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Full Length Article

Toxicological Assessment of Aqueous Extracts of Leaves and Seeds of *Moringa oleifera* on the Blood Biochemical Profile of Rats

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Abstract

Moringa is a known medicinal plant utilized for the food supplementation and treatment of various diseases. A study was conducted to evaluate the toxicity of moringa leaf extract (MLE) and moringa seed extract (MSE). For the purpose, male Sprague-Dawley rats were used and both MLE and MSE up to 2200 mg/kg were orally administered in an acute toxicity trial of the extracts. A sub-acute toxicity trial was also done by daily administration of the extracts at 600, 1000 and1800 mg/kg body weight orally for 21 days and distilled water was given to the control group. In acute toxicity test, moringa extracts caused no death in animals even at 2200 mg/kg dose. In sub-acute toxicity study non-significant differences were observed in all the haematological and biochemical parameters at all doses of MLE and MSE in rats group compared to the control. Moreover, food intake of all the treated rats was reduced compared with the control and significant changes were observed in the body weight of the rats. Hence, the study concluded that both moringa leaf and seed extracts were safe for remedial purpose and can safely be used for human and animal feed purpose.

Keywords: Moringa leaf and seed extract; Acute toxicity; Sub-acute toxicity; Haematology; Biochemical parameters

Introduction

Nutraceutical and functional foods are getting popularity in health conscious people owing to their astonishing medicinal and nutritional properties. According to World Health Organization, almost 60% of the global death toll is due to chronic diseases (WHO, 1999). The best way to cope these chronic conditions is through nutritional intervention, which is an imperative move towards the relief and maintenance of the health. Plant-based food products are incredible sources of essential nutrients and phytochemicals those have been found to acquire various biological activities (Craig, 1999). Pakistan has a diverse range of medicinal plants and many of them are useful for the health of the population. Moringa is one of them, which is a deciduous to evergreen plant, native of Pakistan, a common tree in southern Punjab and most common specie is *Moringa oleifera* Lam. The plant is usually grown in Asia, Africa and other tropical parts of the world as a food (Ramachandran *et al*., 1980). Moringa is called as horse radish, kelor drumstick tree in several parts of the world (Anwar and Bhanger, 2003) while in Pakistan, its common name is 'Sohanjna' (Anwar *et al*., 2005).

Moringa plant has sufficient amounts of vitamins, minerals (calcium, phosphorous, iron, copper, zinc, iodine, sulphur, selenium and manganese) and all essential amino acids (Leonard and Rweyemamu, 2006). Moreover, its leaves are full of phenolic acids (gallic, chlorogenic, ellagic and ferulic acid) and flavonoids (kaempferol, quercetin and rutin) in appreciable quantity (Verma *et al.,* 2009). However, ten phenolic compounds (gallic acid, p-coumaric acid, ferulic acid, caffeic acid, protocatechuic acid, cinnamic acid, catechin, epicatechin,vanillin and quercetin) have also been identified and assessed in seeds powder (Singh *et al.,* 2013). These naturally occurring of moringa could be a good source of antioxidants, antimicrobial and antiparasitic in different industries (Fatima *et al.,* 2014).

There are many other naturally occurring compounds, which have been extracted from the moringa leaves. These include fully acetylated glycosides bearing thiocarbamates, carbamates or nitriles (Faizi *et al.,* 1998) especially; quercetin and kaempferol glycosides are broken down to extract the natural antioxidant flavonoids (Bennett *et al.,* 2003). These phytochemicals play an important role in the

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modulation of lipid peroxidation, which is engaged in atherogenesis, thrombosis and also inhibit the oxidative enzymes e.g. COX-2, lipoxygenase and phospholipidase and act as antioxidant and anti-inflammatory agent (Siddhuraju and Becker, 2003). The components extracted from moringa include 4-(4'-O-acetyl-α-L-rhamnopyranosyloxy) benzyl isothiocyanate (Abrams *et al*., 1993), 4-(α-L-rhamnopyranosyloxy) benzyl isothiocyanate (Abuye *et al.,* 1999), niazimicin (Akhtar and Ahmad, 1995), benzyl isothiocyanate (Anwar *et al.,* 2007), and 4-(α-L-rhamnopyranosyloxy) benzyl glucosinolate (Asres, 1995) have hypo-tensive and anti-cancerous activity.

Most of the medicinal plants are blindly used considering only their beneficial aspects, while toxicity or toxic doses are ignored. Despite the fact that moringa is a renowned medicinal plant utilized for the food supplementation and in the treatment of various diseases; there is no or very less information available on toxicity of moringa leaf and seed extracts of the local landraces. Therefore, this study was aimed to determine the safety or possible toxicological effects of aqueous extracts of moringa on the blood chemistry of rats with a view of utilizing them in food product. The findings from this study are likely to contribute to enhance the overall nutritional and medicinal value of the plant for not only animal feed but also nutritional intervention for human.

Materials and Methods

Plant Materials

The moringa leaves and seeds were obtained from a three years old tree which was planted through seed at experimental farm of the department of Agronomy, University of Agriculture, Faisalabad. For plantation the seeds were obtained from a wild moringa tree located adjacent to Bilal Colony gate, University of Agriculture, Faisalabad. The tree was identified by taxonomist as *Moringa oleifera.* The tree flowers during December and its pods mature during May and June. It bears about one foot long pods with 10-14 seeds per pod.

Freshly harvested leaves were washed with distilled water and dried in the air for three to four days under the shed until constant weight. The dried leaves and seeds were separately ground using an electronic blending machine (Renker, Model: GMO 1 grinder). The powder from different parts was sieved through 250 µm mesh size to remove any residues. The ground and sieved powder was subsequently stored in air tight containers until used (Anjorin *et al.*, 2010).

Extract Preparation

A sample weighing 150 g each of the dried moringa leaf and seed powders was dissolved in warm water (2.5 L) for easy dissolution, thereafter, filtered by Whatman's No. 1 filter paper. The filtrate was then administered to the animals in the course of this study (Adedapo *et al*., 2009).

Animals

The animals used in this study were male Sprague-Dawley (S-D) rats (150- 200 g). Eighty rats were maintained at the Experimental Animal Room in the Department of Food Science, Nutrition and Home Economics, Government College University, Faisalabad, Pakistan. The humidity, room temperature, light and ventilation were controlled (60 to 62%, 23–25°C, 12 h light/dark cycle). The rats were kept in cages, fed on commercial rat cubes and allowed free access to clean fresh water in bottles *ad libitum.* All the animals were weighed during the acclimatization period and clinical observations were conducted on the animals subsequently at weekly intervals. All experimental protocols were in compliance with the Ethics Committee on Research in Animals as well as internationally accepted principles for laboratory animal use and care.

Acute Toxicity Study

The acute toxicity of moringa leaf extract (MLE) and moringa seed extract (MSE) was determined according to the method of Sawadogo *et al.* (2006) with slight modifications. Rats were fasted for 16 h and randomly divided into four groups for MLE, another four groups for MSE and one control group of five rats each group. Graded doses of the both extracts (600, 1000,1800 and 2200 mg/kg) corresponding to groups B, C, D, E for moringa leaf extract and F, G, H, I for moringa seed extract were separately administered to the rats in each of the 'test' groups by means of oral gavages. The control group (A) was treated with orally administered distilled water (3 mL/kg) only. All the animals were then allowed free access to food and water and observed over a period of 48 h for the signs of acute toxicity. The number of deaths within this period of time was recorded to evaluate the acute toxicity in rats.

Sub-acute Toxicity Study

Using a modified method of Cruz *et al.* (2006), the rats were divided at random into seven groups of 5 rats per group. The control group A received only distilled water, while the experimental groups representing groups B, C, D (MLE) and E, F, G (MSE) received aqueous leaves and seeds extract at the doses of 600, 1000 and 1800 mg/kg for both extracts, respectively. The extracts were administered orally for 21 days. All the animals were weighed on the first day and at the end of the experiment.

Collection of Blood and Serum Samples

Paired blood samples were collected into EDTA tubes and

heparinized tubes by the decapitation of animals on the 21st day of the trial for haematological and biochemical analysis of blood.

Haematological Indices

The Leukocyte count (WBC) of rat's blood under study was analyzed by the method of Coles (1986). Whereas, erythrocyte count (RBC), haemoglobin concentration (Hb), haematocrit (HCT), mean corpuscular volume (MCV), mean corpuscular haemoglobin (MCH), mean corpuscular haemoglobin concentration (MCHC), platelet count (PLT) were determined by their respective standard methods as described by Duncan *et al.* (1994).

Biochemical Analysis

Biochemical analysis was performed using blood collected into plain tubes. Blood samples were centrifuged for 5 min at 3000 rpm. Aspartate amino transferase (AST), alanine amino transferase (ALT) and alkaline phosphatase (ALP) were determined by the method of Duncan *et al*. (1994) and urea and creatinine as stated by Coles (1986).

Statistical Analysis

The results from the study were expressed as mean ± SD. The data were subjected to analysis of variance (ANOVA) technique to check the level of significance and means were compared through LSD test using a software SPSS version 17 according to the method described by Steel *et al*. (1997).

Results

Acute Toxicity Study

The results showed that no mortality was observed in any of the groups even at maximum dose i.e., 2200 mg/kg (Table 1). However, slight changes in the behavior were noticed in few rats at the start of the extract administration, but later on they became normal and active. Slight dullness was observed in the one rat in first 2 h of administration of leaf extract at dose of 1800 mg/kg and two rats at the dose of 2200 mg/kg but after this period they became normal. Similarly, few rats showed slight dullness in behavior by the administration of seeds extract but gradually they also became normal (Table 2).

Sub-acute Toxicity Study

Haematological indices: The administration of moringa leaf extract (MLE) at all doses was investigated after 21 days revealed non-significant effect on the haematological parameters as compared to the control group (Table 3). The Hb level slightly increased for MLE (13.91 g/dL) at 600 mg/kg however it gradually decreased in the rats groups at 1000 mg/kg (13.24 g/dL) and 1800 mg/kg (13.43 g/dL) doses in comparison with the control (13.75 g/dL) group. Likewise, the red blood cells count (RBC) was highest (8.06 M/µL) in the groups at 600 mg/kg MLE and lowest (7.71 M/µL) was found in the rats group at 1000 mg/kg dose compared to the control (7.84 M/µL) group. Similarly, the mean values of haematocrit, MCV, MCH and lymphocytes also exhibited the same trend.

However, for MCHC the lowest value (33.34 g/dL) was obtained in the rats group consuming 600 mg/kg MLE which gradually increased and the highest (34.84 g/dL) was observed in 1800 mg/kg rats group. The differences were not significant. Similarly, the mean values of monocytes exhibited an increasing trend. The values were increased non-substantially from 2.50 to 2.69% as the dose increased. Likewise, the mean values of basophils in the present study ranged from 0.21 to 0.23% and eosinophils also showed the similar increasing trend. However, after 21 days the total WBC decreased from 8.75 to 8.34 K/µL. Similarly, platelet counts dropped from 398.00±2.82 K/µL to 385.67 K/µL and the mean values of neutrophils also exhibited the same decreasing trend in the present study.

The results showed non-significant differences among all the treatments for MSE. The Hb level of the rats with MSE group was slightly increased (13.85 g/dL) in the group at 600 mg/kg, whilst gradually decreased (13.38 g/dL) as the dose increased 1000 mg/kg in the rats group compared with the control (13.73 g/dL) group. Similar trend in the results was observed for haematocrit, MCH and WBC of the rats. However, the results showed that the highest value (7.63 M/µL) for RBC was found in 600 mg/kg group, while the lowest value (7.54 M/µL) was observed in the rats group consuming 1800 mg/kg MSE. The RBC showed the decreasing trend from lowest to highest dose. Similar decreasing trend was depicted in the values of MCHC, lymphocytes, monocytes, neutrophils, eosinophils, basophils, and platelet count (Table 4).

Biochemical analysis: The results showed non-significant differences among all the treatments ($p \geq 0.05$) compared to the control (Table 5). The results regarding the hepatic enzymes markers showed that the highest value (43.79 U/L) of ALT was obtained in the rats consuming 600 mg/kg MLE, while the lowest (42.87 U/L) was observed in 1800 mg/kg rats group compared to the control (43.34 U/L) group. The values of ALT were slightly elevated as compared to control but the difference was non-significant. The mean value for ALP and AST also mentioned the non-momentous changes among all the treatments in MLE group. However, the slight decreasing trend from lowest to highest dose was observed with increase in MLE dose in rat's diet.

The mean values for ALP, AST and ALT for MSE group are presented in Table 6. The lowest value (27.19 U/L) of ALP was found in rats consuming 1000 mg/kg MSE, while the highest (28.34 U/L) was observed in the rats consuming 600 mg/kg MSE.

Table 1: Acute (oral) toxicity study in rats after 48 h of administration of aqueous extract of moringa leaf (n=5)

Groups	Treatments	T/D	Period of signs observation (h)	Signs of toxicity observed
A	3 mL (H_2O)	5/0	48	----
B	600 mg/kg	5/0	48	No toxic changes observed
C	1000 mg/kg	5/0	48	No toxic changes observed
D	1800 mg/kg	5/0	48	Slight dullness was observed in the one rat in the first two hours of extract administration, but after this period rats became normal
E	2200 mg/kg	5/0	48	Slight dullness was observed in the two rat in the first five hours of extract administration, but after this period rats became normal

*T/D: number of rats treated/number of death

Table 2: Acute (oral) toxicity study in rats after 48 h of administration of aqueous extract of moringa seed (n=5)

Groups	Treatments	T/D	Period of signs observation (h)	Signs of toxicity observed
F	3 mL (H_2O)	5/0	48	-----
G	600 mg/kg	5/0	48	No toxic changes observed
H	1000 mg/kg	5/0	48	No toxic changes observed
I	1800 mg/kg	5/0	48	Slight dullness was observed in the two rats in the first three hours of extract administration, but after this period rats became normal
J	2200 mg/kg	5/0	48	Slight dullness was observed in the three rats in the first five hours of extract administration, but after this period rats became normal

*T/D: number of rats treated/number of death

Table 3: Effects of the graded doses of the aqueous extracts of moringa leaf on haematological parameters of rats (n =5)

Parameters	Treatments			
	Control	600 mg/kg	1000 mg/kg	1800 mg/kg
Hb (g/dL)	13.75±0.08	13.91±0.17	13.24±0.21	13.43±0.18
RBC (M/µL)	7.84±0.05	8.06±0.12	7.71±0.05	7.80±0.07
Haematocrit (%)	42.38±0.15	42.97±0.31	41.34±0.36	41.65±0.64
MCV (fL)	61.23±0.85	61.36±0.35	61.15±0.83	60.05±0.42
MCH (pg)	20.01±0.20	19.81±0.15	19.34±0.20	19.25±0.20
MCHC (g/dL)	33.56±0.36	33.34±0.62	34.73±0.28	34.84±0.40
WBC (K/µL)	8.75±0.09	8.42±0.09	8.34±0.08	8.66±0.13
Lymphocytes (%)	76.43±0.62	75.81±1.03	73.65±1.05	74.21±1.20
Monocytes (%)	2.50±0.05	2.58±0.02	2.64±0.03	2.69±0.05
Neutrophils (%)	20.35±0.31	20.29±0.50	2 0.10±0.23	20.30±0.23
Eosinophils (%)	3.52±0.02	3.57±0.03	3.45±0.01	3.48±0.07
Basophils (%)	0.21±0.007	0.22±0.003	0.23±0.008	0.21±0.003
PLT (K/µL)	398.00±2.82	396.00±2.74	388.00±5.13	385.67±3.69

Mean ± SD, Non-significant differences (P>0.05) between doses within each parameter at α= 0.05; Hb: Hemoglobin, RBC: Red blood cell count, MCV: Mean corpuscular volume, MCH: Mean corpuscular; Hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, WBC: White blood cells, PLT: Platelet Count

Similarly for ALT, the results depicted that the slight elevation in the level of ALT was noted in the lowest dose however it was gradually decreased as the dose increased. The mean values for AST also exhibited the similar decline from lowest to highest doses although slight elevation was shown at the highest dose (1800 mg/kg).

The results further showed that the non significant differences ($p \geq 0.05$) were observed in the values of urea and creatinine for MLE and MSE groups in comparison with the control group. There was insignificant elevation in the values of creatinine in renal function markers at all the doses for MLE and MSE. The highest level (0.91 mg/dL) of creatinine for MLE was observed in the group at the highest dose 1800 mg/kg, while the lowest (0.86 mg/dL) was depicted in the control group. Similar, trend of creatinine was found for MSE group, which showed the range from 0.86 to 0.90 mg/dL. More so, a lowest (12.09 mmol/L) level of urea was observed in 1000 mg/kg rats group while the highest (12.61 mmol/L) was mentioned in the rats group consuming 600 mg/kg MLE. However, in MSE group urea level was slightly increased from lower to higher doses compared to control.

Body Weight of Rats

The results revealed that all the rats during the study period gained weight, although the rats in control group gained more weight as compared to the rats in the both experimental groups. By increasing the graded doses of MLE, the weight gain in the experimental rats gradually decreased (Fig. 1). Similar trend was noted in the MSE group however, increase in the weight gain was found less in MSE group as compared to MLE group (Fig. 2). The differences in weight gain for MLE were (21.88%) in rats consuming 600 mg/kg and 14.53 and 6.14% for 1000 mg/kg and 1800 mg/kg as compared with control group (Fig. 3). An overall weight gain for MSE group in rats

Table 4: Effects of the graded doses of the aqueous extracts of moringa seed on haematological parameters of rats (n =5)

Parameters	Treatments			
	Control	600 mg/kg	1000 mg/kg	1800 mg/kg
Hb (g/dL)	13.73±0.13	13.85±0.05	13.38±0.32	13.45±0.18
RBC (M/µL)	7.86±0.05	7.63±0.12	7.62±0.14	7.54±0.19
Haematocrit (%)	42.25±0.98	41.55±0.57	41.40±0.36	41.19±0.48
MCV (fL)	61.20±0.18	61.06±0.59	60.84±0.84	60.42±0.88
MCH (pg)	20.37±0.18	20.41±0.32	20.28±0.18	20.16±0.25
MCHC (g/dL)	33.60±0.40	32.79±0.27	32.63±0.21	31.86±0.51
WBC (K/µL)	8.77±0.06	8.84±0.04	8.61±0.12	8.54±0.16
Lymphocytes (%)	76.40±0.50	74.19±0.42	75.65±0.83	75.04±0.93
Monocytes (%)	2.52±0.02	2.59±0.04	2.52±0.05	2.40±0.12
Neutrophils (%)	20.33±0.31	20.22±0.27	19.97±0.21	19.77±0.10
Eosinophils (%)	3.54±0.03	3.51±0.03	3.43±0.01	3.39±0.11
Basophils (%)	0.21±0.00	0.20±0.00	0.21±0.00	0.22±0.00
PLT (K/µL)	410.67±2.99	411.00±1.66	404.00±3.52	403.67±4.94

Mean ± SD, Non-significant differences (P>0.05) between doses within each parameter at α= 0.05; Hb: Hemoglobin, RBC: Red blood cell count, MCV: Mean corpuscular volume, MCH: Mean corpuscular; Hemoglobin, MCHC: Mean corpuscular hemoglobin concentration, WBC: White blood cells, PLT: Platelet Count

Table 5: Effects of the graded doses of the aqueous extracts of moringa leaf on serum biochemical parameters of rats (n =5)

Parameters	Treatments			
	Control	600 mg/kg	1000 mg/kg	1800 mg/kg
ALP (U/L)	26.78±0.41	26.56±0.30	25.71±0.20	26.10±0.20
ALT (U/L)	43.34±0.08	43.79±0.54	44.25±0.28	42.87±0.38
AST (U/L)	55.57±0.54	54.46±0.82	53.78±0.50	53.10±0.63
Urea (mmol/L)	12.52±0.19	12.61±0.10	12.09±0.21	12.37±0.21
Creatinine (mg/dL)	0.86±0.011	0.89±0.009	0.88±0.015	0.91±0.014

Non-significant (P>0.05) differences between doses within each parameter at α= 0.05
Mean ± SD, ALP: Alkaline phosphatase, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase

Table 6: Effects of the graded doses of the aqueous extracts of moringa seeds on serum biochemical parameters of rats (n =5)

Parameters	Treatments			
	Control	600 mg/kg	1000 mg/kg	1800 mg/kg
ALP (U/L)	27.42±0.22	28.34±0.42	27.19±0.31	27.66±0.11
ALT (U/L)	43.30±0.47	43.38±0.33	43.10±0.20	42.89±0.66
AST (U/L)	57.28±0.90	57.18±0.54	56.45±0.52	56.83±0.61
Urea (mmol/L)	12.53±0.11	12.61±0.17	12.93±0.17	13.01±0.20
Creatinine (mg/dL)	0.86±0.013	0.87±0.008	0.89±0.007	0.90±0.007

Non-significant (P>0.05) differences between doses within each parameter at α= 0.05
Mean ± SD, ALP: Alkaline phosphatase, ALT: Alanine aminotransferase, AST: Aspartate aminotransferase

consuming 600 mg/kg was 15.20% followed by 1000 mg/kg (10.12%) and 1800mg/kg (4.62%) as compared to control (Fig. 4).

Discussion

Acute administration of moringa extract at 2.2 g/kg dose is safe orally. Moringa leaf extract was renowned to be non-toxic in animals at 2000 mg/kg body weight in an acute toxicity study reported by Adedapo *et al.* (2009). Many other studies also reported that moringa aqueous leaf extract is safe at very high doses (5000 to 6400mg/kg) used (Diallo *et al.*, 2009; Awodele *et al.*, 2012). Local moringa used in the present study also proved safe for oral supplementation.

In haematological parameters there was slight non-momentous decrease in the level of RBC, Hb, haematocrit, MCV, MCH, and MCHC contents in rats treated with moringa leaf and seed extracts might be occurred due to haemolysis by these extracts. The Hb contents might be decreased due to reduction in the synthesis of Hb which caused impaired oxygen supply to different tissues, which in turn was responsible for less number of RBC through haemolysis (Atamanalp and Yanik, 2003). Furthermore, haemolysis also reduced the haematocrit value (Martinez and Souza, 2002). The decreased value of MCHC indicates the swelling of red blood cells and it may also occur by the less amount of hemoglobin in the circulation due to release of young erythrocytes. Olayemi *et al.* (2016) reported non-significant changes in Hb at doses; 100, 200 and 400 mg/kg of seed extract while significant (P<0.05) decrease was observed in the level of Hb in rats at 1000 mg/kg for 28 days, indicated that

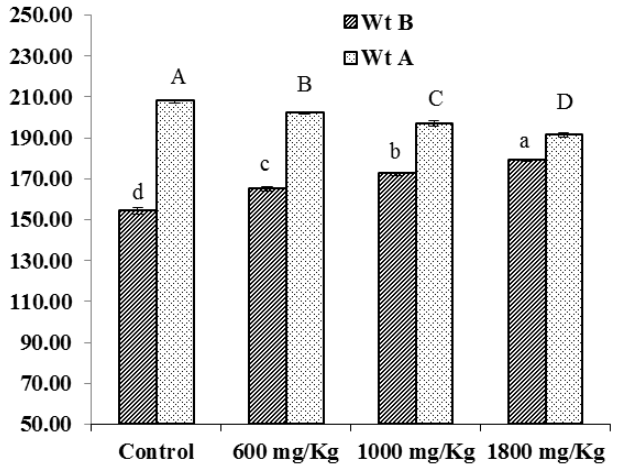

Fig. 1: Effects of the graded doses of the aqueous extracts of moringa leaf on the body weight of rats (n =5), Wt B: weight before extract administration (g), Wt A: weight after 21 days at α=0.05

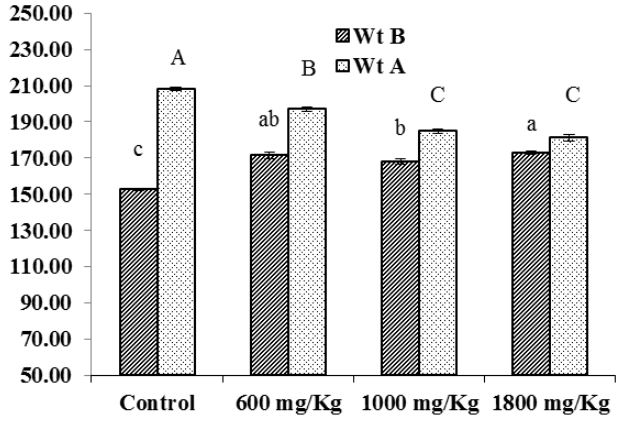

Fig. 2: Effects of the graded doses of the aqueous extracts of moringa seed on the body weight of rats (n =5), Wt B: weight before extract administration (g), Wt A: weight after 21 days at α=0.05

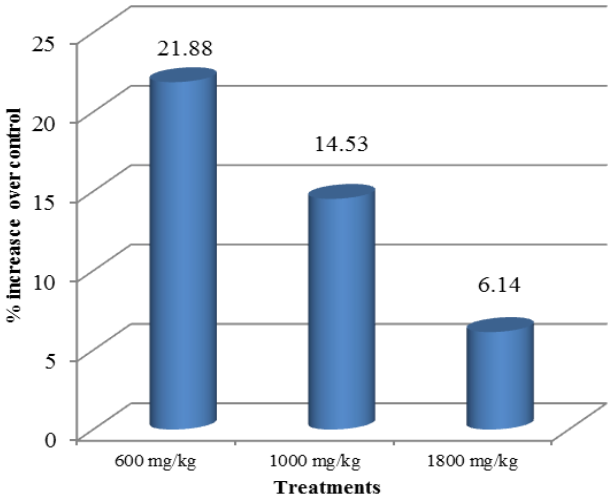

Fig. 3: Effect of Moringa leaf extract on the percent increase in weight gain of the rats

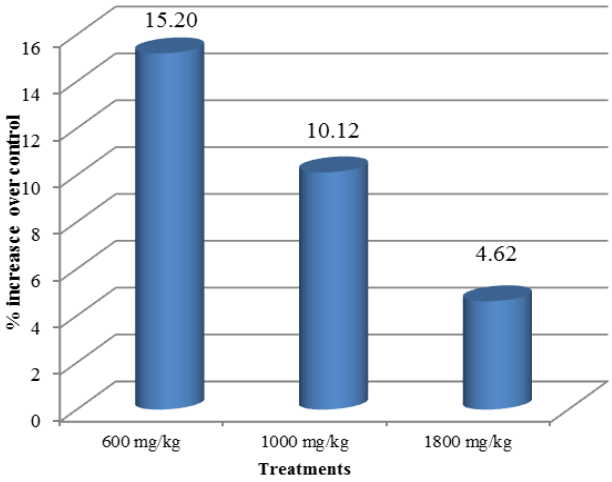

Fig. 4: Effect of Moringa seed extract on the percent increase in weight gain of the rats

exposure to this plant at highest dose for a longer period of time may cause anemia. Asare *et al.* (2012) also observed non-significant changes for all the haematological parameter studied in S-D rats by the administration of 1000 (low dose: LD) and 3000 mg/kg body weight (high dose: HD) of aqueous extract of moringa leaf after 48 h and after 14 days. Likewise Awodele *et al.* (2012) showed that nothing adverse was found haematologically by daily administration with moringa leaf extract at doses 250, 500 and 1500 mg/kg to male Wistar albino mice orally for 60 days.

Moreover, WBCs chemistry is in comparison with that of their normal values, indicating that both of the extracts did not contribute any adverse effects and were found to be non-toxic. However, slight decrease in the WBCs and its differentials depicted that moringa is useful in the reduction of any infection or inflammation. Likewise, non-significant changes in the level of WBC's were observed as compared to the control in the rats exposed to 200 and 1000 mg/kg moringa seed extract for 28 days showed the strengthening of immune system (Olayemi *et al*., 2016). However, the level of WBC's and its differentials were slightly increased significantly ($P<0.05$) in rats at the doses of 400 mg/kg and 800 mg/kg of moringa leaf extract (Adedapo *et al*., 2009) and at 5,000 mg/kg showed the presence of infection/stress (Asiedu-Gyekye *et al.*, 2014). The main function of the WBC's is to play vital role in the defense mechanism of the body by engulfing and destroying the invading microorganisms (Paul, 1993; Swenson and Reece, 1993; Adedapo *et al*., 2005). Therefore, during infection and

inflammations and in any stress conditions of the body they are released from the lymphomyeloid tissues to defend the body against foreign body and its level become high in the blood. So, slight increase in the level of WBC's depicted that the extracts were toxic to some level (Ates *et al*., 2008). Slight differences could results from the toxicity assay, plant extraction processes, geographical location of the plants and may be due to difference in specie, so further investigations are required in this context. Furthermore, platelet counts exhibited the decreasing trend in the present study. Asiedu-Gyekye *et al.* (2014) also reported significant decrease in platelet counts at administration of 1000 mg/kg moringa leaf extract for 14 days in treated rats.

The results further showed that the moringa extracts resisted the increase in hepatic enzyme markers (ALT, AST and ALP) and these were remained at the normal level indicating the safety of the extracts. Many previous studies also exhibited non-momentous changes in hepatic enzyme markers even at the highest dose (3000 mg/kg) throughout the study period (Asare *et al.*, 2012; Awodele *et al.*, 2012). Hepatic enzyme markers (ALT, ALP and AST) are formed in the liver and are good indicators of liver damage and also used to measure the hepatic necrosis. In the blood they are usually present at low levels but when the cells of the liver are damaged, these enzymes are leaked in to the blood and consequently their level increases in the blood (Bush, 1991). Significant increase in the level of serum ALP by the administration of moringa leaf extract at 1600 mg/kg dose indicated the damage of liver cells at early stages but if the extract is used for long period of time it may lead to cholestasis or hyperbilirubinemia. However, significant decrease was observed in the level of these markers at 800 mg/kg and it may be considered as a safest dose (Adedapo *et al*., 2009). Similarly, a significant decrease ($p<0.05$, $p<0.01$ and $p<0.001$) in the hepatic enzyme markers, alkaline phosphatase (ALP) alanine amino transferase (ALT) and aspartate amino transferase (AST), in treated rats with both moringa leaf and seed extracts were observed at doses; 100, 200 and 400 mg/kg by Olayemi *et al*. (2016).

Urea is a non-protein nitrogenous substance, which may be accumulated in the blood due to reduction in renal excretion. Blood urea level may be increased due to high protein diet, severe hemorrhage, shock and dehydration etc (Bush, 1991). In MSE group both creatinine and urea were slightly increased from lowest to highest doses because MSE contained high level of nitrogenous compounds, particularly protein than MLE. So, the consumption of highest dose of moringa seed extract for long period of time may cause nephrotoxicity. Awodele *et al.* (2012) reported slight elevation in urea and creatinine by administration of moringa leaf extract at doses 250, 500 and 1500 mg/kg orally to mice for 60 days.

Weight reduction was seen more in MSE group than MLE group because MSE is rich source of protein and other nutrients are present in low quantity as compared to leaves. Similarly, the fat content of MSE is higher than the leaves but in aqueous extract it is present in negligible amount. Adedapo *et al*. (2009) also confirmed that weight gained by animals decreased with the graded doses of moringa leaf extract from 400 to 1600 mg/kg orally after 21 days. Moreover, the dose-dependent reduction in food consumption of the animals treated with 250 to 1500 mg/kg moringa aqueous leaf extract for 60 days was observed (Awodele *et al.*, 2012). Hence, the medicinal plants are low fat and rich source of bioactive compounds that can help to reduce weight gain.

Therefore, the results of the present study indicated that both of the extracts did not change metabolic processes and did not affect the hormones and the body (Cajuday and Poscidio, 2010). Moringa food intake of all the treated rats was reduced compared with the control animals with consequent reduction in body weight of animals. The previous studies (D'souza and Kulkarni, 1993; Anwar and Bhanger, 2003; Anwar *et al*., 2005) also showed that moringa may serve as a food supplement for weight reduction and also act as preventative against various ailments.

Conclusion

The extract did not bring forth any significant changes ($P\geq0.05$) in hematological and biochemical parameters in the treated rats when compared to the control. Moreover, there was no major difference in body weight of the control and treated animals even though there was a dose-dependent reduction in food consumption of the animals treated with 600 to 1800 mg/kg for both MLE and MSE. The results obtained in this study advocate that the aqueous extract of local moringa leaf and seed are relatively safe for both nutritional and medicinal purpose.

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