

Evaluation of Renal and Hepatic Indices of Rats Exposed To Paracetamol Toxicity with Almond and Vitamin E Supplementation

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Abstract

Paracetamol overdose has been widely implicated to cause toxicity. The post supplementation effect of almond and vitamin E in ameliorating paracetamol induced liver and renal toxicity is imperative. This study investigated the post supplementation antioxidant effects of almond seeds, vitamin E and their combination in paracetamol induced nephrotoxicity and hepatotoxicity in albino rats. Fifty-one (51) male albino rats were divided into nine (9) groups (A-I). Groups A, B and C served as normal control, post-treatment control and pre-treatment control respectively. Groups D, E and F are the post-treatment test groups. The various test groups in the post-treatment groups were given almond seeds, vitamin E and combined treatment by oral gavage for 14 days. 3g/kg b.w paracetamol was used to induce hepatorenal toxicity in the paracetamol control and test groups of the post-treatment groups on day 1 before commencement of treatment while paracetamol control and test groups of the pre-treatment groups were induced on day 14 after treatment. The animals were sacrificed on day 15. Laboratory investigations carried out include renal indices (Urea and Creatinine), liver enzymes (AST, ALT and ALP), lipid profile (TC, TG, HDL, LDL and VLDL) and antioxidant profile tests (MDA, SOD and TAC). The result showed that oral administration of 3g/kg b.w paracetamol caused a significant increase in renal indices and liver enzymes, dyslipidaemia and oxidative stress in rats. Post-treatment result showed that almond group (group D) significantly reduced LDL and increased SOD level. Vitamin E (group E) showed no significant difference in all parameters. The combined treatment (group F) significantly reduced ALT levels. Hence from the results, it is concluded that post-treatment with almond, vitamin E and their combination have potentials in ameliorating hepatic damage, nephrotoxic damage and oxidative stress induced by paracetamol overdose, as well as improving the total antioxidant capacity.

Keywords: Renal, Hepatic, Lipids, Antioxidants, Toxicity, Almond, Vitamin E, Paracetamol

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I. Introduction

Drug induced hepato-renal toxicity is rising in our contemporary society. It accounts for about 10-20% of all cases acute liver and kidney injuries (Nash *et al.*, 2002). They have become an increasingly important issue with the increase in prescription medication and herbal supplement use. Age, pre-existing disease conditions, multiple medications, exposure to more diagnostic and therapeutic procedures are also contributory factors to high prevalence. Drug induced toxicity is the most common form of acute liver and kidney failure in the united states (Larson *et al.*, 2005) and hence one of the reasons for withdrawal of drugs from the market. This has become a common problem in clinical medicine. Treatment can be costly and may require multiple interventions, including hospitalization (Gandhi *et al.*, 2000).

The liver plays a vital role in regulating various physiochemical functions of the body and is always the first target organ for the metabolism of drugs and toxic chemicals (Sahreene *et al.*, 2015; Salama *et al.*, 2015)

The kidney is also a sensitive and dynamic organ responsible for homeostasis and regulation of the extracellular environment. It is also involved in detoxification and excretion of toxic metabolites and drugs (Inui *et al.*, 2010; Parazella and Mockel, 2010). Drugs can exert their toxic effects by inducing nephrotoxicity by one or more common pathogenic mechanisms. Most people suffer from drug induced nephrotoxicity because of the presence of dangerous factors that increases their susceptibility to the damage caused by drugs (Tionget *et al.*, 2014). The drug induced injuries may be repaired or compensated for by the kidneys without signs of injury or may be evident through renal function tests and analysis of biochemical parameters.

Paracetamol (PCM), is an analgesic and antipyretic drug (Aghababian, 2010). At recommended doses, it is generally safe even when taken for a long time. However, paracetamol can be very toxic and fatal when taken at overdose (FDA, 2008). Acute overdose of paracetamol is dose-dependent and causes potentially fatal hepatic necrosis which may be associated with renal tubular necrosis (Ogunbayode *et al.*, 2010). In paracetamol

overdose, there is vigorous depletion of sulfate and glutathione stores which then shunts more of the paracetamol to the CYP-450 mixed function oxidase system, thereby generating more NAPQI reactive intermediates (Lee *et al.*, 2001). Paracetamol induced damage has been demonstrated in both liver and kidney tissue of animal models. Several studies have shown that paracetamol overdose increases the formation of free radicals and depletion of antioxidants which results in oxidative stress. Oxidative stress damages tissues by disrupting cellular functions (McCord, 2000). Antioxidants prevent oxidative damage by interacting with free radicals and terminating chain reactions before vital organs are damaged (Ozcelik *et al.*, 2014).

Vitamin E is a group of lipid-soluble compounds which includes tocopherols and tocotrienols (Traber and Atkinson 2007). Vitamin E is an antioxidant that protects cell membranes and other fat soluble parts of the body from damage by oxidation via peroxides and free radicals (Patel *et al.*, 2011). It carries out this function by acting as peroxyl radical scavenger, thus preventing the propagation of free radicals in tissues (Traber and Stevens, 2011). Vitamin E has been shown to protect cell membrane from acetaminophen induced toxicity by inhibiting lipid peroxidation (Herrera and Barbas, 2001; Traber and Atkinson, 2007). Vitamin E also protects against some forms of xenobiotics that causes damage (Khaster, 2015).

Almond seeds, are consumed as snacks or used as ingredients for processed foods such as various bakeries, confectioneries and chocolates (Takeoka *et al.*, 2000). Almonds are highly nutritious and rich sources of healthy fats, proteins, vitamins, minerals and are also packed with numerous health promoting phytochemicals (USDA, 2004). In addition to its nutritional values, it also has some medicinal values. Almonds are natural antioxidants owing to its phytochemical constituents. Some epidemiological studies have shown that the consumption of foods rich in natural antioxidants increases plasma antioxidant capacity and reduces the risk of diseases (Frisson-Norrie and Sporns, 2002; Philips *et al.*, 2005). Despite the considerable advancements in medicine, synthetic drugs still have many side effects and exacerbate the disease. It has become necessary to use natural and safe alternatives from medicinal plants to replace chemical drugs using various experimental models (Muriel and Rivera-Espinoza 2008, Patwardhan *et al.* 2004). In this context, more attention has been paid to the protective effects of natural antioxidants of herbal medicine and isolated bioactive constituents, which are considered as the most effective and safe treatments for hepatotoxicity/nephrotoxicity (Grajales and Muriel, 2015). It is imperative to ascertain if almond seed and vitamin E supplementation will ameliorate hepatotoxicity/nephrotoxicity in rats exposed to paracetamol toxicity.

II. Materials and Methods

2.1 Chemicals

All drugs and chemicals were analytical grade. Vitamin E in gelatin capsule and powdered paracetamol was purchased from standard vendors

2.2 Pilot Study

A total of 4 adult male albino rats weighing 150 - 170g, were used for the study. After 2 weeks of acclimatization, the rats were weighed and randomly put into individual cages. Two were designated PCM group and the other two, control group. All the rats were fed on standardized rat chow and clean tap water. PCM group were given single dose of paracetamol 3g/kg body weight. Blood samples were collected by cardiac puncture after 24 hours for analysis of liver variables and oxidative profile.

2.3 Study Design and Population

A total of 70 rats were used for this study. Four (4) rats were used for pilot study; fifteen (15) rats were used for acute toxicity study while fifty- one (51) male albino rats were sampled for the main study.

2.4 Acquisition and Acclimatization of Animals

Seventy (70) male albino rats weighing between 130 - 150 g were acquired from a known animal. The rats were kept in the animal house throughout the study at an average temperature of 30°C, relative humidity of 80% and a 12- hour light/dark cycle. The animals were put on standardized rat feed and water for 2 weeks to acclimatize. Fifty- one albino rats were randomly grouped into 9 groups with five animals each in groups A, B, C and six animals each in groups D, E, F, G, H and I. Procedures involving the care and use of the animals were done in compliance with standard guidelines for the use of animals in biomedical research.

2.5 Preparation of Paracetamol (Acetaminophen)

Powdered paracetamol was suspended in distilled water and administered orally at a dose of 3g/kg b.w. This dosage is known to cause hepato-renal toxicity in rats according to the pilot study.

2.6 Extraction of Almond Seeds

Bligh and Dyer method for lipid extraction was used (Bligh and Dyer, 1959). Seven hundred and fifty grams (750g) of almond seeds were weighed and blended using an electric grinder. The extraction was done by adding 1.5 liter of methanol to the grinded almond seeds, stirring and allowing it to stand for 24 hours at room temperature (26 - 28°C). After 24 hours, the mixture was filtered using Whatman No. 1 filter paper. The methanol filtrate was then concentrated by drying with a rotary evaporator at 40-60°C. The essence of drying in

a rotary evaporator is to gently remove the solvent used (methanol). The percentage yield after extraction was 10 percent. The extract obtained was then further dried under the sun and stored in an air-tight plastic container in the refrigerator (4°C) and used for the study.

2.7 Induction of Hepato-nephrotoxicity

Having established from the pilot study that a single dose of 3g/kg b.w of paracetamol was adequate to induce liver dysfunction in the rats, nephrotoxicity was induced by weighing each animal on a weighing scale (Hana brand) and calculating the corresponding dose of paracetamol required for the induction. Powdered paracetamol was suspended in distilled water and administered orally at a dose of 3g/kg b.w. The animals were starved for 24 hours before the commencement of the experiment but had free access to drinking water.

2.8 Extract and Drug Administration

Based on the pre-determined LD50 values of almond extract obtained by using Lorke's method, the dose 1000mg/kg b.w was used for this study. The extract was diluted in distilled water which acted as a vehicle and administered orally through gastric gavage. Vitamin E 100mg/kg b.w was administered also by gastric gavage. A tiny drop of tween 80 was added to increase Vitamin E solubility in distilled water before administration. Single dose of paracetamol 3g/kg b.w was administered orally by gastric gavage to induce nephrotoxicity and hepatotoxicity.

2.8.1 Calculation of Dosage

Dose of paracetamol and Vitamin E corresponding to the average weight of the rats were calculated based on:

$$\text{Average weight} = \text{total weight of rats} / \text{total number of rats}$$

2.9 Experimental Design

Table 2.1 Treatment Schedule of the various groups

GROUPS	TREATMENT
A (Neg C)	Distilled Water (day 1-14)
B (post-C)	PCM (day 1) + distilled water (day 2-14)
C (pre-C)	Distilled water (day 1-13) + PCM (day 14)
POST TREATMENT GROUPS	
D	PCM (day 1) + Almond (day 2-14)
E	PCM (day 1) + Vit E (day 2-14)
F	PCM (day 1) + Almond + Vit E (day 2-14)
PRE TREATMENT GROUPS	
G	Almond (day 1-13) + PCM (day 14)
H	Vit E (day 1-13) + PCM (day 14)
I	Almond + Vit E (day 1-13) + PCM (day14)

PCM is paracetamol, Post-C is post-treatment control group, Pre-C is pre-treatment control group, vit. E is vitamin E. PCM=3g/kg, vit E=100mg/kg, Almond=1g/kg.

This experimental setup lasted for a period of fourteen (14) days. On the 15th day, all the rats were sacrificed and blood collected for biochemical analysis.

2.10 Collection of Blood Samples for Biochemical Analysis

Blood samples were taken by cardiac puncture (after anaesthetizing the animals with diethyl ether inhalation) at the commencement (as baseline measures) of the study, before and after interventions (sacrifice of the animals). This was done on day 15. About 4ml of whole blood was collected from each animal into plain sample bottle, labeled properly for biochemical analysis (urea, creatinine, AST, ALT and ALP).

2.11 Statistical Analysis

Data were analyzed using Graph Pad Prism 5.1. The data were presented as mean and standard deviations. Statistical comparisons were considered significant at $p < 0.05$.

III. Results

3.1 Renal Indices and Liver Enzymes Levels of the Post-Treatment Groups and Control.

The details of the renal indices and liver enzymes levels of the post-treatment groups and control are shown in table 3.1. The table depicted significant differences in urea levels amongst group A vs B, group A vs E, and group A vs F at ($P = 0.013$, $F = 4.104$). There were no significant variations among the rest of the groups. The table also shows a significant variation in creatinine levels amongst group A vs B at ($P = 0.0026$, $F = 5.823$), but there were no significant variations among the rest of the groups. There was also a significant variation in the AST level between group A vs B at ($P = 0.0267$, $F 3.413$). Although no significant differences existed among the rest of the groups. The table also portrays significant variations in ALT levels amongst group

A vs B, group A vs D, group A vs E and group B vs F at (P = 0.0002, F = 9.321).The results for ALP shows no significant variation amongst all the groups at (P = 0.2066, F = 1.619).

Table 3.1 Renal indices and liver enzymes levels of the post-treatment groups and control

	Urea (mmol/L)	Creatinine(μmol/L)	AST(U/L)	ALT(U/L)	ALP(U/L)
Group A	2.74 ± 0.34	95.4 ± 7.44	53.4 ± 9.21	21 ± 3.16	61 ± 9.43
Group B	3.98 ± 0.70	126.75 ± 9.25	80.5 ± 7.19	36.75 ± 3.5	73.25 ± 6.5
Group D	3.06 ± 0.38	114.16 ± 14.74	64.16 ± 14.78	28.67 ± 5.68	64 ± 8.71
Group E	3.4 ± 0.59	120 ± 10.88	77.2 ± 12.43	31.8 ± 4.33	67.4 ± 8.96
Group F	3.21 ± 0.38	116.16 ± 7.67	61.5 ± 17.21	25.5 ± 3.39	62 ± 7.01
p-values	0.013	0.0026	0.0267	0.0002	0.2066
F-values	4.104	5.823	3.413	9.321	1.619
Tukey's Multiple Comparison Test	Summary	Summary	Summary	Summary	Summary
Group A vs Group B	**	*	*	***	ns
Group A vs Group D	ns	ns	ns	*	ns
Group A vs Group E	*	ns	ns	**	ns
Group A vs Group F	*	ns	ns	ns	ns
Group B vs Group D	ns	ns	ns	ns	ns
Group B vs Group E	ns	ns	ns	ns	ns
Group B vs Group F	ns	ns	ns	**	ns
Group D vs Group E	ns	ns	ns	ns	ns
Group D vs Group F	ns	ns	ns	ns	ns
Pre-Vi.E vs Group F	ns	ns	ns	ns	ns

Group A- normal control, Group B – post treatment control, Group D- almond post treatment group, Group E- vitamin e post treatment group, Group F – (almond+vit E) post treatment group.

3.2 Lipid Variables Levels of the Post-Treatment Groups and Control.

The results of the lipids variables levels of the post-treatment groups and control are shown in table 3.2.The table depicted no significant differences amongst all the groups at (P = 0.0908, F = 2.316). The table also showed similar results for TG level at (P = 0.1186, F = 2.087) and VLDL levels at (P = P 0.1129, F = 2.129).However, there are significant variations in HDL levels between group A vs B at (P = 0.0283, F 3.36). The rest groups showed no significant variations amongst them.LDL levels in the table also showed significant variations amongst group A vs B, group A vs E, group A vs F and group B vs D at (P = 0.0005, F = 7.871).

Table 3.2 Lipid variables levels of the post-treatment groups and control

	TC (mmol/L)	TG (mmol/L)	HDL (mmol/L)	LDL (mmol/L)	VLDL (mmol/L)
Group A	2.11 ± 0.21	0.72 ± 0.13	1.1 ± 0.11	0.68 ± 0.15	0.33 ± 0.06
Group B	2.58 ± 0.25	1.14 ± 0.27	0.6 ± 0.08	1.46 ± 0.06	0.52 ± 0.12
Group D	2.21 ± 0.30	0.82 ± 0.37	0.85 ± 0.34	1.0 ± 0.25	0.37 ± 0.17
Group E	2.48 ± 0.26	0.75 ± 0.11	0.93 ± 0.11	1.2 ± 0.29	0.34 ± 0.05
Group F	2.26 ± 0.32	0.77 ± 0.18	0.81 ± 0.22	1.09 ± 0.21	0.35 ± 0.08
p-values	0.0908	0.1186	0.0283	0.0005	0.1129
F-values	2.316	2.087	3.36	7.871	2.129
Tukey's Multiple Test	Summary	Summary	Summary	Summary	Summary
Group A vs Group B	ns	Ns	*	***	ns
Group A vs Group D	ns	Ns	ns	ns	ns
Group A vs Group E	ns	Ns	ns	**	ns
Group A vs Group F	ns	Ns	ns	*	ns

Group B vs Group D	ns	Ns	ns	*	ns
Group B vs Group E	ns	Ns	ns	ns	ns
Group B vs Group F	ns	Ns	ns	ns	ns
Group D vs Group E	ns	Ns	ns	ns	ns
Group D vs Group F	ns	Ns	ns	ns	ns
Group E vs Group F	ns	Ns	ns	ns	ns

Group A- normal control, Group B – post treatment control, Group D- almond post treatment group, Group E- vitamin e post treatment group, Group F – (almond+vit E) post treatment group.

3.3 Antioxidant Profile of the Post-treatment Groups and Control.

The details of the antioxidant profile of the post-treatment groups and control are shown in table 3.3. The table shows no significant variations in MDA levels amongst the group at (P = 0.1103, F = 2.15). There were significant variations in SOD levels between group B vs D and group D vs E at (P = 0.0052, F = 5.059). There were no significant variations amongst the rest of the groups.

Significant variations were also observed in the TAC levels among group A vs B, group A vs D, group A vs E and group A vs F at (P = 0.0002, F = 6.133). The rest groups showed no significant differences.

Table 3.3 Antioxidant profile of the post-treatment groups and control

	MDA (ng/ml)	SOD (ng/ml)	TAC(mmol/L)
Group A	248.8 ± 54.17	2.87 ± 0.36	0.12 ± 0.01
Group B	376 ± 54.02	1.43 ± 0.35	0.05 ± 0.02
Group D	295.83 ± 61.09	3.4 ± 1.18	0.06 ± 0.02
Group E	325 ± 87.52	1.97 ± 0.42	0.07 ± 0.02
Group F	297.83 ± 70.56	2.82 ± 0.97	0.06 ± 0.03
p-values	0.1103	0.0052	0.002
F-values	2.15	5.059	6.133
Tukey's Multiple Test	Summary	Summary	Summary
Group A vs Group B	ns	ns	**
Group A vs Group D	ns	ns	**
Group A vs Group E	ns	ns	*
Group A vs Group F	ns	ns	**
Group B vs Group D	ns	**	ns
Group B vs Group E	ns	ns	ns
Group B vs Group F	ns	ns	ns
Group D vs Group E	ns	*	ns
Group D vs Group F	ns	ns	ns
Group E vs Group F	ns	ns	ns

Group A- normal control, Group B – post treatment control, Group D- almond post treatment group, Group E - vitamin E post treatment group, Group F – (almond+vit E) post treatment group.

IV. Discussion

Post treatment after inducing nephrotoxicity shows non-significant (P>0.05) decrease in urea levels of almond group (group D), Vitamin E (group E) and combined treatment group (group F) compared with the paracetamol group (group B). For almonds, there was no reported study of effect on diseased kidney. However, in human study conducted by Yngbaret *al*, it was rather reported that renal failure occurred due to excessive intake of almond, (Yngbaret. *al*, 2015).

Comparing the urea levels of the pre-treatment group and post treatment groups showed significant (P<0.05) variation in almond groups (P < 0.0001, T=7.55). The vitamin E and combined treatment groups showed no significant variation.

Creatinine levels of the post-treated groups showed a non-significant increase in almond group (group D), vitamin E (group E) and combined treatment group (group F) when compared to the normal control (group A) whereas comparing with paracetamol control group (group B) showed no significant decrease in creatinine levels.

The AST levels of the post treatment groups and control shows no significant decrease in AST levels for almond (group D), vitamin E (group E) and combined treatment (group F) groups compared to the paracetamol control (group B). Previous studies have demonstrated hepatoprotective effect of vitamin E in acetaminophen treated rats (Emmanuel *et al.*, 2015). The ALT levels of the post-treatment groups and control (table 3.1) shows no significant ($P > 0.05$) decrease in almond (group D) and vitamin E (group E) groups compared to the paracetamol control (group B). However, the combined treatment group (group F) showed significant ($P < 0.05$) decrease in the ALT level compared to the paracetamol control (group B). This indicates ameliorative effects of the combined treatment and synergetic effect of almond and vitamin E. In a study by Xiao-Yan *et al.* (2011) almond oil reduced ALT activities in carbon tetrachloride induced hepatotoxic rats (Xiao-Yan *et al.*, 2011).

ALP levels of the post-treatment groups shows no significant ($P > 0.05$) variation in almond (group D), vitamin E (group E) and combined groups (group F).

Post-treatment of almond (group D), vitamin E (group E) and combined treatment (group F) showed no significant decrease in TG level compared to both normal control (group A) and paracetamol control (group B).

Post-treatment with almond (group D), vitamin E (group E) and combined treatment (group F) showed no significant increase in HDL level compared with the paracetamol control group (group B). This indicates that post treatment with almond, vitamin E and their combination may not have any effect on HDL levels in paracetamol induced toxicity.

Post treatment result recorded a significant decrease in LDL levels of the almond group (group D) compared with the paracetamol control (group B). However, there was no significant decrease in the vitamin E (group E) and combined group (group F) compared with the paracetamol group (group B). The almond result is in line with Berryman *et al.* (2011). They found that almond have a consistent LDL-C lowering effect in healthy individual and in individuals with high cholesterol and diabetes. Almonds are low in saturated fatty acids and rich in unsaturated fatty acids and contain fibre, phytosterols, plant protein, α -tocopherol, arginine, magnesium, copper, manganese, calcium and potassium. The mechanism responsible for the LDL-C reduction is associated with the nutrients they contain (Berryman *et al.*, 2011).

Post treatment result reveals no significant difference in the VLDL levels of almond (group D), vitamin E (group E) and combined group (group F) compared to the paracetamol control group (group B) and normal control (group A).

This study shows a significant increase in MDA and corresponding decreases in SOD but TAC levels were significant when values for rats that were induced on the first day (post treatment control, group B) were compared with those of the normal control (group A). However, for rats that were induced on the 14th day (pre-treated control, group C), there was significant increase in MDA levels when values were compared with that of the normal control group (group A). This is an indication that paracetamol induced hepatotoxicity is accompanied with increase in production of reactive oxygen species. These species have been implicated in oxidative stress particularly lipid peroxidation and the increase in the production of MDA. Oxidative stress has been considered as a conjoint pathological mechanism, and it contributes to initiation and progression of liver injury. The liver is a major organ attacked by ROS (Sanchez-Valle *et al.*, 2012). Parenchymal cells are primary cells subjected to oxidative stress induced injury in the liver. Moreover, Kupffer cells, hepatic stellate cells and endothelial cells are potentially more exposed or sensitive to oxidative stress-related molecules.

MDA is the index for lipid peroxidation. Lipid peroxidation once initiated results in oxidative deterioration of polyunsaturated lipids and hence it is a marker of cell membrane injury. Results of the pre-treatment groups showed significant decrease in MDA levels of all the groups (almond (group G), vitamin E (group H) and combined (group I). This implies that almond, vitamin and their combined groups all have antioxidant effects. The vitamin E result is in accordance with previous works, (Wariboet *et al.*; 2017). Antioxidant properties of almonds have also been reported (Barry, 2000). These antioxidant effects assist in the preservation of membrane integrity through radical scavenging (Gonzalez *et al.*; 2011). There is no known study so far on the combined effects of almond and vitamin E.

Post-treatment groups showed no significant difference in MDA levels of almond (group D), vitamin E (group E) and combined groups (group F) compared with the paracetamol control (group B) and the normal control (group A).

Post-treatment groups for SOD levels revealed significant increase in almond group (group D) compared with the paracetamol control (group B). However, vitamin E (group E) and combined treatment group (group F) showed no significant difference. This finding is suggestive of the ability of almond to boost the production of the natural antioxidant SOD within the system of the experimental animals and also an evidence

of the quenching capacity on the free radicals. This corroborates with the findings of Barry who reported a strong antioxidant potential of almond and vitamin E administered separately and in combination to alcohol induced hepatotoxic albino rats, (Barry, 2000). Almond by phytochemical analysis demonstrate strong composition of flavonoid and alkaloids. These two phytochemical are known for their strong antioxidant properties. Natural antioxidants contained in edible or medicinal plants often possess strong antioxidant and free radical scavenging abilities as well as anti-inflammatory action, which are also supposed to be the basis of other bioactivities and health benefits. Rutin is a flavonoid glycoside that possessed different protective effects against lipid peroxidation and oxidative-stress-mediated diseases, (Dhibiet *al.*, 2011). This implies that almonds have the ability to increase SOD in paracetamol induced toxicity. Post treatment results for TAC levels recorded a no significant increase in almond (group D), vitamin E (group E) and combined (group F) groups compared to the paracetamol control (group B) and a significant decrease compared to the normal control (group A). This implies that these treatment groups may not repair or protect against oxidative damage caused by paracetamol. This is not in line with reported studies on vitamin E which is capable of reversing oxidative damage to cell membrane. The difference in these studies could be as a result of differences in dosage of vitamin E administered.

V. Conclusion

Post-supplementation of almond seed and vitamin E may confer some lipid lowering effect on and hepatic cell regeneration in rats exposed to paracetamol toxicity. The supplementation may also boost the antioxidant capacity through the increase in SOD and TAC levels.

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