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RESEARCH ARTICLE

Effect of *Aloe vera* gel on some haematological parameters and serum electrolytes in high salt loaded Wistar rats

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ABSTRACT

This study investigated the effect of *Aloe vera* gel on some haematological parameters and serum electrolytes in high salt loaded rats. Twenty (20) male Wistar rats (180-250 g) were randomly assigned into 4 groups (n=5): Control-received 0.2 ml normal saline; *Aloe*-received 600 mg/kg of *Aloe vera* gel orally once daily; Salt-fed (SF) received high salt diet (8% NaCl in feed + 1% NaCl in H_2O); Saltfed-treated (SF+*Aloe*) received high salt diet + *Aloe vera* gel. All groups had access to rat feed and water throughout the duration (six weeks) of treatment. Blood samples were collected from each animal via cardiac puncture for analysis. Red blood cell (RBC) count, haemoglobin (Hb) concentration and packed cell volume (PCV) were significantly ($p<0.05$) increased in SF and SF+*Aloe* groups compared with control and *Aloe* groups. Total white blood cell count was significantly ($p<0.001$) decreased in SF group compared with control and *Aloe* groups and increased ($p<0.001$) in SF+*Aloe* group compared with SF group. Neutrophil and lymphocyte counts were significantly increased and decreased respectively in SF+*Aloe* group compared with control ($p<0.01$), *Aloe* ($p<0.05$) and SF ($p<0.001$) groups. Na^+, K^+ and Cl^- concentrations were significantly increased in SF and SF+*Aloe* group compared with control and *Aloe* groups. HCO_3^- concentration was significantly increased in *Aloe* and SF+*Aloe* groups compared with control. High salt diet (HSD) caused alterations in red cell indices and posed threat to the immune system of rats. *Aloe vera* could not reverse these alterations but exhibited an immune-stimulatory effect. Both *Aloe vera* and HSD caused electrolyte imbalance.

Keywords: *Aloe vera* gel; Electrolyte; Haemoglobin; High salt diet; Red blood cell; White blood cell.

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INTRODUCTION

Salt is an essential component of life. It is composed chemically of sodium (Na^+) and chloride (Cl^-). It is used as ingredient in food and also useful in areas such as water conditioning processes, ice control and road stabilization, preservation of meat and fish and production of some other chemicals [1]. Because of its abundance and essentiality to life, salt has been designated as the fifth element being equated with earth, air,

water and fire [2, 3]. Consumption of 5 g of salt/day is the World Health Organisation (WHO)'s recommendation for adults while for children; this amount should be reduced based on the energy requirement of children relative to those of adults [4]. Excessive intake of salt is dangerous to health. It has demonstrated several deleterious effects in the body. It has been implicated in hypertension [5], kidney damage [6], osteoporosis [7], liver toxicity and fibrosis [8, 9] and has been reported to decrease plasma concentration and urinary excretion of nitrates [10]. High salt diet (HSD) ingestion has also been reported to increase the severity of asthma and is strongly related to gastric carcinoma [11]. The deleterious effects of high salt diet ingestion have been associated with oxidative stress [12-14].

Aloe vera, a plant of the family, Asphodelaceae has been reported to have the ability to combat oxidative stress [15]. It can be separated into two basic products: gel and latex. The gel is the transparent mucilage that is gotten from the pulp of the leaves while the latex (juice) is the bitter yellow exudate that is gotten from the outer skin of the leaves [16]. *Aloe vera* has demonstrated several therapeutic effects. It has been reported to inhibit growth of tumor in mice [17], alleviate respiratory tract disorders [18] and cardiovascular system disorders [19, 20]. It is also effective in treating radiation-induced dermatitis [21] and have anti-atherogenic [22], anti-ulcer [23] and immune-stimulatory [17] effects. *Aloe vera* has also been reported to reverse haemostatic derangement caused by salt loading [24].

Studies have recorded the effect of *Aloe vera* on blood physiology [22, 25-29]. But no study has recorded the effect of *Aloe vera* gel on haematological parameters and serum electrolytes of Wistar rats fed on HSD. In view of the desirability and expedience of cheaper remedies to combat complications associated with high salt intake, coupled with the therapeutic efficacies of *Aloe vera* and the paucity of information on the effect of *Aloe vera* gel on blood parameters and serum electrolytes following HSD, this study was therefore carried out to investigate the effect of *Aloe vera* gel on some haematological parameters and serum electrolytes in high salt loaded rats.

MATERIALS AND METHODS

Experimental animals

Twenty male Wistar rats (180-250 g) bought from the Department of Agriculture, University of Calabar, Nigeria were employed in the study. The animals were handled according to standard principles [30]. They were kept in properly ventilated metabolic cages in the animal house of Department of Physiology, University of Calabar and exposed to 12/12 hours light/dark cycle. The rats were given rat feed and water *ad libitum* and allowed to explore their new habitat for seven days before commencement of experiment.

Preparation of *Aloe vera* gel extract

Aloe vera plant was obtained from a garden in the University of Calabar. The leaves were being certified by the chief Hebarium in the Department of Botany, University of Calabar. The fresh leaves were thoroughly washed with tap water to remove dirt. Surgical blades were used to cut the base and apex of the leaves. The leaves were then sliced open along the margin to reveal the transparent mucilage which was then scooped into a beaker using a spatula. The mucilage was further processed by blending for 20 minutes in an electric blender and a greenish gel-like liquid obtained. This liquid was kept for 20 minutes to settle and later sieved using Whatman filter paper to obtain a particulate-free gel [31]. The *Aloe vera* extract was refrigerated (4-6°C) for 3 days after use each day.

Preparation of high salt diet and drinking water

High salt diet containing 8% of sodium chloride was prepared using a standard diet containing 0.3% sodium chloride as described by Obiefuna and Obiefuna [32].

Experimental design and extract administration

Twenty male Wistar rats were randomly assigned into four (4) groups (n=5) thus: Group 1 (control) received normal rat feed and water. Group 2 (*Aloe*) received 600 mg/kg of *Aloe vera* gel orally once daily. Group 3 (salt-fed) received high salt diet (8% NaCl feed + 1% NaCl drinking water) and group 4 (salt-fed-treated [SF+*Aloe*]) received same as group 2 + high salt diet. All groups had access to rat feed and water throughout the duration (six weeks) of the experiment.

Collection of blood samples

At the end of the 6 weeks, the rats were sacrificed under chloroform anaesthesia (3.5%) and blood samples collected via cardiac puncture using 5 ml syringes with 21G needles into sample bottles and pre-labelled ethylenediaminetetraacetate (EDTA) vials for measurement of serum electrolytes concentration and haematological parameters respectively. The samples in the EDTA vials were gently agitated to ensure uniform spread of EDTA.

Measurement of haematological parameters

Haematological parameters were measured using automated cell counter (Coulter Electronics, Luton, Bedfordshine, UK) having standard calibrations in line with the instructions of the manufacturer as previously used by Archibong et al. [33]. Parameters measured were: RBC count, PCV, Hb concentration, MCV, MCH, MCHC, WBC count, lymphocyte count and neutrophil count.

Measurement of serum electrolytes concentration

The collected blood samples were allowed for 1 hour to clot and retract. Blood in the sample bottles were centrifuged at 300 rpm at room temperature for 15 minutes using a bucket centrifuge machine (B-Bran Scientific and Instrument Company, England) and serum was obtained. The serum obtained was then used to determine serum Na^+, K^+, Cl^- and HCO_3^- levels using ion-selective electrolyte analyser (Biolyte 2000/ BioCare Corporation, Hsinchu 300, Taiwan).

Statistical Analysis

Results are presented as mean ± standard error of mean (SEM). Data were analysed using Computer software, SPSS (version 21). Statistical measure used was one-way analysis of variance (ANOVA) along with post hoc multiple comparison test (least square difference). $P<0.05$ was the criterion for statistical significance.

RESULTS

Comparison of haematological parameters in the different experimental groups

RBC count, haemoglobin concentration and PCV

Table 1 shows RBC count ($x10^6$ cell/µl), Hb concentration (g/dl) and PCV (%) for control, *Aloe*, Salt-fed (SF) and saltfed-treated (SF+*Aloe*) groups. RBC count was significantly increased in SF and SF+*Aloe* groups compared with control ($p<0.001$) and *Aloe* groups ($p<0.01$ and $p<0.001$, respectively). Hb concentration was significantly ($p<0.05$) increased in SF and SF+*Aloe* groups compared with control and *Aloe* groups. PCV was also significantly ($p<0.05$) increased in SF and SF+*Aloe* groups compared with control and *Aloe* groups. RBC count, Hb concentration and PCV were not significantly different between control and *Aloe* groups.

Table 1. Comparison of RBC, Hb concentration and PCV in the different experimental groups.

Parameter	Control	*Aloe*	SF	SF+*Aloe*
RBC Count (x10^6 cell/µl)	4.58±0.09	4.92±0.12	5.52±0.16^{***,b}	5.78±0.19^{***,c}
Hb conc (g/dl)	16.36±0.34	16.53±0.58	17.62±0.34^{*,a}	17.62±0.34^{*,a}
PCV (%)	49.20±1.02	49.67±1.74	53.00±1.74^{*,a}	53.00±1.96 ^{*,a}

Values are expressed as mean ± SEM, n = 5.
*p<0.01, ***p<0.001 vs control; a = p<0.05, b = p<0.01, c = p<0.001 vs *Aloe.*

Red cell absolute values

Table 2 shows MCV (fL), MCH (pg) and MCHC (g/dL) for control, *Aloe*, SF and SF+*Aloe* groups. MCV and MCH were significantly decreased in SF (p<0.001) and SF+*Aloe* (p<0.001) groups compared with control. MCV was significantly (p<0.005) decreased in *Aloe* group compared with control. MCV was significantly decreased (p<0.01) in SF+*Aloe* group compared with *Aloe* group. MCH was significantly decreased (p<0.01) in SF and SF+*Aloe* groups compared with *Aloe* group. There was no significant difference in MCHC in the different experimental groups.

Table 2. Comparison of red cell absolute values in the different experimental groups.

Parameter	Control	*Aloe*	SF	SF+*Aloe*
MCV (fL)	107.45±1.53	100.99±0.85*	96.22±0.85***	92.00±0.54^{***,b}
MCH (pg)	35.73±0.50	35.62±0.97	31.99±0.28^{***,b}	30.58±0.18^{***,b}
MCHC (g/dL)	33.25±0.02	33.29±0.03^{ns}	33.24±0.02^{ns}	33.23±0.01^{ns}

Values are expressed as mean ± SEM, n = 5.
ns = not significant; *p<0.01, ***p<0.001 vs control; b= p<0.01 vs *Aloe*.

White blood cell indices

Table 3 shows TWBC (x10^3 cell/µl), NEUT (%) and LYM (%) for control, *Aloe*, SF and SF+*Aloe* groups. TWBC was significantly (p<0.001) decreased in SF group compared with control and *Aloe* groups and significantly (p<0.001) increased in SF+*Aloe* group compared with SF group. NEUT count was significantly increased in SF+*Aloe* group compared with control (p<0.01), *Aloe* (p<0.05) and SF (p<0.001) groups. LYM count was significantly decreased in SF+*Aloe* group compared with control (p<0.01), *Aloe* (p<0.05) and SF (p<0.001) groups. There was no significant difference in NEUT and LYM count between control, *Aloe* and SF groups.

Table 3. Comparison of white blood cell indices in the different experimental groups.

Parameter	Control	*Aloe*	SF	SF+*Aloe*
TWBC (x10^3 cell/µl)	8.84±0.05	8.63±0.12	3.84±0.10^{***,c}	9.08±0.46^{z}
NEUT (%)	62.60±2.44	70.17±2.13^{ns}	55.80±3.40^{ns}	80.60±1.89^{**,a,z}
LYM (%)	36.20±2.29	28.50±2.08^{ns}	42.80±3.27^{ns}	18.20±2.24^{**,a,z}

Values are expressed as mean ± SEM, n = 5.
ns = not significant vs control; **p<0.01, ***p<0.001 vs control; a= p<0.05, c= p<0.001 vs *Aloe*; z= p<0.001 vs SF.

Comparison of serum electrolytes concentration in the different experimental groups

Table 4 shows serum concentrations of Na^+ (mmol/l), K^+(mmol/l), Cl^- (mmol/l) and HCO_3^- (mmol/l) for control, *Aloe*, SF and SF+*Aloe* groups. Na^+ concentration was significantly increased in *Aloe* ($p<0.01$), SF ($p<0.001$) and SF+*Aloe* ($p<0.001$) groups compared with control. It was also significantly increased in SF ($p<0.001$) and SF+*Aloe* ($p<0.01$) groups compared with *Aloe* group and significantly ($p<0.001$) decreased in SF+*Aloe* group compared with SF group.

K^+ concentration was significantly increased in SF ($p<0.05$) and SF+*Aloe* ($p<0.001$) groups compared with control and *Aloe* groups. K^+ was also significantly ($p<0.001$) increased in SF+*Aloe* group compared with SF group. There was no significant difference in K^+ concentration between control and *Aloe* groups.

Cl^- concentration was significantly ($p<0.001$) increased in all experimental groups compared with control. It was significantly ($p<0.01$) increased in SF group compared with *Aloe* group and decreased ($p<0.05$) in SF+*Aloe* group compared with SF group.

HCO_3^- concentration was significantly increased in *Aloe* ($p<0.05$) and SF+*Aloe* ($p<0.001$) groups compared with control. It was also significantly increased in SF+*Aloe* group compared with *Aloe* ($p<0.05$) and SF ($p<0.001$) groups.

Table 4. Comparison of serum electrolytes concentration in the different experimental groups.

Parameter	Control	*Aloe*	SF	SF+*Aloe*
Na^+	140.25± 0.63	143.00± 0.41**	150.00± 0.82^{***,c}	145.75± 0.48^{***,b,z}
K^+	4.45± 0.06	4.43± 0.05	4.68± 0.05^{*,a}	5.58± 0.11^{***,c,z}
Cl^-	94.75± 0.48	98.25± 0.85***	101.00± 0.58^{***,b}	98.50± 0.29^{***,x}
HCO_3^-	20.50± 0.29	22.50± 0.96*	21.00± 0.58	25.00± 0.58^{***,a,z}

Values are expressed as mean ± SEM, n = 5.
*p<0.05, **p<0.01, ***p<0.001 vs control; a= p<0.05, b= p<0.01, c=p<0.001 vs *Aloe*; x= p<0.05, z= p<0.001 vs SF.

DISCUSSION

High salt intake (HSI) has been reported to impact negatively on various cells and tissues of the body [8-11]. *Aloe vera* has been shown to protect cells from damages caused by various toxic substances [21-24].This study investigated the effect of *Aloe vera* gel on some haematological parameters and serum electrolytes in high salt loaded Wistar rats.

Results from this study show that RBC, Hb concentration and PCV were significantly increased in salt-fed (SF) and saltfed-treated (SF+*Aloe*) groups compared with control and *Aloe* groups. Our results for RBC, Hb concentration and PCV are consistent with Ofem et al. [28] who reported that high salt intake and co-administration of salt and *Aloe vera* gel increased RBC count, Hb concentration and PCV in rats. But in their study, Hb concentration was not significantly affected by HSI. The increase in RBC and PCV could be due to dehydration caused by high salt loading. This increase is a predisposing factor to hypertension as it could possibly lead to increase blood viscosity. *Aloe vera* gel was unable to reverse this increase caused by HSI as the group that received salt diet + *Aloe vera* gel also had elevated RBC count and PCV. PCV increased following the increased RBC count. The increase in Hb concentration is probably due to the increase in RBC count or stimulation of haeme biosynthesis during the process of erythropoiesis.

MCV was significantly decreased in all treatment groups compared with control. It was also significantly decreased in SF+*Aloe* group compared with *Aloe* group. The decreased MCV indicates that the RBCs became microcytic following administration of *Aloe vera* gel and salt separately and in combination. The effect was greatest when salt and *Aloe vera* gel were co-administered as observed in the SF+*Aloe* group (Table 2). This

decrease in MCV could be attributed to dehydration caused by high salt loading. Our result for MCV contradicts Ofem et al. [28] who reported that high salt loading and co-administration of salt diet and *Aloe vera* gel did not significantly alter MCV. MCH was significantly decreased in SF and SF+*Aloe* groups compared with control and *Aloe* groups. The decrease in MCH in these groups indicates microcytic hypochromic anaemia caused by high salt diet. This decrease in MCH can be attributed to the HSI since *Aloe vera* gel alone did not cause any significant effect on Hb concentration and MCH. It is likely that the salt loading suppressed the synthesis of iron which resulted in microcytic RBCs and hence decreased Hb concentration. *Aloe vera* at the administered dose was unable to prevent this effect. Our result for MCH in SF group is consistent with Ofem et al. [28]. MCHC was not significantly different between the experimental groups.

TWBC count was significantly decreased in SF group compared with control and *Aloe* groups. NEUT count was also decreased although non-significantly in SF group compared with control and *Aloe* groups. This is contrary to Ofem et al. [28] who reported significant increase in TWBC count following salt loading. The decrease in TWBC count in our study indicates the suppression of the defense mechanism and immune system of rats due to salt loading. *Aloe vera* gel however demonstrated a protective effect on the defense mechanism as TWBC count was significantly increased in SF+*Aloe* group compared with SF group and NEUT count significantly increased in this group compared with other groups. LYM count was increased although not significant, in SF group compared with control and *Aloe* groups. This increase could be due to agitation of the immune system following salt loading. LYM count was significantly decreased in SF+*Aloe* group compared with other groups. This could be a demonstration of immune-stimulatory effect of *Aloe vera*. *Aloe vera* had been previously reported to have immune-stimulatory effect [17].

Serum electrolytes play a contributory role in body fluid homeostasis and are important regulators of neuromuscular activities [34]. In addition to altered hormonal status, dietary habit is a factor that causes hormonal imbalances [35]. Results from this study show alterations in serum electrolytes concentrations. Na^+ concentration was significantly increased in all experimental groups compared with control. It was also significantly increased in SF group compared with *Aloe* group and decreased in SF+*Aloe* group compared with SF group. The increase in Na^+ concentration in SF group is consistent with earlier reports that salt loading leads to elevation of serum Na^+ concentration [36]. Salt ingestion increases the osmolarity of body fluids. This stimulates the taste centers to increase water intake and the posterior pituitary gland to increase the release of antidiuretic hormone [37]. Excessive salt intake causes elevated levels of Na^+ which causes vasoconstriction and increases the pumping force and consequently hypertension [38]. The elevated level of Na^+ in the SF group is an indication of the hypertensive effect of high salt load. The increased Na^+ concentration may mean that *Aloe vera* gel stimulated the renin angiotensin aldosterone system or is probably rich in Na^+. Increased Na^+ levels in blood (hypernatraemia) represents deficit of water in relation to the body's sodium stores [39] which may be as a result of impairment of thirst or access to water. The increased Na^+ concentration in the *Aloe* group may also mean that *Aloe vera* gel decreased body water by probably impairing the thirst centers of the hypothalamus and/or increasing urinary excretion of water. Administration of *Aloe vera* gel however reduced the hypertensive effect of high salt intake as Na^+ concentration was significantly decreased in SF+*Aloe* group compared with SF group. Entry of Na^+ into a cell is accompanied by water to increase volume. Despite the elevated levels of Na^+, in all experimental groups, MCV was not increased in these groups but was rather decreased. This may mean that *Aloe vera* gel and salt loading inhibited the Na^+-K^+- ATPase preventing the entry of Na^+ and water into the RBC to increase intracellular volume.

K^+ concentration was significantly increased in SF and SF+*Aloe* groups compared with control and *Aloe* groups. This is in contrast with report of Ofem et al. [36] who reported decreased K^+ concentration following salt loading. The increase in K^+ concentration observed in this study could mean that salt loading decreased renal potassium excretion.

Cl^- concentration was significantly increased in all experimental groups compared with control. It was also significantly increased in SF group compared with *Aloe* group and decreased in SF+*Aloe* group compared with SF group. This result for Cl^- concentration is similar to that of Na^+ in all experimental groups. This increase in the *Aloe* group could also arise as a result of inadequate water intake or loss of thirst

perception as described above. The increase in Cl^- following high salt load is consistent with Ofem et al. [36]. Na^+ and Cl^- move hand in hand. It is obvious that the increase in Cl^- observed in the SF group is because they were fed on NaCl diet. Na^+ reabsorption is coupled with Cl^- reabsorption. The same is applicable to their excretion [40].

HCO_3^- concentration was significantly increased in *Aloe* and SF+*Aloe* groups compared with control but it was not significantly different between control and SF groups. Increase HCO_3^- is an indication of increased metabolic activities. HCO_3^- is a marker for measuring the pH of blood. It acts as a buffer to maintain the pH of blood and body fluids [41]. The present results show that *Aloe vera* gel has the ability to increase blood pH.

CONCLUSION

High salt intake altered red cell indices and posed threat to the immune system of Wistar rats. *Aloe vera* gel was unable to reverse the alterations in red cell indices associated with salt loading but demonstrated an immune-stimulatory effect. Both *Aloe vera* gel and high salt load caused electrolyte imbalance.

AUTHORS' CONTRIBUTION

This research was carried out in collaboration by all authors. ANA conceived and designed the study and performed the data analysis. ALU, AAA and SAL carried out the laboratory work and collected the data. ALU interpreted the results and wrote the first draft of the article. ANA edited the initial draft. All authors read and approved the final manuscript.

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