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Serum Biochemical Changes in Rabbits Experimentally Infected with *Trypanosoma evansi* and Treated with Ethanolic Stem Bark Extract of *Butyrospermum paradoxum* (*Sapotaceae*)

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ABSTRACT

The serum biochemical changes in rabbits experimentally infected with *Trypanosoma evansi* and treated with crude ethanolic stem bark extract of *Butyrospermum paradoxum* (*Sapotaceae*) was determined. Thirty-five New Zealand rabbits were used for this study; they were divided into seven groups (A-G) of five rabbits each. Rabbits in groups (A-E) were infected each with 1.0 x 10^6 *Trypanosoma evansi.* Group A were simultaneously treated with 100 mg/kg of the extract; group B (200 mg/kg of extract) and group C (400 mg/kg of extracts) were treated for 4 days at 16 dpi (peak of parsitemia), while group D was treated with 3.5 mg/kg of Berenil® at 16 dpi, group E (infected untreated), group F (uninfected control). Group G was uninfected, but treated with extract at 400 mg/kg. There was complete clearance of parasites from the blood of rabbits in Groups B, C and D by day 26, while there was no clearance of parasite in group E. it took a minimum of 1 day and a maximum of 10 days to clear the parasites in the blood of treated groups. Infected rabbits treated with 200 mg/kg of the extract had longer clearance time for *T. evansi* induced parasitaemia. The enzyme activities of alanine aminotransferase and aspartate aminotransferase, and direct bilirubin concentration increased significantly ($p<0.05$) in the infected rabbits, while serum glucose significantly decreased ($p<0.05$). These biochemical parameters however, attained their normal pre-infection status at 40 days in the groups treated with 400mg/kg of the extract and 3.5mg/kg of Berenil®. The study shows that 400mg/kg of the extract was effective in eliminating the parasite at 19 dpi and a reversal of the biochemical parameters to normal.

Keywords: Biochemical changes; *Butyrospermum paradoxum*; Rabbits; *Trypanosoma evansi*

INTRODUCTION

Trypanosomosis is one of the limiting factors to livestock industry in Sub-Saharan Africa despite all the attempts at controlling it (Kamunga, 2003). The disease is characterized by slow progression, loss of body condition, accompanied by arrays of colonial disorders which include anaemia, central nervous manifestation, weakness, emaciation, coma, infertility and abortion (Monzoo *et al.,* 2003, Chechet *et al.,* 2010). Haemato-pathological and serum biochemical aberrations are characteristics of trypanosomosis in domestic animals and man (Anosa, 1988). Marked elevations in the levels of serum Aspartate Amino-Transferase (AST), Alkaline Phosphatase (ALP) and Alanine Amino-Transferase (ALT) have been observed in both rabbits and rats experimentally infected with *Trypanosoma brucei* (Oruhe, *et al.,* 2005) and *T. congolense* (Egbe-Nwiyi *et al.,* 2005). Increases in ALT, creatinine and total bilirubin in camels experimentally infected with *T. evansi* have also been reported (Mbaya *et al.,* 2014). Other biochemical changes that have been reported in trypanosomosis include hypoglycaemia (Anosa, 1988), increased plasma bilirubin in *T. brucei* infected dogs (Omotainse *et al.,* 1994) and rabbits (Arowolo *et al.,* 1989. An increase in urea in rats experimentally infected with *T. brucei* has also been reported (Egbe-Nwiyi, *et al.,* 2005).

Butyrospermum paradoxum extract contain varying number of alkaloids, steroids, tannins, saponins and flavonoids and it has been found to be useful in the traditional treatment of several human and animal diseases (Rabo, 1998, Ogunwande *et al.,* 2001. Its stem bark extract has been shown to produce anti-trypanosomal effects by reducing the level of parasitaemia in rats infected with *Trypanosoma congolense* and *T. brucei brucei* (Mbaya *et al.,* 2007*).* Currently, there is no data on the effect of the extract in *T. evansi* infected rabbits. Therefore, this work was aimed at determining the changes in serum biochemistry in rabbits experimentally infected with *T. evansi* and treated with graded doses of ethanolic extract of *B. paradoxum* stem bark.

MATERIALS AND METHODS

Plant Collection and Identification

The stem bark of *Butyrospermum paradoxum* (Sapotaceae) was collected along Maiduguri-Damboa Road, Borno state, Nigeria. The plant was taxonomically authenticated as *Butyrospermum paradoxum* at the Department of Biological Sciences, University of Maiduguri and deposited at habarium of the Department of Biological Science under a voucher specimen 'Vet 225 A4'.

Stem bark in distilled water and air-dried under a shade. The dried stem bark was then ground into fine powder using pestle and mortar and sieved to remove excess coarse plant materials. The powder (1000 g) was exhaustively soxhlet-extracted in absolute ethanol using a soxhlet-extractor 6730® and condenser 6740® (Quick fit, England) for 10hr at 60ºC (WHO, 1992).

Parasite Isolation

Trypanosoma evansi strain used in this study was initially isolated from a naturally infected camel in Sokoto State, Nigeria. The Trypanosome parasites were inoculated intraperitoneally into four donor rabbits, which were then transported to the Veterinary Parasitology Laboratory, University of Maiduguri, Nigeria. Parasitaemia and parasite counts were determined according to Herbert and Lumsden (1976). Following the establishment of parasitaemia, *Trypanosoma evansi* organisms were maintained in the laboratory by serial passages into other rabbits.

Experimental Animals

Thirty-five apparently healthy adult New Zealand rabbits of both sexes, aged 5-6 months and weighing 1.1-1.7kg were used for the study. They were fed with Vital feed (Grand cereal Jos Plateau State). grower's mash and fresh green vegetables spinach, carrots, cabbage and cucumber occasionally). Water was provided ad-libitum. The animals were preconditioned for14 days in order to acclimatise them to their new environment before the commencement of the experiment. This research was conducted in line with the guidelines of the Animal Care and Use Committee, Faculty of Veterinary Medicine, University of Maiduguri, Nigeria with approval code: PARA 021.

Experimental Design

Thirty-five (25) rabbits of both sexes were randomly separated into seven groups (A-G) of five rabbits each. Each rabbit in groups A-E was were intraperitoneally infected with 1.0 x 10^6 *Trypanosoma evansi* diluted with phosphate buttered glucose saline (pH 7.2). The Group A rabbits was simultaneously treated intraperitoneally with 100 mg/kg of the extract at the time of infection. Group B and C rabbits were treated intraperitoneally for 4 days with 200 mg/kg and 400 mg/kg of the extract at 16 days post infection (P.I) coinciding with peak of parasitaemia, respectively. The group D rabbits were treated with diminazene aceturate Berenil® at a single dose of 3.5 mg/kg on day 16 PI. Group E served as infected-untreated control, while group F was the uninfected untreated control. Group G was uninfected but treated with 400 mg/kg. The experiment was terminated at day 40 PI.

Blood Sample Collection and Estimation of Parasitaemia

Blood sample was obtained from the ear vein of infected rabbits and examined using wet mount technique under light microscopy (x400 magnification). The degree of parasitaemia was estimated at 4 days intervals as previously described (Herbert and Lumsden, 1976). Serum sample for biochemical test was harvest from whole blood collected using plain sample bottles prior to euthanasia of the rabbits.

Biochemical Analysis

The concentration of alkaline phosphates (ALP) was determined as described by Babson *et al.* (1996), while alanine amino transferase (AST) and aspartate aminotransferase (AST) was determined as described by Schmidt and Schmidt (1963). Total bilirubin and direct bilirubin were determined calorimetrically (Jendrassik and Grof, 1938). Urea nitrogen was determined using the diacetyl method of Natelson (1951). Glucose was determined using the colorimetric enzyme method as described by Baker *et al.,* (2011). All experiments were conducted using commercial kits manufactured by Randox Laboratories®

Statistical Analysis

Data generated were analysed using SPSS statistical software version 21.0. The data were expressed as Mean ± standard deviation (S.D) and One-way analysis of variance (ANOVA) was employed to determine the relationships between the experimental groups. $P < 0.05$ was considered significant.

RESULTS

Based on the phytochemical constituents, the stem bark extract of *Butyrospermum paradoxum* contained carbohydrates, tannins, cardiac glycosides, saponin glycosides, flavonoids and alkaloids (Table 1).

Onset and Level of Parasitemia

Trypanosome parasites appeared in the blood of rabbits in Groups B, C, D and E at six days post infection. On day nine post infection, all the infected rabbits (Groups B, C, D and E) had parasitemia. There were no variations in the mean onset of parasitemia (OP) in rabbits of the infected groups (Table 2).

Clearance of Parasites Post Treatment

Treatment commenced at the peak of parasitemia (16 dpi). On day 19, only group B and E had parasitemia, whereas no parasites were seen in groups C and D. There was complete clearance of parasites from the blood of rabbits in Groups B, C and D by day 26, while there was no clearance of parasite in group E. it took a minimum of 1 day (group D) and a maximum of 10 days (group B) to clear the parasites in the treated groups (Table 2).

The mean serum alkaline phosphatase (ALP) activity in different groups is presented in Table 3. There were no differences ($p>0.05$) between all groups at day 0. However, at day 12, increased ALP concentration was observed in

groups B, C, D and E. Similarly, at day 40, increased ($p<0.05$) ALP concentration (2 folds) was observed in groups E.

The mean serum alanine amino transferase activity in different groups is presented in Table 4. While no differences were observed at day 0, increased ALT concentration was observed in groups B, C, D, E and F which was up to 4-fold increases at day 12. However, at day 40, only group F showed increased ALT activity.

The mean serum aspartate amino transferase activity in different groups is presented in Table 5. While no differences were observed at day 0, increased AST concentration was observed in groups B, C, D and E ranging from 16-18-fold increases at day 12. However, at day 40, only group E showed increased AST concentration.

The mean direct bilirubin concentration (DBR) in different groups is presented in Table 6. While no differences ($p>0.05$) were observed at day 0, increases ($p<0.05$) of up to 7 folds in DBR concentration was observed in groups B, C, D and E at day 12. At day 40, DBR concentration increased by 3 folds in group B and 12 folds in group E.

The mean total bilirubin concentration (TBR) in different groups is presented in Table 7. While no differences ($p>0.05$) were observed at day zero, 2-fold increases ($p<0.05$) in TBR concentration were observed in groups B, C, D and E at day 12. At day 40 post treatment, only group E had a 3-fold increase ($p<0.05$) in TBR.

The mean urea nitrogen concentration (BUN) in different groups is presented in Table 8. While no differences ($p>0.05$) were observed at day 0, increases ($p<0.05$) of up to 6 folds in BUN concentration was observed in groups B, C, D and E at day 12. However, at day 40, an 11-fold increase in BUN was observed in group E alone.

Table 1: Phytochemical constituents of the ethanolic extract of the stem bark of *Butyrospermum paradoxum*

Phytochemical Constituents	Tests	Inferences
Carbohydrates	Molisch's	+
	Barfoed's	-
	Free reducing sugars (Fehling's)	+
	Combined reducing sugars	+
	Ketoses	+
	Pentoses	-
	Soluble starch	-
Tannins	Ferric chloride	+
	Lead	+
Phlobatannins		-
Glycosides	Free anthraquinone	-
	Combined anthraquinone	-
Cardiac glycosides	Solkowski's test	+
	Lieberman-Buchard test	+
	Terpenoids	+
Saponin glycosides	Frothing	+
Flavonoids	Shinoda's test	+
	Ferric chloride test	+
	Lead acetate	+
	Sodium	-
Alkaloids	Dragendorff's reagent	+
	Mayers reagent	+

Keys
+ = Present
- = Absent

Table 2: The effect of ethanolic extract of *Butyrospermum paradoxum* stem bark on *in vitro* parasite count ($\times 10^6$/ml) in rabbits experimentally inoculated with *Trypanosoma evansi*

Groups/Treatment Regimes (n=5)	**Days Post Infection/ *in vitro* parasite count ($\times 10^6$/ml)**					
	6	9	16	19	26	40
Group B	7.16±0.5	Swarm	3.1±0.5	2.1±0.5	0	0
Group C	6.93±0.6	Swarm	2.1±0.4	0	0	0
Group D	7.13±0.5	Swarm	0	0	0	0
Group E	7.17±0.6	Swarm	Swarm	Swarm	Swarm	0
Group F	0	0	0	0	0	0

Table 3: Mean serum alkaline phosphatase (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum*

Groups/Treatment Regimes (n=5)	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A	140.2 ± 1.48[a]	140.6 ± 1.48[a]	140.5 ± 1.48[a]
Group B	140. ± 1.48[a]	187.6 ± 1.71[b]	152.2 ± 1.54[c]
Group C	140.2 ± 1.48[a]	187.9 ± 1.71[b]	140.2 ± 1.48[a]
Group D	142.6 ± 1.48[a]	177.9 ± 1.48[b]	142.4 ± 1.49[b]
Group E	140.6 ± 1.48[a]	289.0 ± 2.13[b]	330.8 ± 2.27[c]
Group F	140.3 ± 1.48[a]	140.3 ± 1.48[a]	140.2 ± 1.48[a]
Group G	140.2 ± 1.48[a]	140.0 ± 1.48[a]	140.3 ± 1.48[a]

[a,b,c] Numbers with different superscripts in rows and columns differed significantly ($p<0.05$) **Group A:** Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract.

Table 4: Mean serum alanine amino transferase (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum*

Groups/Treatment Regimes	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A	6.6 ± 0.32[a]	6.7 ± 0.32[a]	6.8 ± 0.39[a]
Group B	6.4 ± 0.32[a]	6.4 ± 0.32[a]	6.4 ± 0.32[a]
Group C	6.8 ± 0.32[a]	26.8 ± 0.63[b]	8.8 ± 0.37[c]
Group D	6.6 ± 0.32[a]	27.0 ± 0.65[b]	6.6 ± 0.32[a]
Group E	6.4 ± 0.32[a]	26.6 ± 0.63[b]	6.3 ± 0.32[a]
Group F	6.5 ± 0.32[a]	27.8 ± 0.66[b]	47.8 ± 0.86[c]
Group G	6.8 ± 0.32[a]	6.9 ± 0.32[a]	6.7 ± 0.32[a]

[a,b,c] Numbers with different superscripts in rows and columns differed significantly ($p<0.05$)
Group A: Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract

Table 5: Mean serum aspartate amino transferase (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum* and their controls

Groups/Treatment Regimes	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A	15.6 ± 0.48[a]	15.2 ± 0.48[a]	150.0 ± 0.48[a]
Group B	15.2 ± 0.48[a]	250.0 ± 1.98[b]	18.7 ± 0.54[a]
Group C	15.4 ± 0.48[a]	240.2 ± 1.94[b]	15.5 ± 0.48[a]
Group D	16.0 ± 0.5[a]	280.2 ± 1.90[b]	16.0 ± 0.5[a]
Group E	16.2 ± 0.5[a]	260.2 ± 2.02[b]	360.0 ± 2.37[c]
Group F	15.8 ± 0.48[a]	15.7 ± 0.48[a]	15.8 ± 0.48[a]
Group G	15.6 ± 0.48[a]	15.7 ± 0.48[a]	15.6 ± 0.48[a]

[a,b,c] Numbers with different superscripts in rows and columns differed significantly ($p<0.05$)
Group A: Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract

Table 6: Mean direct bilirubin (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum*

Groups/Treatment Regimes	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A	3.6 ± 0.24[a]	3.7 ± 0.24 [a]	3.7 ± 0.24 [a]
Group B	3.5 ± 0.24 [a]	27.0 ± 0.65 [b]	10.8 ± 0.41 [c]
Group C	3.6 ± 0.24 [a]	26.7 ± 0.65 [b]	3.6 ± 0.24 [a]
Group D	3.4 ± 0.24 [a]	26.6 ± 0.64 [b]	3.5 ± 0.23 [a]
Group E	3.2 ± 0.24 [a]	27.2 ± 0.65 [b]	43.7 ± 0.83 [c]
Group F	3.6 ± 0.24 [a]	3.5 ± 0.24 [a]	3.6 ± 0.24 [a]
Group G	3.5 ± 0.24 [a]	3.6 ± 0.24 [a]	3.5 ± 0.24 [a]

[a,b,c]Numbers with different superscripts in rows and columns differed significantly ($p<0.05$)
Group A: Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract

The mean creatinine concentration (CRT) in different groups is presented in Table 9. While no differences ($p>0.05$) were observed at day 0, a 2-fold increases ($p<0.05$) in CRT concentration was observed in groups B, C, and D at day 12. At day 40, a 3-fold increase was observed in group E.

The mean glucose concentrations in different groups are presented in Table 10. There were no differences in the glucose concentration between all groups at day 0. At day 12, rabbits from groups B, C, D and E had a lower ($p<0.05$) glucose concentration than the rest of the groups. However, at day 40, group C had a lower ($p<0.05$) glucose concentration than other groups.

Table 7: Mean total bilirubin (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum*

Groups/Treatment Regimes	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A	15.0 ± 0.48[a]	15.2 ± 0.48 [a]	15.0 ± 0.48 [a]
Group B	15.2 ± 0.48 [a]	42.3 ± 0.81 [b]	17.0 ± 0.52 [a]
Group C	15.0 ± 0.48 [a]	42.2 ± 0.81 [b]	15.0 ± 0.48 [a]
Group D	15.6 ± 0.48 [a]	40.0 ± 0.76 [b]	15.6 ± 0.48 [a]
Group E	15.0 ± 0.48 [a]	36.8 ± 0.76 [b]	47.8 ± 0.86 [c]
Group F	15.2 ± 0.48 [a]	15.3 ± 0.48 [a]	15.2 ± 0.48 [a]
Group G	15.5 ± 0.48 [a]	15.6 ± 0.4 [a]	15.4 ± 0.48 [a]

[a,b,c]Numbers with different superscripts in rows and columns differed significantly ($p<0.05$)
Group A: Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract

Table 8: Mean urea nitrogen (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum*

Groups/Treatment Regimes	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A:	4.8 ± 0.27[a]	4.7 ± 0.27 [a]	4.8 ± 0.27 [a]
Group B:	4.7 ± 0.27 [a]	27.3 ± 0.65 [b]	8.8 ± 0.37 [a]
Group C:	5.0 ± 0.27 [a]	27.0 ± 0.65 [b]	5.2 ± 0.27 [a]
Group D:	4.8 ± 0.27 [a]	26.8 ± 0.65 [b]	4.7 ± 0.27 [a]
Group E:	5.2 ± 0.27 [a]	26.7 ± 0.65 [b]	55.6 ± 0.93 [c]
Group F	4.9 ± 0.27 [a]	4.8 ± 0.27 [a]	4.8 ± 0.27[a]
Group G:	4.7 ± 0.27 [a]	4.7 ± 0.27 [a]	4.6 ± 0.27 [a]

[a,b,c]Numbers with different superscripts in rows and columns differed significantly ($p<0.05$)
Group A: Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract

Table 9: Mean creatinine (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum*

Groups/Treatment Regimes	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A	84.6 ± 1.15[a]	84.7 ± 1.15 [a]	84.6 ± 1.15 [a]
Group B	84.7 ± 1.15 [a]	167.9 ± 0.12 [b]	90.2 ± 1.19 [a]
Group C	90.2 ± 1.19 [a]	168.9 ± 1.62 [b]	90.2 ± 1.19 [a]
Group D	84.8 ± 1.15 [a]	168.2 ± 1.62 [b]	84.8 ± 1.15[a]
Group E	90.4 ± 1.19 [a]	168.8 ± 1.62 [a]	236.6 ± 1.92 [c]
Group F	89.9 ± 1.19 [a]	89.8 ± 1.19 [a]	89.7 ± 1.19[a]
Group G	87.7 ± 1.17 [a]	87.8 ± 1.17 [a]	87.7 ± 1.17 [a]

[a,b,c]Numbers with different superscripts in rows and columns differed significantly ($p<0.05$)
Group A: Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract

Table 10: Mean serum glucose (mmol/l) of New Zealand Rabbits Experimentally infected with *T. evansi* and treated with graded doses of the ethanolic stem bark extract of *B. paradoxum* and their controls

Groups/Treatment Regimes	Pre-infection (Day 0)	Pre-treatment (Day 12)	Post-treatment (Day 40)
Group A:	4.5 ± 0.27[a]	4.5 ± 0.27 [a]	4.6 ± 0.27 [a]
Group B:	4.6 ± 0.27 [a]	1.9 ± 0.77 [b]	3.6 ± 0.24 [a]
Group C:	4.0 ± 0.27 [a]	1.8 ± 0.17 [b]	4.0 ± 0.27 [a]
Group D:	4.5 ± 0.27 [a]	2.0 ± -0.18 [b]	4.6 ± 0.27[a]
Group E:	4.2 ± 0.27 [a]	2.2 ± 0.19[b]	0.8 ± 0.11 [c]
Group F:	4.0 ± 0.27[a]	4.2 ± 0.27 [a]	4.0 ± 0.27[a]
Group G:	4.6 ± 0.27 [a]	4.6 ± 0.27 [a]	4.7 ± 0.27 [a]

[a,b,c]Numbers with different superscripts in rows and columns differed significantly ($p<0.05$)
Group A: Extract (100mg); **Group B:** Extract (200mg); **Group C:** Extract (400mg); **Group D:** Berenil® 3.5mg; **Group E**: Infected Control; **Group F**: Uninfected; **Group G**: Uninfected, treated with 400mg Extract

DISCUSSION

Serum biochemical changes in rabbits experimentally infected with *trypanosoma evansi* and treated with ethanolic stem bark extract of *butyrospermum paradoxum* (sapotaceae) was carried out in this study. The increased in ALP, ALT, AST, direct bilirubin and total bilirubin observed in this study were suggestive of hepatocellular damage with intrahepatic cholestatsis. The increase in ALT agrees with the observation in *T. evansi* infected Camel (Mbaya *et al.,* 2014). Increased ALP and AST in the infected groups agrees with the observations in *T. vivax* infection of cattle (Gray, 1969; Kadima *et al.,* 2000); *T. congelense* infected rabbit (Takeet and Fagbemi, 2009), *T. evansi* infected camels (Boid *et al.,* 1972) and *T. congolense* infected cattle (Weilde *et al.,* 1974). However, the continuous increases in enzyme activities in the infected untreated control (Group E) may also be due to destruction of trypanosomes by the host defence system which resulted in release of the trypanosomal AST and ALP. The values of ALT, AST and ALP returned to normal at day 40 of treatment which suggests that the treatment had an affect (Gray, 1969).

Elevations in direct bilirubin and total bilirubin in all the infected groups agrees with the reports of Sivajothi *et al.* (2015) and Mbaya *et al.* (2014) in Camels infected in *T. evans;* Arowolo *et al.* (1989) who observed elevated bilirubin in rabbits infected with *T. brucei*; Omotainse *et al.* (1994) in *T. brucei* infected dogs; Gow *et al.* (2007) in dogs naturally infected with *T. congolense* Takeet and Fagbami, (2009). The increase in bilirubin is as a result of massive red blood cell destruction and hepatic cholestatsis as previously reported in *T. brucei* infected rabbits (Arowolo *et al.,* 1988) and *T. congolense* infected rabbits (Takeet and Fagbami, 2009). The elevations in urea nitrogen and creatinine are suggestive of azotemia (Anosa, 1988) and agrees with the reports of Sadique *et al.* (2001) and Egbe-Nwiyi *et al. (*2005). Anemia as seen in trypanasomosis caused reduced blood volume which in turn results in hypoperfusion of the kidneys. This results in a pre-renal azotemia due to poor excretion of urea and creatinine. The gradual significant decrease in the values of bilirubin, creatinine and urea at day 40 of the treatment could be as a result of the treatment with the extract.

The hypoglycaemia observed in this study is consistent with the findings of Weilde *et al.* (1974), Takeet and Fagbami (2009) and Mbaya *et al.* (2014). This might be as a result of excessive utilization of blood glucose by trypanosomes for their metabolism (Anosa, 1988; Igbokwe, 1994) and may also be associated with the fact that the high energy demand in rabbits during high parasitaemia and impaired glucose release from the glucogenic pathways (Mbaya *et al.,* 2014). The significant increase (hyperglycaemia) in the blood glucose observed at day 40 of the treatment could be due to the effect of the extract.

Conclusion

The results of this study concluded that *T. evansi* infection in rabbits resulted in alterations of various biochemical parameters that were suggestive of liver and kidney

dysfunctions. However, intervention with *Butyropermmum paradoxum* extract at 400mg/kg improved these alterations induced by *T. evansi.* Thus, these findings support the use of this plant in traditional medical practice for the treatment of Trypanosomosis.

Conflict of Interest

The authors declare that they have no conflict of interest.

Authors Contribution

FK and AWM designed the work. FK, KAS and ZMK conducted the laboratory work. YA analysed the data and interpreted the results. All authors have read and approved the final manuscript.

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