry and Physics of Lipids*, 165: 638 – 647.

Piyachaturawat P, Poprasit J and Glinsukon T (1991). Gastric mucosal secretions and lesions by different doses of Streptozotocin in rats. *Toxicology Letters*, 55: 21 – 29.

Plantspedia (2017). *Musanga cecropioides* countries. [Online] [Available at [:http://plantspedia.wikia.com/wiki/File:Musanga_cecropioides_countries.png](http://plantspedia.wikia.com/wiki/File:Musanga_cecropioides_countries.png)] [Accessed: 02/03/2018].

Plummer DT (1978). *An Introduction to Practical Biochemistry*. 3rd Edition. McGraw – Hill Book Company, Maidenhead, Berkshire. 347p.

Polshettiwar SA and Ganjiwale RO (2007). Spectrophotometric estimation of total tannins in some ayurvedic eye drops. *Indian Journal of Pharmaceutical Sciences*, 69(4): 574 – 576.

Punithavathi VR, Anuthama R and Prince PS (2008). Combined treatment with naringin and vitamin C ameliorates streptozotocin-induced diabetes in male Wistar rats. *Journal of Applied Toxicology*, 28(6): 806 – 813.

Rahman MK, Barua S, Islam MF, Islam MR, Sayeed MA, Parvin MS and Islam ME (2013). Studies on the anti-diarrheal properties of leaf extract of *Desmodium puchellum*. *Asian Pacific Journal of Tropical Biomedicine*, 3(8): 639 – 643.

Raman A and Lau C (1996). Anti-diabetic properties and phytochemistry of *Momordica charantia* L. (Cucurbitaceae). *Phytomedicine*, 2(4): 349 – 362.

- Rao RVK**, Ali N and Reddy MN (1978). Occurrence of both sapogenins and alkaloid lycorine in *Curculigo orchoides*. *Indian Journal of Pharmaceutical Sciences*, 40: 104 - 105.
- Razak MA**, Begum PS, Viswanath B and Rajagopal S (2017). Multifarious Beneficial Effect of Nonessential Amino Acid, Glycine: A Review. *Oxidative Medicine and Cellular Longevity*, 2017: 1 – 7. Doi: <https://doi.org/10.1155/2017/1716701>
- Re R**, Pellegrini N, Proteggente A, Pannala A, Yang M and Rice-Evans C (1999). Antioxidant activity applying an improved ABTS radical cation decolorization assay. *Free Radical Biology and Medicine*, 26(10): 1231 – 1237.
- Reid HL** and Ugwu AC (1987). A simple technique of rapid determination of plasma viscosity. *Nigerian Journal of Physiology*, 3: 45 – 48.
- Reitman S** and Frankel S (1957). A colorimetric method for the determination of serum glutamic oxalacetic and glutamic – pyruvate transaminases. *American Journal of Clinical Pathology*, 28(1): 56 – 63.
- Rhoads MJ** and Wu G (2009). Glutamine, arginine, and leucine signaling in the intestine. *Amino Acids*, 37: 111 – 122.
- Rogers DF** (2007). Mucoactive agents for airway mucus hypersecretory diseases. *Respiratory Care*, 52: 1176 – 1193.
- Saha S**, Nosa'l'ova' G, Ghosh D, Flešková D, Capek P and Ray B (2011). Structural features and in vivo antitussive activity of the water extracted polymer from *Glycyrrhiza glabra*. *International Journal of Biological Macromolecules*, 48: 634 – 638.

Said HM and Ross C (2013). Riboflavin. *Modern Nutrition in Health and Diseases*, 11: 325 – 330.

Salami EO, Ozolua RI, Okpo SO, Eze GI and Uwaya DO (2013) Studies on the anti-asthmatic and antitussive properties of aqueous leaf extract of *Bryophyllum pinnatum* in rodent species. *Asian Pacific Journal of Tropical Medicine*, 6: 421 – 425.

Sarwar N, Gao P, Seshasai SR, Gobin R, Kaptoge S, Di Angelantonio E, Ingelsson E, Lawlor DA, Selvin E, Stampfer M, Stehouwer CD, Lewington S, Pennells L, Thompson A, Sattar N, White IR, Ray KK, Danesh J and Emerging Risk Factors Collaboration (2010) Diabetes mellitus, fasting blood glucose concentration, and risk of vascular disease: a collaborative meta-analysis of 102 prospective studies. *Lancet*, 26(375): 2215 – 2222.

Savithramma N, Rao ML and Suhrulatha D (2011). Screening of Medicinal Plants for Secondary Metabolites. *Middle-East Journal of Scientific Research*, 8(3): 579 – 584.

Saxena M, Saxena J, Nema R, Singh D and Gupta A (2013). Phytochemistry of Medicinal Plants. *Journal of Pharmacognosy and Phytochemistry*, 1(6): 168 – 182.

Schappert SM (1993). National ambulatory medical care survey: 1991: Summary. In: *Vital and Health Statistics*, Publication No. 230. US Department of Health and Human Services. pp 1 – 20.

Schiffer RB, Sunderman FW, Baggs RB and Moynihan JA (1991). The effects of exposure to dietary nickel and zinc upon humoral and cellular immunity in SJL mice. *Journal of Neuroimmunology*, 34(2-3): 229 – 239.

Schwalfenberg GK (2017). Vitamins K1 and K2: The Emerging Group of Vitamins Required for Human Health. *Journal of Nutrition and Metabolism*, 2017: 6254836. Doi:10.1155/2017/6254836

Schwarzova L, Hubacek JA and Vrablik M (2015). Genetic predisposition of human plasma triglyceride concentrations. *Physiological Research*, 64(3): 341 – 354.

Senjobi CT, Ettu AO and Gbile ZO (2012). Pharmacological screening of Nigerian species of *Musanga cecropioides* R. Br. Ex. Teddlie (Moraceae) in rodents as anti-hypertensive. *African Journal of Plant Science*, 6(8): 232 – 238.

Sepici-Dincel A, Açikgöz Ş, Çevik C, Sengelen M and Yeşilada E (2007). Effects of in vivo antioxidant enzyme activities of myrtle oil in normoglycaemic and alloxan diabetic rabbits. *Journal of Ethnopharmacology*, 110(3): 498 – 503.

Shah TZ, Ali AB, Jafri SA and Qazi MH (2013). Effect of Nicotinic Acid (Vitamin B3 or Niacin) on the lipid profile of diabetic and non-diabetic rats. *Pakistan Journal of Medical Sciences*, 29(5): 1259 – 1264.

Sharif HB, Mukhtar MD, Mustapha Y, Baba G and Lawal AO (2015). Acute and Subchronic Toxicity Profile of *Euphorbia pulcherrima* Methanol Extract on Wistar Albino Rats. *Advances in Pharmaceutics*, 2015: 1 – 9.

Sharma OP, Sharma S, Pattabhi V, Mahato SB and Sharma PDA (2007). Review of the hepatotoxic plant *Lantana camara*. *Critical Reviews in Toxicology*, 37: 313 – 352.

Sharma R, Yang Y, Sharma A, Awasthi S and Awasthi Y (2004). Antioxidant role of glutathione S-transferases: protection against oxidant toxicity and regulation of stress-mediated apoptosis. *Antioxidants and Redox Signalling*, 6(2): 289 – 300.

Shebis Y, Iluz D, Kinel-Tahan Y, Dubinsky Z and Yehoshua Y (2013). Natural Antioxidants: Function and Sources. *Food and Nutrition Sciences*, 4: 643 – 649.

Shemishere UB, Taiwo JE, Erhunse N and Omoregie ES (2018). Comparative Study on the Proximate Analysis and Nutritional Composition of *Musanga cecropioides* and *Maesobotrya barteri* leaves. *Journal of Applied Sciences and Environmental Management*, 22(2): 287 – 291.

Shenkin A (2006). Micronutrients in health and disease. *Postgraduate Medical Journal*, 82: 559 – 567.

Sheweita SA, Mashaly AA, Newairy HMA, and Eweda SM (2016). Changes in Oxidative Stress and Antioxidant Enzyme Activities in Streptozotocin-Induced Diabetes Mellitus in Rats: Role of *Alhagi maurorum* Extracts. *Oxidative Medicine and Cellular Longevity*, 2016: 1 – 8. Doi: <http://dx.doi.org/10.1155/2016/5264064>

Shin YS, Takeda K and Gelfand EW (2009). Understanding asthma using animal models. *Allergy, Asthma and Immunology Research*, 1: 10 – 18.

Shoba FG and Thomas M (2001). Study of antidiarrhoeal activity of four medicinal plants in castor-oil induced diarrhoea. *Journal of Ethnopharmacology*, 76(1): 73 – 76.

- Shola OB** and Olatunde OF (2015). Hyperglycaemic environment: contribution to the anaemia associated with diabetes mellitus in rats experimentally induced with alloxan. *Anaemia*, 2015: 1 – 6.
- Silva EM**, Souza JNS, Rogez H, Rees JF and Larondelle Y (2007). Antioxidant activities and polyphenolic contents of fifteen selected plant species from the Amazonian region. *Food Chemistry*, 101: 1012 – 1018.
- Sinbad OO**, Folorunsho AA, Olabisi OL, Ayoola OA and Temitope EJ (2019). Vitamins as Antioxidants. *Journal of Food Science and Nutrition Research*, 2: 214 – 235.
- Sindhi V**, Gupta V, Sharma K, Bhatnagar S, Kumari R and Dhaka N (2013). Potential applications of antioxidants – A review. *Journal of Pharmacy Research*, 7: 828 – 835.
- Sofowora A** (1993). *Medicinal Plants and Tradition Medicine in African*. 2nd Edition. Spectrum Books Ltd., Ibadan, Nigeria. 289p.
- Sofowora A**, Ogunbodede E and Onayade A (2013). The Role and Place of Medicinal Plants in the Strategies for Disease Prevention. *African Journal of Traditional, Complementary and Alternative Medicines*, 10(5): 210 – 229.
- Sowemimo A**, Okwuchuku E, Samuel FM, Ayoola O and Mutiat I (2015). *Musanga cecropioides* leaf extract exhibits anti-inflammatory and anti-nociceptive activities in animal models. *Revista Brasileira de Farmacognosia*, 25: 506 – 512.
- Srivastava A**, Srivastava P, Pandey A, Khanna VK and Pant AB (2019). Phytomedicine: A Potential Alternative Medicine in Controlling Neurological Disorders. In: *New Look to*

Phytomedicine Advancements in Herbal Products as Novel Drug Leads. Academic Press. pp 625 – 655.

Takechi M, Matsunami S, Nishizawa J, Uno C and Tanaka Y (1999). Haemolytic and antifungal activities of saponins or anti-ATPase and antiviral activities of cardiac glycosides. *Planta Medica*, 65: 585 – 586.

Tapas AR, Sakarkar DM and Kakde RB (2008). Flavonoids as Nutraceuticals: A Review. *Tropical Journal of Pharmaceutical Research*, 7: 1089 – 1099.

Taylor AJ and Vadgama P (1992). Analytical reviews in clinical Biochemistry: The estimation of urea. *Annals of Clinical Biochemistry*, 29: 245 – 264.

Tchounwou PB, Yedjou CG, Patlolla AK and Sutton DJ (2012). Heavy metal toxicity and the environment. *Experientia Supplementum*, 101: 133 – 164.

Tchouya RF and Nantia EA (2015). Phytochemical analysis, antioxidant evaluation and total phenolic content of the leaves and stem bark of *Musanga cecropioides* R.Br. Ex Tedlie (Cecropiaceae), growing in Gabon.. *Journal of Pharmacognosy and Phytochemistry*, 3(5): 192 – 195.

Teo S, Stirling D, Thomas S, Hoberman A, Kiorpes A, and Khetani V (2002). A 90-day oral gavage toxicity study of Dmethylphenidate and D, L- methylphenidate in Sprague Dawley rats. *Toxicology*, 179: 183 – 196.

Tietz NW (1990). *Clinical Guide to Laboratory Tests*. 2nd Edition. WB Saunders Company, Philadelphia, PA, USA. pp 554 – 556.

Tietze F (1969). Enzymic method for quantitative determination of nanogram amounts of total and oxidized glutathione. *Analytical Biochemistry*, 27: 502 – 522.

Tiwari AK (2001). Imbalance in antioxidant defence and human diseases: multiple approach of natural antioxidant therapy. *Current Science*, 81(9): 1179 – 1187.

Todou G and Meikeu-Kamdem MG (2011). *Musanga cecropioides* R.Br. Ex Tedlie. In: Lemmens, R.H.M.J., Louppe, D. and Oteng-Amoako, A. A. (Editors). *Prota* 7(2): Timbers/Bois D'œuvre 2. [CD-Rom]. PROTA, Wageningen, Netherlands.

Tom ENL, Nyunaï N, Djaouro KG, Medou FM, Nankia, FD and Dimo T (2018) Acute and Subacute Toxicity Evaluation of the Stem Bark Aqueous Extract of *Harungana madagascariensis* in Rodents. *Journal of Advanced Pharmaceutical Science and Technology*, 1(4): 1 – 12.

Traore F, Faure R, Ollivier E, Gasquet M, Azas N, Debrauwer L, Keita A, Timon-David P and Balansard G (2000). Structure and antiprotozoal activity of triterpenoid saponins from *Glinus oppositifolius*. *Planta Medica*, 66: 368 – 371.

Trease GE and Evans WC (2002). *Textbook of Pharmacognosy*. 15th Edition. WB Sanders Publishers, London, UK. 393p.

Trinder P (1969). A simple turbidimetric method for the determination of serum cholesterol. *Annals of Clinical Biochemistry: International Journal of Laboratory Medicine*, 6: 165 – 166.

Uddin SJ, Sjolpi JA, Alam SM, Alamgir M, Rahman MT and Sarker SD (2005). Antidiarrhoeal activity of the methanol extract of the barks of *Xylocarpus moluccensis* in

castor oil- and magnesium sulphate induced diarrhoea models in mice. *Journal of Ethnopharmacology*, 101: 139 – 143.

Ugochukwu SC, Arukwe UI and Onuoha I (2013). Preliminary phytochemical screening of different solvent extracts of stem bark and roots of *Dennetia tripetala* G. Baker. *Asian Journal of Plant Science and Research*, 3(3): 10 – 13.

Upston J, Kritharides L and Stocker R (2003). The role of Vitamin E in atherosclerosis. *Progress in Lipid Research*, 42: 405 – 422.

Usman N, Ozolua RI, Uwaya DO, Osagiede BE and Ugiagbe EE (2016). Acute and Sub-Acute Toxicological Evaluation of Aqueous Leaf Extract of *Nauclea latifolia* (Rubiaceae) in Albino Rats. *European Journal of Medicinal Plants*, 12(2): 1 – 10.

Uwah AF, Otitoju O, Ndem JI and Peter AI (2013). Chemical composition and antimicrobial activities of adventitious root sap of *Musanga cecropioides*. *Der Pharmacia Lettre*, 5: 13 – 16.

Valentine BA, Blue JT, Shelley SM and Cooper BJ (1990). Increased serum alanine amino transferase activity associated with muscle necrosis in the dog. *Journal of Veterinary Internal Medicine*, 4(3): 140 – 143.

Valko M, Leibfritz D, Moncol J, Cronin MTD, Mazur M and Telser J (2007). Free radicals and antioxidants in normal physiological functions and human disease. *The International Journal of Biochemistry and cell Biology*, 39: 44 – 84.

Valko M, Rhodes CJ, Moncol J, Izakovic M and Mazur M (2006). Free radicals, metals and antioxidants in oxidative stress-induced cancer. *Chemico-Biological Interactions*, 160: 1 – 40.

Van Andel T, Myren B and Van Onselen S (2012). Ghana's herbal market. *Journal of Ethnopharmacology*, 140(2): 368 – 378.

Varashree BS and Bhat PG (2011). Correlation of lipid peroxidation with glycated haemoglobin levels in diabetes mellitus. *Online Journal of Health and Allied Sciences*, 10(2): 2 – 5.

Varshney R and Kale RK (1990). Effects of calmodulin antagonists on radiation-induced lipid peroxidation in microsomes. *International Journal of Radiation Biology*, 58: 733 – 743.

Vázquez-Ortiz FA, Caire G, Higuera-Ciapara I and Hernández G (1995). High performance liquid chromatographic determination of free amino acids in shrimp. *Journal of Liquid Chromatography*, 18: 2059 – 2068.

Venkatesan N, Thiyagarajan V, Narayanan S, Arul A, Raja S, Kumar SGV, Rajarajan T and Perianayagam JB (2005). Anti-diarrhoeal potential of *Asparagus racemosus* wild root extracts in laboratory animals. *Journal of Pharmacy and Pharmaceutical Sciences*, 8(1): 39 – 46.

Wang D, Zhu J, Wang S, Wang X, Ou Y, Wei D and Li X (2011). Antitussive, expectorant and anti-inflammatory alkaloids from *Bulbus Fritillariae Cirrhosae*. *Fitoterapia* 82: 1290 – 1294.

Wang W, Qiao S and Li D (2009). Amino acids and gut function. *Amino Acids*, 37: 105 – 110.

Weaver CM (2013). Potassium and Health 1–3. American Society for Nutrition. *Advances in Nutrition*, 4: 368S–377S,

WHO (1977). *Resolution, Promotion and Development of Training and Research in Traditional Medicine*. WHO Press, Geneva. pp 30 – 49.

WHO (2004). *World Health Report*. WHO Press, Geneva. pp 120 – 125.

WHO (2007). *The World Health Report: A Safer Future: Global Public Health Security in the 21st Century*. WHO Press, Geneva. 96 P.

WHO (2010a). Recommendations on the Management of Diarrhoea and Pneumonia in HIV-Infected Infants and Children: Integrated Management of Childhood Illness (IMCI). Geneva: World Health Organization. [Online] [Available at: <https://www.ncbi.nlm.nih.gov/books/NBK305341/>] [Accessed: 20/01/2020]

WHO (2010b). *The WHO Recommended Classification of Pesticides by Hazard, and Guidelines to Classification*. WHO Press, Geneva. pp 1 – 81.

WHO (2017). Diarrhoea Disease. [Online] [Available at: <http://www.who.int/en/news-room/fact-sheets/detail/diarrhoeal-disease>] [Accessed: 17/04/2018].

WHO (2018a). Diabetes fact sheet. [Online] [Available at: <https://www.who.int/news-room/fact-sheets/detail/diabetes>] [Accessed: 20/01/2020]

WHO (2018b). Global Health Estimates 2016: Disease burden by Cause, Age, Sex, by Country and by Region, 2000-2016. Geneva, World Health Organization. [Online] [Available at: https://www.who.int/healthinfo/global_burden_disease/estimates/en/index1.html] [Accessed: 20/01/2020]

Wu G (2009). Amino acids: metabolism, functions, and nutrition. *Amino Acids*, 37: 1 – 17.

Wu LC, Hsu HW, Chen YC, Chiu CC, Lin YI and Ho JA (2006). Antioxidant and anti-proliferative activities of red pitaya. *Food Chemistry*, 95: 319 – 327.

Wu Y, Jian T, Lv H, Ding X, Zuoa Y, Rena B, Chena J and Li W (2018). Antitussive and expectorant properties of growing and fallen leaves of loquat (*Eriobotrya japonica*). *Revista Brasileira de Farmacognosia*, 28: 239 – 242.

Yakubu MI, Abbas MY, Chindo BA and Anuka JA (2018). Toxicity Screening of Ethanol Extract of *Cussonia barteri* Leaf seeman (Araliaceae) in Wistar Rats. *Nigerian Journal of Pharmaceutical and Biomedical Research*, 3(2): 147 – 153.

Yin P, Zhao S, Chen S, Liu J, Shi L, Wang X, Liu Y and Ma C (2011). Hypoglycemic and hypolipidemic effects of polyphenols from burs of *Castanea mollissima* blume. *Molecules*, 16(11): 9764 – 9774.

Yu L, Haley S, Perret J, Harris M, Wilson J and Qian M (2002). Free radical scavenging properties of wheat extracts. *Journal of Agriculture and Food Chemistry*, 50: 1619 – 1624.

Zafar M and Naqvi SN (2010). Effects of STZ-Induced diabetes on the relative weights of kidney, liver and pancreas in albino rats: a comparative study. *International Journal of Morphology*, 28(1): 135 – 142.

Zelko I, Mariani T and Folz R (2002). Superoxide dismutase multigene family: a comparison of the CuZn-SOD (SOD1), MnSOD (SOD2), and EC-SOD (SOD3) gene structures, evolution, and expression. *Free Radical Biology and Medicine*, 33(3): 337 – 349.

Zempleni J, Wijeratne SS and Hassan YI (2009). Biotin. *BioFactors*, 35(1): 36 – 46.

Zhang T and Zhou X (2014). Clinical application of expectorant therapy in chronic inflammatory airway diseases (Review). *Experimental and Therapeutic Medicine*, 7: 763 – 767.