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PROTECTIVE EFFECT OF *HIPPOPHAE SALICIFOLIA* ON THE ALUMINIUM INDUCED BEHAVIOURAL AND BIOCHEMICAL CHANGES IN FEMALE WISTAR RATS

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ABSTRACT

To analyze the effect of hydroalcoholic fruit pulp extract of *Hippophae salicifolia* on the influence of aluminium chloride induced changes in serum and tissue antioxidants, tissue ATPases, learning and memory, motor activity and coordination in female Wistar Albino rats.These rats (n=24) were administered *H. salicifolia* and $AlCl_3$ in the form of solution orally continuously for 60 days. The pharmacological studies included evaluation of antioxidant property, estimation of - lipid peroxidation, reduced glutathione level, catalase, glutathione-S-transferase,superoxide dismutase activities and analysing the effect *H. salicifolia* on membrane bound adenosine triphosphatases in Alcl3 induced toxicity.The effect of the extract of *H. salicifolia* on animal behaviour and motor coordination were assessed.Phytochemical analysis of *H.salicifolia* demonstrated the presence of carbohydrates, glycosides, phytosteroids, fixed oils and fats, saponins, gums and mucilage, tannins and phenolic compounds. Heart and lung of $AlCl_3$ treated group demonstrated a statistically significant increase in lipid peroxidation. $AlCl_3$ and *H salicifolia* treated group demonstrated increase in the reduced glutathione in lung and catalase activity in heart. An increase in the activity of glutathione-S-transferase was observed in serum, liver, lung and kidney of *H. salicifolia* treated group. A statistically significant increase in the level of Na^+/K^+ ATPase was observed in the heart and lung of $AlCl_3$ and *H. salicifolia* extract treated groups. Also increase in activity of Ca^{2+} ATPase was observed in kidney of $AlCl_3$, *H salicifolia* and both $AlCl_3$ and extract treated groups. An increase in the level of Mg^{2+} ATPase was observed in heart of $AlCl_3$ and *H. salicifolia* treated group. An increase in the time taken was observed in Jumping box in $AlCl_3$ and *H. salicifolia* treated groups. In Rota-rod, time taken was increased in *H.salicifolia* extract treated group. A decrease in the time taken in photoactometer was observed in both $AlCl_3$ and extract treated group. A decrease in the time taken in Hebb-William's maze was observed in the *H.salicifolia* treated group. Treatment with $AlCl_3$ demonstrated an increase in tissue catalase in heart and a decrease in glutathione in liver, heart and lung. *H.salicifolia* suppressed the effect of $AlCl_3$ on liver and heart. *H.salicifolia* reduced the memory blunting effect of $AlCl_3$.

KEYWORDS: $AlCl_3$,*Hippophaesalicyfolia*,.Antioxidants,ATPases,Learning and Memory

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INTRODUCTION

Hippophae (sea-buckthorn) a thorny, dioecious, deciduous, perennial, actinorhizal plant belongs to the family Elaeagnaceae[1]. The genus of *Hippophae* comprises 4 species; *Hippophae rhamnoides* L., *Hippophae salicifolia* D. Don, *Hippophae tibetiana* Schlecht and *Hippophae neurocarpa* S.W. liu et T.N. He. In India, *Hippophae* grows naturally in high-altitude areas of Jammu and Kashmir, Himachal Pradesh, Uttar Pradesh and Sikkim[2]. *Hippophae* is cultivated worldwide owing to its nutritional and medicinal properties[3]. Every part of the plant is considered as source of a large number of bioactive compounds. Leaves and fruit are rich sources of vitamins, carotenoids, flavonoids and sterols[4]. Leaves are also reported to possess anti-inflammatory properties[5]. *H. salicifolia* can thrive under extreme climatic stress, therefore, it is considered that the phytochemical profile must be distinctive and the antioxidant profile of *H. salicifolia* unique. The leaves, berries and seeds of *H. salicifolia* have high nutritional and medicinal value and are an excellent source of vitamins C, B1, B2, E, F, K, P, pro-vitamin A, sugars and organic acids. High content of vitamin C and E and other bioactive sub-stances makes it a suitable species for pharmaceutical, cosmetic and food industry. Aluminium (Al), the most abundant metal in the earth's crust, is ubiquitous in the environment and its extensive industrial utilization has stimulated considerable interest in the possible environmental toxicity of this metal. However, little is known about possible effects of Al as a trace element in animals and humans in normal conditions. It has recently become clear that when Al is mobilized from soil by acid rain, it poses a hazard to all exposed organisms[6]. Al is also thought to be a causal agent in some cases of encephalopathy and osteomalacia observed in patients with chronic renal failure caused by long-term hemodialysis[7]. Al toxicity in humans has been implicated in many neurodegenerative diseases such as Alzheimer's disease, amyotrophic lateral sclerosis, and parkinsonism-dementia[8,9,10]. The mechanism of neurotoxicity induced by aluminium and the measures to counteract these impairments should be given utmost priority especially in developing countries. Aluminium is considered to be localized in the chromatin region of nuclei and relatively strong interaction between Aluminium and DNA occurs and also causes cytogenetic damage[11,12]. Aluminium administration has been reported to induce oxidative stress by inflicting damage to membrane lipid, proteins and anti- oxidative enzyme defense system [13]. *In vitro*, Aluminium has been demonstrated to preferentially accumulate in cultured astrocytic cells [14]. Reports of *in vivo* studies suggested that Aluminium-treatment causes apoptosis like changes[15], vacuolated astrocytes with numerous lipofuscin deposits[16], abnormal mitochondrial swelling, thinning of myelin sheath, cytoplasm with multivesicular bodies[17] synaptic vesicle accumulation and hepatic dysfunction[18]. Aluminium provokes cardiotoxicity, nephrotoxicity and neurotoxicity[19]. In large amounts, Aluminium is a neurotoxicant that causes dialysis encephalopathy (dialysis dementia) in renal patients unable to effectively excrete plasma Aluminium [20]. Bioavailable Aluminium also has a causal role in Alzheimer's disease (AD)[21].Medicinal plants have been used as traditional treatments for numerous human diseases for thousands of years. Phytochemicals are non-nutritive plant chemicals that have protective/disease preventive properties. Though they are produced by plants to protect themselves, they can also protect humans against diseases. A large number of phytochemicals have attracted interest for their role in nutrition and health. Many of these phytochemicals affect the antioxidant status directly due to their function as antioxidants, indirectly by chelating prooxidant divalent metals such as Fe and Cu, or by sparing other antioxidants. Exposure to aluminium cannot be avoided because it is so common and widespread in the environment. Eating large amounts of processed food containing aluminium additives or frequently cooking acidic foods in aluminium pots may expose a person to higher levels of aluminium.The present study analyzed the effect of hydroalcoholic fruit pulp extract of *Hippophae salicifolia* on the influence of aluminium chloride induced changes in serum and tissue antioxidants, tissue ATPases,

memory and learning, and motor activity and coordination in female Wistar Albino rats.

MATERIALS AND METHODS

The present study was carried out in the Department of Pharmacology and Environmental Toxicology, Dr. A.L.M. Post Graduate Institute of Basic Medical Sciences, taramani, chennai. Institutional animal ethical committee approval was obtained prior to the study. The study has been designed for the evaluation of antioxidant property, the effect on adenosine triphosphatases and the effect on learning and memory of hydroalcoholic pulp extract of *Hippophae salicifolia* in aluminium chloride induced toxicity in female Wistar albino rats.

Plant extract

Hydroalcoholic pulp extract of *Hippophae salicifolia* was kindly provided by Prof. S. L. Maheswari, Department of Pharmacology and Environmental Toxicology, Dr. A.L.M.PG. Institute of Basic Medical Sciences, Taramani. The nature of extract was dark brown and semisolid. The extract was stored in a refrigerator at 4^{o}C till further use.

Experimental animals

Twenty four Wistar albino female rats weighing between 150-200 g were used in this study. The animals were weighed periodically and doses calculated accordingly (see Table. 1). For all animals, food was withheld for 3-4 hours prior to dosing.

Table 1
Grouping of animals and dosing into four with six animals in each group.

Groups	Group details	Dosages
Group 1	Control group	1 ml of distilled water
Group 2	$AlCl_3$ treated group	300 mg/kg body weight of $AlCl_3$ in 1 mL of distilled water once a day
Group 3	Hydroalcoholic pulp extract of *Hippophae salicifolia*	400 mg/kg body weight of hydroalcoholic pulp extract of *Hippophae salicifolia* in 1 ml of distilled water once a day
Group 4	$AlCl_3$ + Hydroalcoholic pulp extract of *Hippophae salicifolia*	300 mg/kg bodyweight of $AlCl_3$ and 400 mg/kg of hydroalcoholic pulp extract of *Hippophae salicifolia* both given at 1 hour interval, once a day

Administration of doses

The hydroalcoholic pulp extract of *Hippophae salicifolia* and $AlCl_3$ were administered in the form of solution with double distilled water using 16 gauge oral feeding tube continuously for 60 days.

Preparation of extract

The extract was prepared in double distilled water in concentration of 250 mg/ml.

Preparation of Aluminium chloride

The aluminium chloride was prepared in concentration of 100 mg/ml in double distilled water.

Preliminary phytochemical screening

The plant extract was tested for alkaloids, carbohydrates, glycosides, steroids and terpenoids, fixed oil and fats, saponins, tannins and phenolic compounds, proteins and amino acids.

Pharmacological studies

Evaluation of antioxidant property Hydro alcoholic pulp extract of *H. salicifolia* was evaluated by the estimation of following: lipid peroxidation, catalase activity, reduced glutathione level, glutathione-S-transferase activity, and superoxide dismutase activity.

Effect on adenosine triphosphatases

Effect of the hydro alcoholic pulp extract of *Hippophae salicifolia* on membrane bound adenosine triphosphatases in aluminium chloride induced toxicity were estimated by the Na^{+} K^{+} ATPase, Ca^{2+} ATPase and Mg^{2+} ATPase.

Assessment of behavioural changes and motor coordination

Assessment of motor activity by actophotometer Locomotor and behavioural activity was measured using the actophotometer. Treated animals were administered the test material or the vehicle meant for the day 90 minutes before the study for a period of 60 days. After 90 minutes of dosing, the animals were let into the actophotometer compartment. After a 5 min habituation period, the activity meter was zeroed and counts were taken for 3 minutes. The results were expressed as counts/3 minutes.

Evaluation of motor coordination by Rota-Rod

Rationale of this test is to make the animal to maintain itself on a moving rod and the animal having defective motor coordination drops from the rod. Evaluation of Rota rod performance was done on the 60th day in all the four groups. Dosing for the day on the day of study was made with the test material or the vehicle 90 minutes before the evaluation. The results are expressed in seconds.

Evaluation of learning and memory (Hebb-William's Maze)

The apparatus consists of two chambers A and B, separated by a maze. Testing was conducted in a quiet room that is illuminated by a dim light. The rat was placed in chamber A and allowed to explore the maze and the reward (food pellets) is provided at chamber B. Time taken by the animals to traverse the maze and to reach the food compartment is considered as the criterion for successful learning and memory activity. If the traversing time (counts/3minutes) is shorter than control, it shows that memory is improved or the activity of the animals is stimulated. Animals were trained in maze before the start of the treatment for the chronic study. Dosing for the day on the day of study was made with the test material or the vehicle 90 minutes before the evaluation was made with the maze. Time taken to traverse from chamber A to B (transit time) was automatically recorded in seconds. Evaluation was done on the 60th day.

Evaluation of conditioned and unconditioned reflexes using jumping box

The conditioned and unconditioned reflexes were evaluated with jumping box consisting of rectangular box and an electrifiable grid floor. The box is divided by a Plexiglas obstacle and each compartment is illuminated with bulb. A fixed resistance shock (~20mV) source with controlling switch is present. On the day of experiment, the animals were withheld food and water from the morning. The apparatus was placed in a dimly lit room with a masking noise background. The animal was allowed to explore the apparatus for 15 sec with the light switched on. Later, a tone (buzzer) was presented in the compartment containing animal for 15 sec. Then, the floor shock was applied until the animal escapes to other compartment by crossing the obstacle or up to 45 sec (cut-off time). The transit time in seconds to reach the safe area was noted. Animals were trained in jumping box before the start of the treatment for the chronic study. Dosing for the day on the day of study was made with the test material or the vehicle 90 minutes before the evaluation was made with the maze. Time taken to traverse from chamber A to B (transit time) was automatically recorded in seconds. Evaluation was done on the 60th day.

Statistical analysis

The results were subjected to one way Analysis Of Variance (ANOVA) and Dunnet's multiple comparison tests using SPSS statistical package (version 17). Results were tabulated and the values are presented as mean±standard deviation. The p-Value of <0.05 is considered to be significant.

RESULTS

The phytochemical analysis of the hydroalcoholic pulp extract of *H salicifolia* demonstrated the presence of carbohydrates, glycosides, phytosteroids, fixed oils and fats, saponins, gums and mucilage, tannins and phenolic compounds, flavonoids and proteins and amino acids. The plant extract was devoid of alkaloids (see. Table. 2).

Antioxidants property (see Fig. 1 and Table. 3)

Lipid peroxidation: Among the four groups only heart and lung of $AlCl_3$ treated group demonstrated a statistically significant increase in lipid peroxidation.

Reduced Glutathione

A decrease in the levels of reduced glutathione was observed in the liver, heart and lung of aluminium treated group. Aluminium chloride and *Hippophae salicifolia* treated group demonstrated an increase in the reduced glutathione in lung. The results were statistically significant in these groups.

Catalase

A statistically significant increase in the level of catalase activity in heart of aluminium chloride treated group and in the heart of both aluminium chloride and *Hippophae salicifolia* extract treated group were observed.

Superoxide dismutase

The aluminium treated group demonstrated a decrease in the activity of superoxide dismutase activity and an increase was observed in both aluminium chloride and *Hippophae salicifolia* extract treated groups. But the results were not statistically significant.

Glutathione-S-transferase

A decrease in the activity of glutathione-S-transferase activity was observed in serum, liver, heart and kidney in the aluminium chloride treated group. An increase in the activity of glutathione-S-transferase was observed in serum, liver, lung and kidney of *Hippophae salicifolia* treated group when compared to control. But these results were not statistically significant.

Effect on adenosine triphosphatases (see Fig. 2 and Table 4)

Na^+/K^+ ATPase

A statistically significant increase in the level of the Na^+/K^+ ATPase was observed in the heart and lung of aluminium chloride and *Hippophae salicifolia* pulp extract treated groups. The level of enzyme activity in liver of both aluminium chloride and extract treated group demonstrated an increase in the level of Na^+/K^+ ATPase enzyme. The result observed was statistically significant when compared with the control group.

Ca^{2+} ATPase

A statistically significant increase in enzyme activity was observed in kidney of aluminium chloride, *Hippophae salicifolia* and both aluminium chloride and extract treated groups. An increase in the level of this enzyme was also observed in liver of Group 4 (both aluminium and extract treated) which was statistically significant when compared with the control group.

Mg^{2+} ATPase

An increase in the level of this enzyme was observed in heart of aluminium chloride and *Hippophae salicifolia* treated group. An increase was also observed in liver of both aluminium chloride and extract treated group. The results were statistically significant when compared to the control group.

Behavioural studies (see. Fig. 4)

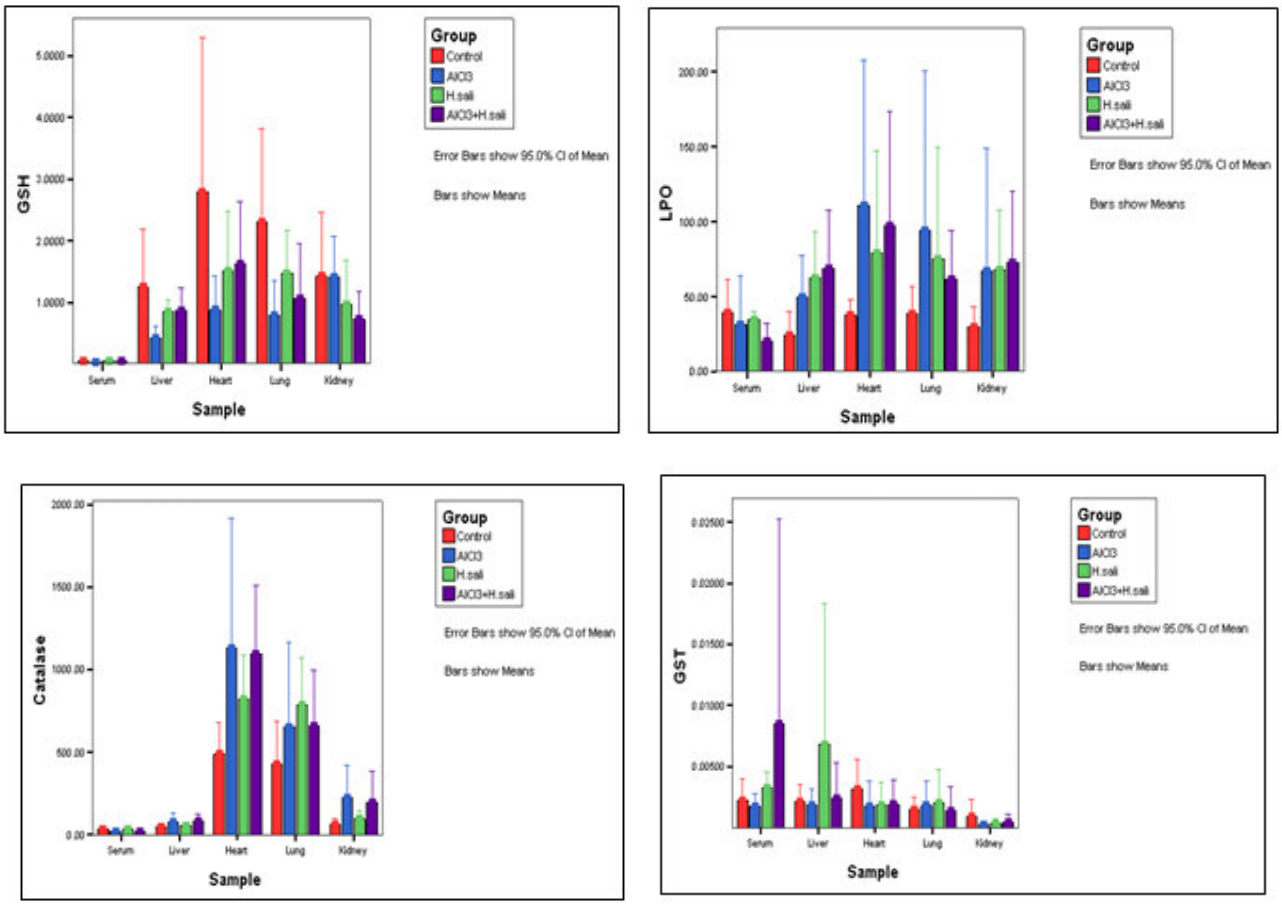
A significant increase in the time taken was observed in aluminium chloride and both aluminium chloride and *Hippophae salicifolia* treated groups in Jumping box.In Rota-rod, though there was a decrease and increase of time taken in aluminium chloride and *Hippophae salicifolia* extract treated groups respectively, the results are not statistically significant when compared with the control group. An increase in the time taken in photoactometer was observed in aluminium chloride treated group and a decrease was observed in group of both aluminium chloride and extract treated which was of no statistical significance when compared with control.An increase in the time taken in Hebb-William's maze was observed in the aluminium chloride treated group and a decrease was observed in the *Hippophae salicifolia* treated group. But, the results were not statistically significant.

Table 2
Phytochemical analysis of the hydroalcoholic pulp extract of Hippophae salicifolia

S. No	Qualitative Test	Results
1	Carbohydrates	+
2	Glycosides	+
3	Phytosteroids	+
4	Fixed oils and fats	+
5	Saponins	+
6	Gums and mucilage	+
7	Tannins and phenolic compounds	+
8	Flavonoids	+
9	Alkaloids	–
10	Proteins and amino acids	+

+: Positive for qualitative tests; –: Negative for qualitative test

Figure 1
Antioxidant properties as observed in the control, $AlCl_3$, H. Salicifolia and $AlCl_3$+H. Salicifolia



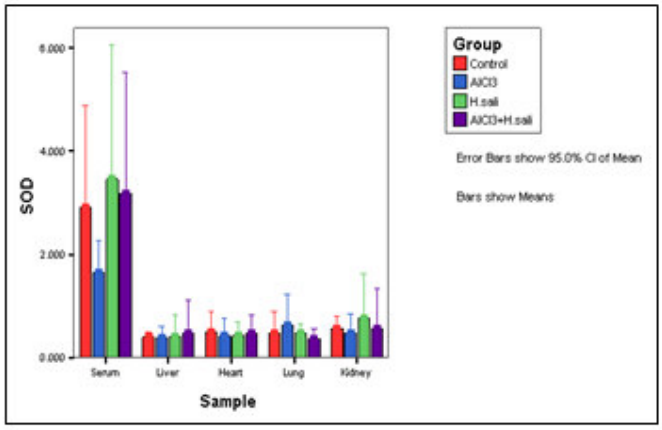


Table. 3

Antioxidant properties as observed in the control, $AlCl_3$, H. Salicifolia and $AlCl_3$+H. salicifolia (*p<0.05; compared with control)

Sample	Group 1	Group 2	Group 3	Group 4
Lipid Peroxidation				
Serum	39.304±21.35	31.607±30.677	34.844±5.304	19.842±11.808
Liver	24.473±14.93	49.665±26.41	62.168±29.81	68.807±37.27
Hear	37.259±10.35	110.961±92.45*	79.331±72.29	97.658±81.16
Lung	38.262±17.28	94.483±100.75*	74.915±79.869	61.575±34.409
Kidney	29.831±12.54	67.308±77.95	67.744±38.08	72.705±45.21
Reduced Glutathione (GSH)				
Serum	0.5618±0.0336	0.03348±0.0228	0.05623 ±0.2079	0.04398 ±0.0451
Liver	1.2440±0.8903	0.4197 ±0.177*	0.8468 ±0.189	0.8624 ±0.36
Hear	2.7954 ±2.377	0.8764 ±0.527*	1.5080 ±0.915	1.6289±0.9842
Lung	2.2952±1.455	0.7936 ±0.529*	1.4738 ±0.652	1.0658 ±0.8466*
Kidney	1.4188±0.986	1.4058 ±0.6326	0.9551 ±0.692	0.7273 ±0.423
Catalase				
Serum	33.842±15	20.688±6.912	30.516±5.155	22.53±13.31
Liver	49.586±0.016	72.596±0.057	54.95±0.0192	83.109±0.038
Hear	422.93±0.258	907.505±0.75*	819.091±0.257	1096.19±0.39*
Lung	425.87±0.248	653.76±0.486	783.529±0.278	658.671±0.321
Kidney	62.49±0.031	222.58±0.188	95.882±0.0485	194.433±0.179
Superoxide dismutase (SOD)				
Serum	2.9172±1.8718	1.64916±0.5923	3.459±2.4766	3.1822±2.2379
Liver	0.3954±0.099	0.38614±0.2175	0.4016±0.396	0.4813±0.599
Hear	0.498±0.372	0.301415±0.324	0.4228±0.254	0.4774±0.34
Lung	0.4691 ±0.397	0.390215±0.584	0.4623±0.18036	0.36138±0.178
Kidney	0.56604±0.221	0.4725±0.3497	0.7486±0.838	0.564229±0.726
Glutathione –S- Transferase (GST)				
Serum	0.00223±0.00171	0.001751±0.00102	0.003234±0.003234	0.00235±0.002352
Liver	0.002128±0.0013	0.001832±0.0012	0.002467±0.00049	0.002374±0.002759
Hear	0.003483±0.0019	0.00176±0.00195	0.001854 ±0.0017	0.001903 ±0.00186
Lung	0.001458±0.0009	0.001812±0.00186	0.002032±0.002	0.001419±0.0018
Kidney	0.000935±0.0012	0.000298 ±0.002	0.000342±0.0003	0.000485 ±0.00055

Figure 2

Antioxidant properties as observed in the control, $AlCl_3$, H. Salicifolia and $AlCl_3$+H. salicifolia

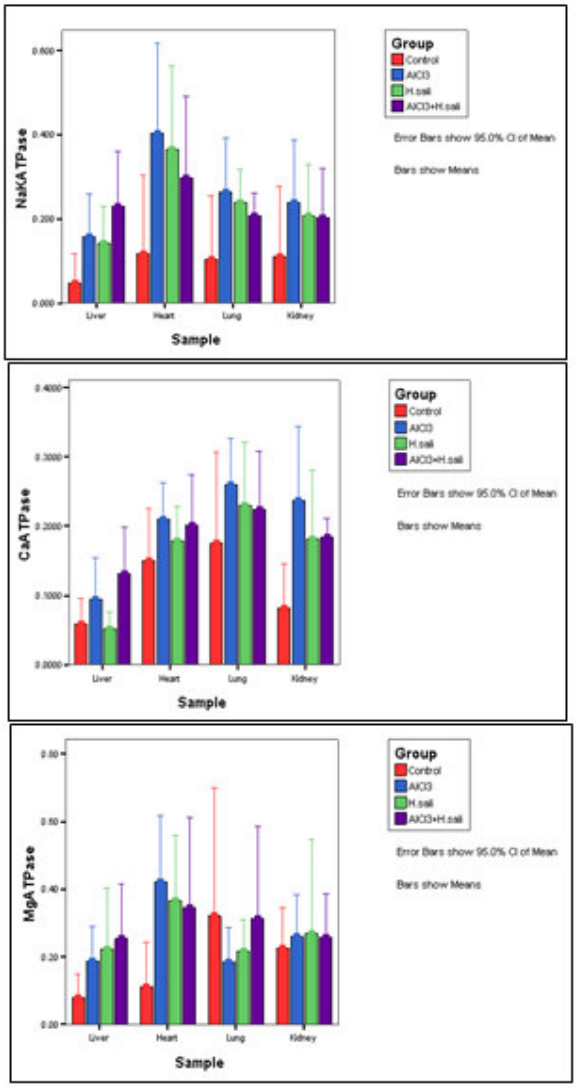
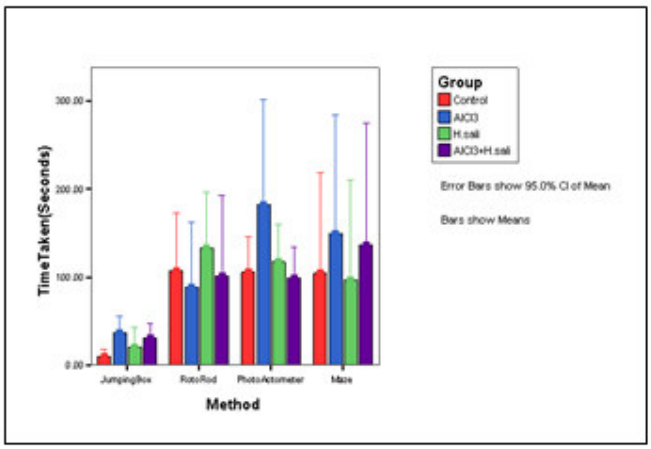


Table. 4

Effect of control, $AlCl_3$, H. Salicifolia and $AlCl_3$+H. salicifolia on adenosine triphosphatases (*p<0.05; compared with control)

Sample	Group 1	Group 2	Group 3	Group 4
Sodium and potassium dependent ATPase				
Liver	0.0486 ± 0.066	0.1587 ± 0.096	0.1429 ± 0.08	0.2295 ± 0.125*
Hear	0.1178 ± 0.1765	0.4028 ± 0.203*	0.3646 ± 0.189*	0.2971 ± 0.184
Lung	0.1038 ± 0.144	0.2647 ± 0.122*	0.2393 ± 0.073*	0.2070 ± 0.052
Kidney	0.1096 ± 0.159	0.2389 ± 0.140	0.2071 ± 0.116	0.2023 ± 0.111
Calcium dependent ATPase				
Liver	0.0589 ± 0.035	0.0952 ± 0.056	0.0517 ± 0.022	0.1219±0.0674*
Hear	0.1504 ± 0.0712	0.21 ± 0.049	0.1781 ± 0.0477	0.2009 ± 0.069
Lung	0.1753 ± 0.1248	0.2601 ± 0.063	0.2302 ± 0.0859	0.2434 ± 0.0926
Kidney	0.0823 ± 0.0599	0.2372±0.100*	0.1821 ± 0.094*	0.1760 ± 0.032*
Magnesium dependent ATPase				
Liver	0.0792 ±0.066	0.1881 ± 0.097	0.2229 ± 0.172	0.2541 ± 0.153*
Hear	0.1121 ±0.123	0.422 ±0.185*	0.36582 ±0.185*	0.3465 ± 0.252
Lung	0.3215 ±0.359	0.1841 ± 0.099	0.2175 ± 0.088	0.3138 ± 0.258
Kidney	0.2262 ±0.114	0.2592 ± 0.117	0.2686 ± 0.2645	0.2584 ± 0.120

Figure 4
Behavioural studies as observed in the control, $AlCl_3$, H. Salicifolia and $AlCl_3$+H. salicifolia



DISCUSSION

The present study assessed the effect of aluminium on certain biochemical parameters of tissues. The effects of *Hippophae salicifolia* were analyzed for its effect on aluminium induced biochemical changes. Production of free radicals during various biochemical reactions in the body has been reported to cause structural and functional derangement at cellular as well as at tissue levels. Biochemical parameters related to assessment of free radical production and the level of natural antioxidants present in the tissues to combat these free radicals suggest that aluminium causes an imbalance in these aspects. Lipid peroxidation assessed as an indicator of the extent of free radical production is found to be more in heart and lung in animals exposed to aluminium chloride to a significant extent. No significant change was seen in liver, kidney and serum levels of lipid peroxidation. *Hippophae salicifolia* has been observed to produce no statistically significant change in lipid peroxidation in all the tissues assessed. The plant extract seems to suppress excessive free radical production by aluminium since the increase seen in heart and lung after exposure to aluminium chloride alone is not seen in groups treated with both aluminium chloride and *Hippophae salicifolia* extract. Antioxidants present in the tissues play a vital role in scavenging the free radicals produced during various biochemical reactions and thereby protect the tissues from damage by free radicals. Enzymatic as well as non-enzymatic antioxidants have been assessed for their level in the tissues in the present study. Aluminium chloride is found to increase the level of catalase enzyme in heart tissue. Whether the increase seen is due to a response to increased free radical production as assessed by increased lipid peroxidation in this tissue needs to be investigated further. This is because such an increase in the enzyme activity is also seen in the groups co-treated with aluminium chloride and *Hippophae salicifolia*. No significant change has been observed in other tissues. As against this observation Super Oxide Dismutase and Glutathione-S-Transferase in the tissues has not been influenced by either aluminium chloride treatment or treatment with *Hippophae salicifolia*.Reduced glutathione has been found to be reduced in liver, heart and lung to a significant extent. Since, free radical production is found to have been increased only in heart and lung tissues during treatment with aluminium chloride, the reduction in liver also suggest the possibility that the effect may be a direct influence on the enzyme. This effect of aluminium chloride is not suppressed by *Hippophae salicifolia* as reduction is also observed in the group treated with both aluminium chloride as well as *Hippophae salicifolia*. Since, increase in free radical production or decrease in tissue antioxidant level can lead to tissue damage, the effect of *Hippophae salicifolia* in overcoming the effect of aluminium chloride can have therapeutic

importance. Furthermore, we observed a significant reversal in above stated changes by the co-administration of *Hippophae salicifolia*. These biochemical modifications indicate that *Hippophae salicifolia* possess strong antioxidative property. ATPases play a vital role in the cellular functions. Na^+ K^+ ATPase is found increased in lung and heart to a significant extent after aluminium chloride treatment. A similar effect is observed during treatment with *Hippophae salicifolia* also. Ca^{2+}ATPase is found to be more in kidney after treatment with aluminium chloride, as well as *Hippophae salicifolia*, while Mg^{2+}ATPase is found to be increased only in heart after treatment with aluminium chloride or *Hippophae salicifolia*. ATPases play a vital role in providing energy, fluctuations in their activity seen after exposure to aluminium chloride and *Hippophae salicifolia* needs to be investigated further. The results of this research show that the long-term administration of *Hippophae salicifolia* influences the explorative activity in Wistar rats. Experimentation with parameters that assess motor activity, learning and memory indicate that aluminium chloride can cause suppression of learning and memory. This observation is made from the result of investigation with jumping box wherein an increase in time to respond to painful stimulus is seen in group treated with aluminium chloride alone. Though a significant increase in the response time is seen in the group treated with aluminium chloride as well as *Hippophae salicifolia* also, the blunting effect of aluminium chloride seems to have been suppressed by co-administration with *Hippophae salicifolia*, because the delay seen was not to the extent seen in the group treated with aluminium chloride alone. Motor activity assessed with photoactometer and muscle coordination assessed by Rota-rod has not been influenced by treatment with aluminiumchloride or *Hippophae salicifolia*.Memory assessed with Jumpingbox has been found to be improved by *Hippophae salicifolia* .Further investigations are warranted to analyze the clinical usefulness and the influence of *Hippophae salicifolia* on the effect of aluminium chloride with reference to memory. Kumar et al.[22] had reported that increased Al and lipofuscin concentration could deleteriously affect the neurons, leading to depletion of antioxidants. However, we observed that in *Hippophae salicifolia* treated rats cerebellum there was significantly reduced level of lipid and protein peroxidation products.

CONCLUSION

The present study demonstrated that aluminium increased free radical production, particularly in heart and lung. Treatment with aluminium chloride resulted in an increase in tissue catalase in heart and a decrease in glutathione in liver, heart and lung. *Hippophae salicifolia* is considered to be associated with the suppression of this effect of aluminium chloride on liver and heart. Combination of aluminium chloride and *Hippophae salicifolia* causes fluctuations in tissue ATPases. *Hippophae salicifolia* is found to reduce the memory blunting effect of aluminium chloride .Thus, *Hippophae salicifolia* is reported to be effective in counteracting the biological effects of aluminium based on the free radical production, changes in non-enzymatic antioxidants in specific tissues and memory impairment.

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