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Review Article

Effect of *Moringa olifera* on Haematology and Cholesterol Level

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Abstract

Moringa oleifera is a fast growing well-known cultivated species of plant belonging to the family Moringaceae, genus *Moringa*, common name of *Moringa oleifera* (MO) is (also known as "drumstick") horseradish and ben oil tree. *Moringa* products have a wide range of applications in agricultural, nutritional, industrial and pharmaceutical processes. Moringa leaves have a relatively high crude protein content which varies from 25% to 32%. A high proportion of this protein ,amino acids is potentially available for digestion due to a high proportion of pepsin soluble nitrogen (82-91 %) and low proportion (1-2%) of acid detergent insoluble protein. chemical composition was evaluated in Moringa Leaves then Five iso-nitrogenous and iso-caloric experimental broiler diets were formulated as MOL0%, MOL5%, MOL10%, MOL15% and MOL20%, chemical analysis of lipid profile(triglycerides, total cholesterol, HDL, LDL and vLDL), and haematological analysis(Hb, RBC, PCV, MCV, MCHC, Plt, MPV, PCT, PDW, WBC, LYM) were recorded. There was a high correlation between body weight and some blood parameters of the broiler chicken. Age and body weight effect on blood parameters PCV, WBC, RBC, Hb, MCV and MCH. Decrease in the triglycerides level, plasma cholesterol, blood glucose, platelets count, plasma proteins and albumin. There was a significant increase in the body weight. White blood cells (WBCs) and packed cell volume (PCV) increased significantly, but the changes in Red blood cells (RBCs), hemoglobin level. The seed extracts of moringa are rich in polyunsaturated fatty acid. *M. oleifera* is an antibiotic that can improve the performance and health status, blood chemistry, increase cholesterol level (HDL, and decrease LDL, VLDL) of chickens.

Key words: *Moringa oleifera*, *Moringa* seeds, *Moringa* Leaves, blood haematology, serum biochemistry.

INTRODUCTION

Moringa oleifera is a fast growing well-known cultivated species of plant belonging to the family Moringaceae, genus Moringa. The common name of *Moringa oleifera* (MO) is (also known as "drumstick") horseradish and ben oil tree, originally native from the Himalayans but currently cultivated in many tropical and subtropical regions around the world [1]. *M. oleifera* tree is native to South Asia, especially India, Sri Lanka, Pakistan, Bangladesh, Afghanistan; North Eastern and South Western Africa, Madagascar, and Arabia.

M. oleifera has the capability to survive in humid or dry hot climates and poor soils [2]. *M. oleifera* is a highly nutritious plant, being ideal to treat malnutrition in developing countries [3]. *M. oleifera* gained the title of "Miracle Tree" and commercial attention such as nutritional values, amino acids and flavones content which can be used in food supplements and cosmetic industry [4].

Different parts of MO such as leaves, fruits, flowers, roots, bark, pods, seed oil and roots have been used as food and in traditional medicine [5]. Leaves, is the most commonly used part, contain many nutrients including beta-carotene; vitamins B, C, and E; minerals (calcium, iron, potassium, magnesium, etc.); essential and non-essential amino acids; and carbohydrates, among others [6]. MO has been used in traditional medicine for the treatment of various conditions and, more recently, has been proposed to be of benefit in numerous diseases including cardiovascular, diabetes, cancer, neurological, gastroenterological, and inflammatory hematological and hepatorenal disorders [7]. Vast amounts of compounds present in the different parts of the tree. For instance, phytochemicals derived from the seeds of MO including glycosidic glucosinolates (GLSs), isothiocyanates (ITCs), nitriles,

carbamates, and thiocarbamates, have shown anti-inflammatory, antioxidant, hypotensive, antibacterial, and chemopreventive properties [8].

Moringa leaves are excellent food source that are high in flavonoids and triterpenoids. Flavonoids and triterpenoids are very effective in reducing blood glucose levels and regulate lipogenesis in liver [9]. It is also high in vitamin C. *Moringa* leaves juice control blood glucose and cholesterol level. Moringa is drought-tolerant and grows at a rainfall of 250-1500 mm per year [10]. Rich in nutrients such as protein and minerals, *Moringa* is one of those plants that have not been studied for many years but now is being investigated for its fast growth, higher nutritional value, and increasing utilization as a livestock fodder crop [11]. *Moringa oleifera* can be used as a source of micronutrient and as a dietary supplement in poultry [12]. *Moringa* has been used in folk medicine to control blood pressure and glucose levels.

Moringa oleifera leaf powder has anti-septic and detergent properties due to presence of different phytochemicals in the leaves [13]. The seed extracts of moringa are rich in polyunsaturated fatty acid. *M. oleifera* is an antibiotic that can improve the performance and health status, blood chemistry, increase cholesterol level (HDL, and decrease LDL, VLDL) of chickens [14]. Increased in RBC and WBC counts, as well as an increase in PCV, Hb, in broiler chickens. This study aimed to evaluate the effect of *Moringa olifera* in the blood glucose, serum lipids, hemoglobin, hematologic values of blood cells, and the possible organ toxicity of this plant [14]. *Moringa* was used as an anti-microbial agent. It is well known for its pharmacological action too and is used for the traditional treatment of diabetes mellitus, cancer, ulcer, anti Cholestrolic, hepatotoxicity, Rheumatism, venomous bites, and also for cardiac stimulation [12]. This plant is richer than milk in calcium, stores more dietary iron than spinach, and outweighs carrots in βeta carotene content.

(a)Moringa oleifera flowers (b) Moringa oleifera leaves (c) Moringa oleifera fruits (d) Moringa oleifera seeds (e) Moringa oleifera powder [15]

M. Olifera Composition

MO Fruit, Seed, and Oil: MO seeds are about 1.0-1.5 cm (long) and 2.0 cm (broad). Close to 40% oil content, among which are present a high amount of fatty acids, including oleic acid (considered a cholesterol lowering agent), tocopherols, and sterols, among others. Fruits and seeds contain GLSs, ITCs, nitriles, carbamates, and thiocarbamates, which may confer other potential uses including anti-inflammatory, antihypertensive, antifungal, antiseptic, and due to its high vitamin C content, useful for scurvy prevention [16].

Leaves: The leaves are green in color have high protein content (total protein content 24.8–35.3 g/100 g) together with high levels of calcium, phosphorus, iron, and manganese. [20]Leaves are rich in several bioactive compounds including beta-carotene, vitamins (B, C, and E), polyphenols, phenolic acids, alkaloids, GLSs, ITCs, tannins, saponins, oxalates, phytates, and antioxidants [21, 22]. Moringa leaves composed of five chemical constituents were identified in methanolic leaves extract and they are oleic acid (84%), ascorbic acid- 2, 6-dihexadecanoate (9.80%), 9-octadecenoic acid (1.88%), methyl ester-hexadecanoic acid (1.31%) and 9-octadecenamide (0.78%).

Roots and Barks: Potassium, sodium, magnesium, phosphorus and calcium were the most abundant macronutrients in Moringa roots and barks powder solutions. Low levels of zinc, iron and copper were also detected, the highest concentration (600 mg/L), and higher initial E. coli concentration (50 MPN/100 mL) [23]. Bark and roots has proved to serve as an antiulcer agent, together with antisecretory and cytoprotective activity. Contain high levels of carbohydrates, sodium, arginine, lysine, and ascorbic acid (but they lack thiamine, riboflavin, and pyridoxine) [24].

Table-01: The nutrient compositions of leaves, leaf powder, seeds and pods [17-19]

Nutrients	Fresh leaves	Dry leaves	Leaf powder	Seed	Pods
Calories (cal)	92	329	205	–	26
Protein (g)	6.7	29.4	27.1	35.97 ± 0.19	2.5
Fat (g)	1.7	5.2	2.3	38.67 ± 0.03	0.1
Carbohydrate (g)	12.5	41.2	38.2	8.67 ± 0.12	3.7
Fibre (g)	0.9	12.5	19.2	2.87 ± 0.03	4.8
Vitamin B1 (mg)	0.06	2.02	2.64	0.05	0.05
Vitamin B2 (mg)	0.05	21.3	20.5	0.06	0.07
Vitamin B3 (mg)	0.8	7.6	8.2	0.2	0.2
Vitamin C (mg)	220	15.8	17.3	4.5 ± 0.17	120
Vitamin E (mg)	448	10.8	113	751.67 ± 4.41	–
Calcium (mg)	440	2185	2003	45	30
Magnesium (mg)	42	448	368	635 ± 8.66	24
Phosphorus (mg)	70	252	204	75	110
Potassium (mg)	259	1236	1324	–	259
Copper (mg)	0.07	0.49	0.57	5.20 ± 0.15	3.1
Iron (mg)	0.85	25.6	28.2	–	5.3
Sulphur (mg)	–	–	870	0.05	137
Isolucine(g/16gn)	4.4	6.3	0.83	-	4.4

Table-02: The Amino acid composition of the dried leaves of Moringa [25]

Amino acid	Composition mg/100g	Amino acid	Composition mg/100g
Threonine	48.35	phenylalanine	3.42
Lysine	69.13	valine	62.34
Leucine	94.36	Methionine	0.43
Isoleucine	46.98	Tryptophan	0.486
Histidine	29.56	Tyrosine	2.03
proline	1.87	Aspartate acid	13.76
glycine	2.31	Alanine	4.93
glutamate acid	18.03	cysteine	2.15

Table-03: Nutritional composition and medicinal uses of different parts of Moringa

Part of tree	Medicine use	Nutritive properties	References
Leaves	Moringa leaves treat asthma, hyperglycemia, Dyslipidemia, flu, heart burn, syphilis, malaria, pneumonia, diarrhea, headaches, scurvy, skin diseases, bronchitis, eye and ear infections. Also reduces, blood pressure and cholesterol and acts as an anticancer, antimicrobial, Antioxidant, antidiabetic and anti-atherosclerotic agents, neuroprotecta	Moringa leaves contain fiber, fat proteins and minerals like Ca, Mg, P, K, Cu, Fe, and S. Vitamins like Vitamin-A (Beta-carotene), vitamin B-choline, vitamin B1-thiamine, riboflavin, nicotinic acid and ascorbic acid are present. Various amino acids like Arg, His, Lys, Trp, Phe, Thr, Leu, Met, Ile, Val are present. Phytochemicals like tannins, sterols, saponins, trepenoids, phenolics, alkaloids and flavanoids like quercitin, isoquercitin, kaemfericitin, isothiocyanates and glycoside compounds are present	[29,30,31, 32, 33]
seeds	Seeds of moringa help in treating hyperthyroidism, Chrohn's disease, antiherpes-simplex virus arthritis, rheumatism, gout, cramp, epilepsy and sexually transmitted diseases, can act as antimicrobial and anti-inflammatory agents	Contains oleic acid (Ben oil), antibiotic called pterygospermin, and fatty acids like Linoleic acid, linolenic acid, behenic acid, Phytochemicals like tannins, saponin, phenolics, phytate, flavanoids, terpenoids and lectins. Apart from these, fats, fiber, proteins, minerals, vitamins like A, B, C and amino acids	[29,30,38, 39, 40]
Root bark	Root bark acts as a cardiac stimulant, anti-ulcer and anti-inflammatory agent	Alkaloids like morphine, moriginine, minerals like calcium, magnesium and sodium	[34,35]
Flower	Moringa flowers act as hypocholesterolemic, anti-arthritic agents can cure urinary problems and cold	It contains calcium and potassium and amino acids. They also contain nectar	[31,37]
pods	Moringa pods treat diarrhea, liver and spleen problems, and joint pain	Rich in fiber, lipids, non-structural carbohydrates, protein and ash. Fatty acids like oleic acid, linoleic acid, palmitic acid and linolenic acid are also present	[31]

Health benefit of moringa olifera

Medicinal properties

M. oleifera is often referred as a panacea and can be used to cure more than 300 diseases. Moringa has long been used in herbal medicine by Indians and Africans. The presence of phytochemicals makes it a good medicinal agent.

Anti-diabetic properties

Moringa has been shown to cure both Type 1 and Type 2 diabetes. Beta cell dysfunction, which fails to sense glucose levels, hence reduces the signaling to insulin, resulting in high blood glucose levels [26]. Moringa can act as an anti-diabetic agent reduces insulin secretion leading to hyperglycemia and in turn diabetes mellitus Type-2. STZ induced diabetes rats with Moringa seed powder and noticed that the fasting blood glucose level [27]. The high glucose in blood enters glycolysis in the mitochondria of beta cells and forms reactive oxygen species, causes apoptosis of beta cells which in turn leads to decreased insulin secretion, hyperglycemia and finally Type-2 diabetes. The cell apoptosis of beta cells can be averted by the use of moringa. Moringa has antioxidants which combine with the reactive oxygen species and prevent cell damage and further consequences [26, 28].

Anticancer properties

M. oleifera can be used as an anticancer agent as it is natural, reliable and safe, at established concentrations. *Moringa* can be used as an anti-neoproliferative agent, thereby inhibiting the growth of cancer cells. Soluble and solvent extracts of leaves have been proven effective as anticancer agents. The ROS production by moringa is specific and targets only cancer cells, making it an ideal anticancer agent. Anticancer agents targeting cancer using ROS induction are common, but these substances should also be able to attack the antioxidant enzymes, and the anticancer activities are glucosinolates, niazimicin and benzyl isothiocyanate Benzyl isothiocyanate has been shown to be linked with cancer. Research shows that BITC causes intracellular ROS, which leads to cell death. This could be one of the reasons for moringa to be a good anticancer agent.

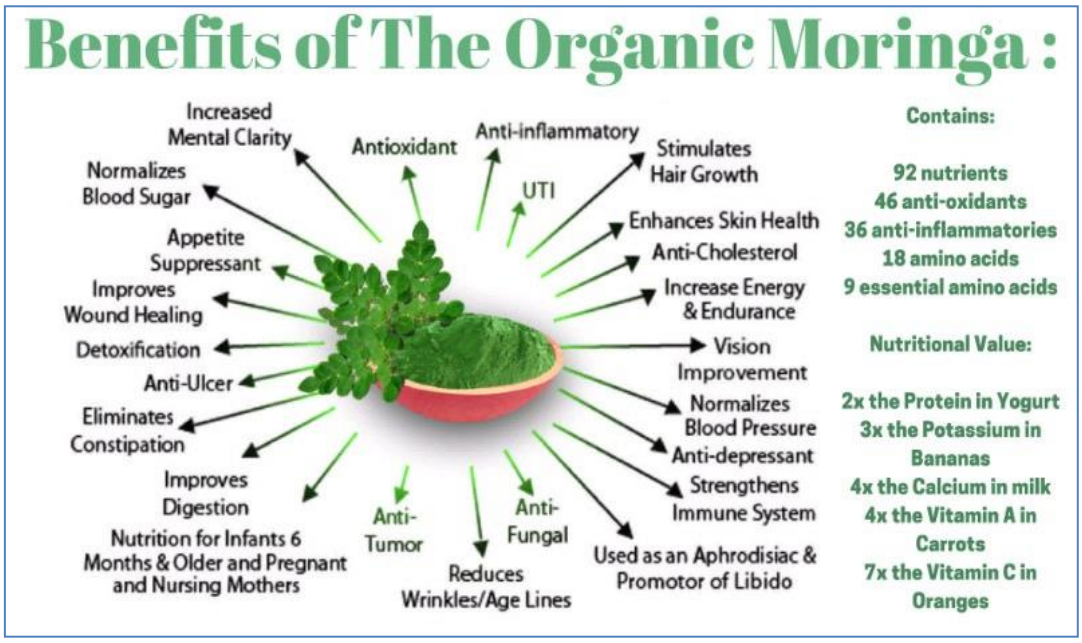

Fig-2: Health befits of *moringa olifera*[37]

Haematological properties

Moringa leaves extracts increased the level of hemoglobin, red blood cell count, hematocrit, and total iron content in blood. *M. oleifera* fruit powder affects in significant reduction in plasma fluoride level and increase in Hb%, PCV, TLC and altered DC and neutrophil count was significantly lower due to moringa olifera leave extract. Haematology has been defined as the study of blood and it plays an important role in pathology as well as in disease diagnostic process. Haematology includes not only the examination of the cellular and fluid portions of blood, but also the study of tissues that form, store and circulate blood cells [45]. The serum is the plasma component of blood which lacks coagulation factors. serum include proteins, which assist with maintaining pH and osmotic balance while giving viscosity to the blood; antibodies, or specialized proteins that are important for defense against viruses and bacteria; lipids, including cholesterol.

Impact of Moringa powders on the blood glucose and cholesterol level

Moringa oleifera leaf powder and seeds powder showed a reduction in fasting blood glucose which was significantly at one per cent level. Moringa oleifera leaves powder also showed to bring about the

hypocholesteromic effect through increased excretion of bile acids and the neutral steroids. Blood lipid and serum levels of Cholesterol, Triglyceride, LDL cholesterol and HDL cholesterol reduced significantly blood cholesterol and triglyceride are the major risk factors for heart diseases. Cholesterol fraction normally low- density lipoprotein (LDL-C) is the most important though not the causative agent. LDL cholesterol, from which is a strong atherogen [42].

Antioxidant and Hepatoprotective Effects

Polyphenols have strong antioxidant properties and can decrease oxidative damage in tissues by scavenging free radical. *M. olifera* leaves contains chlorogenic acid, rutin, quercetin glucoside, and kaempferol rhamnoglucoside, whereas in the root and stem barks, several procyanidin peaks are detected [43]. The *Moringa* genus has high antioxidant activity mainly due to its high content of bioactive polyphenols. Restore glutathione (GSH) level and prevent lipid peroxidation in liver [44]. This protective effect may be related to a variety of phytochemicals such as ascorbic acid and phenols (catechin, epicatechin, ferulic acid, ellagic acid, and myricetin) through scavenging radiation-induced free radicals. Cadmium -induced hepatotoxicity of the rats through suppressing the elevated alkaline phosphatase (ALP), glutamic oxaloacetic transaminase (aspartate aminotransferase, AST), glutamic pyruvic transaminase (alanine aminotransferase, ALT), and LPO levels and increasing superoxide dismutase (SOD) level. *M.oleifera* extract also reveals a significant protective action to the liver damage induced by anti-tubercular drug such as isoniazid (INH), rifampicin (RMP), or pyrazinamide (PZA), as evidenced by the recovered AST, ALT, ALP, and bilirubin levels in serum, as well as the reduced lipid peroxidation in liver [45] *M. oleifera* leaves can also effectively reduce high-fat-diet (HFD)-induced liver damage of mice.

Neuroprotective Effect

M. oleifera has been shown to stimulate neuronal outgrowth observed to increase the number and length of dendrites and axonal branches, the length of axons, and eventually facilitate synaptogenesis mechanically, it can also decrease Malondialdehyde (MDA) levels and acetyl cholinesterase (Ache) activity, but can increase SOD and catalase (CAT) activity [67]. Aluminum chloride-induced temporal cortical degeneration protected against aluminum chloride-induced neurotoxicity of the temporal cortex of rats by decreasing the expression of neuron specific enolase (NSE) and glial fibrillary acidic protein [68].

Table-04: Effect of Moringa oleifera on biochemical indices

Plant	Age	Research model	Results / Findings	Reference
Moringa oleifera pods	21-30 day old	Diabetic albino rats	Increased antioxidant levels in pancreatic tissue, with concomitant decreases in levels of thiobarbituric acid. degenerative changes in b-cells	[45]
M. oleifera fresh leaves powder	7-12 weeks old	Broiler chickens (*Gallus gallus domesticus*)	PCV, Hb, MVC and MCH values increased, while WBC and RBC values decreased with age. Age and body weight effect on the haematological parameters were observed for PCV, WBC, RBC, Hb, MCV and MCH for the duration of the study, age increased decreased the effect.	[46]
leaves of Moringa oleifera Lam (Moringaceae)	40-50 years old peoples	Obese people with type II diabetes	M. oleifera decreased the HDL levels. Lowering of blood glucose, heart weight, and body weight. Improvement in lipid profile along with marker enzymes in serum and heart homogenate. Moringa oleifera was found to increase the excretion of faecal cholesterol, possesses a hypolipidaemic effect and decreased the levels of thiobarbituric acid reactive substances and improved antioxidant status by increasing the activities of antioxidant enzymes.	[47,48]
Fresh Moringa leaves (FML)	Two hundred (200) days-old	Broiler Chickens	Adverse effects on the haematological , serum biochemical profile , and high values of haemoglobin, red blood cells, packed cell volume,albumin and total protein were obtained, beyond the 15% level of inclusion of MOLM,	[49]
Moringa oleifera Leaf Meal (MOLM)		Growing Rabbits	Decrease number of WBC, indication of allergic conditions, anaphylactic shock and certain parasitism, hypocholestrolemic agent ,while elevated values (leucocytosis) indicates the existence of infection, usually with bacteria. Reduction in serum and cholesterol level of rabbit.	[50,51]
Moringa oleifera leaves powder +high fat diet.	5 weeks of age	Mice	High fat diet might alter the haematological parameters.RBC tend to increased concentration of HB (hemoglobin) and HCT (haematocrit) *slightly decreased of WBC, decreased the granulocyte percentage,*were tended to	[52,53]

Plant	Age	Research model	Results / Findings	Reference
			decrease obesity as a low grade inflammation that tends to come up with iron-deficiency anemia.	
Moringa oleifera leaf/ seed powder + soya been oil	5-8 weeks of age	Broiler chicks	Higher pH and Lower number of RBCs, WBCs, PVC, and lymphocytes higher glutathione peroxidase in plasma and low cholesterol level. No deleterious effects on normal physiology and growth of broiler chicks.	[54,55]

Table-05: Effect of moringa olifera on cholesterol level

Plant	Age	Research model	Results / Findings	Reference
Moringa oleifera leaf meal (MOLM)	6-7 month old	Broiler chicken	Increased serum HDL and decreased serum LDL, cholesterol, triglycerides, reduced the serum lipid level and thigh, breast muscle. High serum cholesterol and consequently a higher risk of arteriosclerosis and coronary heart disease in humans.	[56]
Moringa Leaves Juice	25-60 years old	Adults male& female	Decreased blood glucose level and total cholesterol, no serious metabolic disease, no infection, no chronic disease, and able to consume moringa leaves juice Fasting blood glucose levels. Flavonoids and triterpenoids are effective in reducing blood glucose levels and regulate lipogenesis in liver.	[57,58]
Moringa oleifera leaves, pods Polyphenols	45 Days old	Male Wister rats	Inhibiting HMG CoA reductase activity and faecal bile acid binding increase in biliary cholesterol level and increase body weight. Increased HDL level, decreases LDL level due to highly fat diet effect.	[59]
Kelor (Moringa oleifera) seed meal		Broiler chickens	In present study, the broiler chickens fed the diets supplemented with 6 and 8% kelor seed meal had bigger breasts, increased body weight, increased growth, increased HDL decresed VLDL level, in the bone development, decreased pH of the digestive tract, decrease cholesterol concentration.	[61,62]
Moringa oleifera leaves , dried flowering powder	12 weeks old	German shepherd dogs	Improving immune diseases such as rheumatoid arthritis, erythematosus (SLE), and psoriasis reduced blood cholesterol and lipid peroxidation. Increase in antibody titer against parvovirus in vaccinated dogs and has a promising effect as an immune boosting agent.	[60]
Moringa oleifera seed powder, pestles,	40-45 days old	Albino rats	Decrease in the triglycerides level, plasma cholesterol, increases the HDL blood glucose, platelets count, plasma proteins and albumin. White blood cells (WBCs) and packed cell volume (PCV) increased changes in Red blood cells (RBCs), hemoglobin level, blood urea and creatinin. Effect of Moringa on plasma protein and albumin. Inhibit apoprotein β synthesis in intestine mucosa, cholesterol esterification, and intestinal lipoprotein production.	[63,64]
Moringa oleifera leave meal (MOLM)	30 weeks old	Hens	Reduction of the intestinal microflora, as the decrease in the number of white blood cells and lymphocytes and improved albumin levels. Decrease in RBC did not affect the productivity. Egg production increase. Low concentration of Hb and RBC and PCV decreased with increasing level of MOLM in diet cholesterol decreased HDL and LDL level.	[65,66]

CONCLUSION

Moringa oleifera (MO) is (also known as "drumstick") horseradish and ben oil is a fast growingplant. *Moringa* products have a wide range of applications in agricultural, industrial and pharmaceutical processes. Parts of MO such as leaves, fruits, flowers, roots, bark, pods, seed oil and roots have been used as food and in traditional medicine.Moringa olifera haveAnti-diabetic properties, anticeptic, anticancer properties, haematological properties, antioxidant and Hepatoprotective effect, hypocholestrolmic effect. MOLM in the broiler diet, high values of haemoglobin, red blood cells, packed cell volume serum albumin and total protein were obtained haematological and serum biochemical indices were reduced, thus implying the maximized effects on the

haematological and serum biochemical profile.Age and body weight effect on blood parameters PCV, WBC, RBC, Hb, MCV and MCH.Decrease in the triglycerides level, plasma cholesterol, (HDL, LDL, VLDL), blood glucose, platelets count, plasma proteins and albumin. There was a significant increase in the body weight. White blood cells (WBCs) and packed cell volume (PCV) increased significantly, but the changes in Red blood cells (RBCs), haemoglobin level.

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