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RESEARCH ARTICLE

Antitumor activity of *Sansevieria roxburghiana* rhizome against Ehrlich ascites carcinoma in mice

Pallab Kanti Haldar[1], Biswakanth Kar[1], Asis Bala[1], Sanjib Bhattacharya[2], and Upal Kanti Mazumder[1]

[1]Department of Pharmaceutical Technology, Jadavpur University, Kolkata, India, and [2]Bengal School of Technology, Sugandha, Hooghly, West Bengal, India

Abstract

Context: *Sansevieria roxburghiana* Schult. & Schult. f. (Agavaceae) is a herbaceous perennial plant traditionally used for coughs, rheumatism; as an expectorant, febrifuge, purgative, and tonic.

Objective: To evaluate the hydroalcoholic extract of *S. roxburghiana* rhizome (HASR) for antitumor activity against Ehrlich ascites carcinoma (EAC) in Swiss albino mice.

Methods: Twenty-Four hours after intraperitoneal inoculation of tumor (EAC) cells in mice, HASR was administered at 50 and 100 mg/kg body weight for nine consecutive days. On day 10 half of the mice were sacrificed and rest were kept alive for assessment of increase in life-span. The antitumor effect of HASR was assessed by evaluating tumor volume, packed cell count, viable and non-viable tumor cell count, median survival time and increase in life-span of EAC bearing hosts. Hematological profiles and serum biochemical parameters were estimated. Further, antioxidant properties were assessed by estimating lipid peroxidation, reduced glutathione (GSH), superoxide dismutase (SOD) and catalase (CAT).

Results and discussion: HASR showed a significant ($p < 0.001$) decrease in tumor volume, packed cell volume and viable cell count and increased the life span of EAC bearing mice. Hematological and serum biochemical profiles were restored to normal levels in HASR treated mice as compared to EAC control. HASR treatment significantly ($p < 0.001$) decreased lipid peroxidation and recovered GSH, SOD and CAT towards normal as compared to EAC control.

Conclusion: The present study demonstrates that *S. roxburghiana* rhizome exhibited remarkable antitumor activity in Swiss mice that is plausibly attributable to its augmenting endogenous antioxidant mechanisms.

Keywords: *Antitumor;* sansevieria roxburghiana*; Ehrlich ascites carcinoma; antioxidant*

Introduction

Cancer can be characterized by a rapid and uncontrolled formation of abnormal cells which may mass together to form a tumor, or proliferate throughout the body indicating abnormal growth at other sites. The aim of current research has been on the identification of natural and synthetic compounds that can be used in the prevention and/or treatment of cancer. Several methods exist for the treatment of cancer in modern medicine. Chemotherapy is now considered as the most effective method of cancer treatment.

Unfortunately, currently available cancer chemotherapeutic agents insidiously affect the host cells, especially bone marrow, epithelial tissues, reticulo-endothelial system, and gonads (Mascarenhas, 1994). Many antineoplastic agents produce serious chronic or delayed toxicities that may be irreversible, particularly in heart, lungs, and kidneys (Nitha et al., 2005). The approach for minimizing unwanted toxicity is to employ newer natural products that may act by different and distinct mechanism(s) and/or precipitate fewer, or different side effects. Hence, natural products now have been contemplated of exceptional value in the development of effective anticancer drugs

Address for Correspondence: Dr. Pallab Kanti Haldar, Department of Pharmaceutical Technology, Jadavpur University, Kolkata 700032, West Bengal, India. Tel.: + 91 9433230566; E-mail: pallab_haldar@rediffmail.com

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with minimum host cell toxicity possessing good antioxidant potential (Gupta et al., 2004).

The Ehrlich tumor was initially described as a spontaneous murine mammary adenocarcinoma. It is a rapidly growing carcinoma with very aggressive behavior and is able to grow in almost all strains of mice. In ascitic form it has been used as a transplantable tumor model to investigate the antitumor effects of several substances (Chen & Watkins, 1970; Segura et al., 2000).

Sansevieria roxburghiana Schult. & Schult. f. (Agavaceae), called *murva* in Sanskrit and Hindi, Indian bowstring hemp in English, is a herbaceous perennial plant with short fleshy stem and stout rootstock, occurring in the Eastern coastal region of India, also in Sri Lanka, Indonesia and tropical Africa (Eggli, 2002; Prakash et al., 2008). The whole plant is traditionally used as cardiotonic, expectorant, febrifuge, purgative, tonic, in glandular enlargement and rheumatism (Dhiman, 2006; Pulliah, 2006; Khare, 2007). The rhizomes are mucilaginous and used in consumptive complaints, long lasting chronic persistent coughs, for quick relief of common cough and cold, in ear pain (Kirtikar & Basu, 1935; Khan & Khanum, 2005; Khare, 2007; Prakash et al., 2008). The juice of tender shoots is administered to children for clearing viscid phlegm from throats. The roots are used as febrifuge in snake bite and hemorrhoids (Khan & Khanum, 2005; Khare, 2007). No pharmacological investigation has yet been reported on *S. roxburghiana*. The present study was therefore aimed to investigate the antitumor effects of hydroalcohol extract of *S. roxburghiana* against Ehrlich ascites carcinoma in Swiss albino mice.

Materials and methods

Plant material

The rhizome of *S. roxburghiana* was collected during October 2008 from the forest region of Cuttack, Orissa, India. The specimen was identified by M.S. Mondal, taxonomist at Central National Herbarium, Botanical Survey of India, Howrah, West Bengal, India and a voucher specimen (CNH/I-I/(280)/2008/Tech.II/322) was preserved in our research laboratory for future reference. Just after collection the rhizomes were washed thoroughly with water, cut into small pieces, shade-dried at room temperature (24°–26°C) and ground mechanically into a coarse powder.

Drugs and chemicals

Bovine serum albumin and 5-fluorouracil from Sigma (St. Louis, MO); trichloroacetic acid (TCA) from Merck (Mumbai, India); thiobarbituric acid (TBA), nitroblue tetrazolium chloride (NBT) from Loba Chemie (Mumbai, India); 5,5′-dithio *bis*-2-nitro benzoic acid (DTNB), phenazonium methosulfate (PMS), nicotinamide adenine dinucleotide (NADH) and reduced glutathione (GSH) from SISCO (Mumbai, India). All the other reagents used were of analytical reagent grade obtained commercially.

Preparation of extract

The powdered plant material (450 g) was macerated at room temperature (24°–26°C) with 60% aqueous ethanol (750 mL) for 4 days with occasional shaking, followed by re-maceration with the same solvent similarly for 3 days. The macerates were combined, filtered and evaporated to dryness *in vacuo* (at 35°C and 0.8 MPa) in a Buchi evaporator, R-114 (yield 9.35%). The dry extract (HASR)was kept in a vacuum desiccator until use. Preliminary phytochemical analysis and chromatographic studies (Harborne, 1998) of HASR revealed the presence of alkaloids, triterpenes, steroids, flavonoids, saponins, and mucilage.

Animals

Adult male Swiss albino mice of about 2 months of age weighing 20 ± 2 g were obtained from the Laboratory Animal Centre, Department of Pharmaceutical Technology, Jadavpur University, Kolkata, India. The mice were grouped and housed in polyacrylic cages (38 × 23 × 10 cm) with not more than four animals per cage and maintained under standard laboratory conditions (temperature 25° ± 2°C with dark/light cycle 12/12 h). They were allowed free access to standard dry pellet diet (Hindustan Lever, Kolkata, India) and water *ad libitum*. The mice were acclimatized to laboratory conditions for 7 days before commencement of the experiment. All experimental procedures were reviewed and approved by the University Animal Ethics Committee, Jadavpur University (367001/C/CPCSEA).

Tumor cells

The transplantable murine tumor cells namely Ehrlich ascites carcinoma cells were obtained from Chittaranjan National Cancer Institute (CNCI), Kolkata, India. The EAC cells were maintained in the ascitic form *in vivo* by sequential passages in Swiss mice, by means of intraperitoneal transplantation of 2×10^6 cells/mouse after every 10 days. Ascitic fluid was drawn out from EAC bearing mice 8 days after transplantation. The freshly drawn fluid was diluted with ice-cold sterile normal saline and the tumor cell count was adjusted to 2×10^7 cells/ml by sterile normal saline.

Acute toxicity

The acute oral toxicity of HASR in male Swiss albino mice was studied as per OECD guideline 425 (OECD, 2008).

LD_{50} value of HASR was determined using the method of maximum likelihood.

Treatment schedule

The animals were divided into five groups (n = 12). All groups except the first group received 0.1 mL of EAC cell suspension (2×10^6 cells/mouse, i.p.). This was taken as day '0'. The first group served as normal saline control (5 mL/kg body weight, i.p.). The second group served as EAC control. After 24 h of tumor inoculation the third and fourth group received HASR at the doses of 50 and 100 mg/kg body weight, i.p., respectively, and the fifth group received reference drug 5-fluorouracil (20 mg/kg body weight, i.p.) for 9 consecutive days. Blood was collected from six mice of each group 24 h after the last dose and 18 h of fasting, by cardiac puncture for the estimation of hematological and serum biochemical parameters, and then sacrificed by cervical dislocation for the study of antitumor and liver biochemical parameters. The remaining six mice of each group were kept alive with food and water *ad libitum* to check the increase in the life-span of the tumor hosts (Gupta et al., 2007). The effect of HASR on tumor growth and host's survival time was assessed by observation of tumor volume, packed cell volume, viable and non-viable cell count, median survival time (MST) and percentage increase in life-span (%ILS).

Determination of tumor and packed cell volume

The mice were dissected and the ascitic fluid was collected from the peritoneal cavity. The volume was measured using a graduated centrifuge tube, and packed cell volume was determined by centrifuging at 1000 *g* for 5 min.

Estimation of viable and non-viable tumor cell count

The ascitic fluid was taken in a white blood cell (WBC) pipette and diluted 100 times. Then a drop of the diluted suspension was paled on the Neubauer counting chamber and the cells were then stained with Trypan blue (0.4% in normal saline) dye. The cells that did not take up the dye were viable and those took the stain were non-viable. These viable and non-viable cells were counted.

$$\text{Cell count} = \frac{(\text{number of cells} \times \text{dilution factor})}{(\text{area} \times \text{thickness of liquid film})}$$

Determination of median survival time and percentage increase in life-span

The mortality was monitored by recording percentage increase in life-span (%ILS) and median survival time (MST) as per the following formulae.

$$\%\text{ILS} = \left[\left(\frac{\text{Mean survival time of treated group}}{\text{Mean survival time of control group}}\right) - 1\right] \times 100$$

$$\text{Median survival time}^* = (\text{First death} + \text{Last death})/2$$

(*Time denoted by number of days.)

Estimation of hematological and serum biochemical parameters

Collected blood was used for the estimation of hemoglobin (Hb) content; red blood cell count (RBC) (D'Armour et al., 1965) and WBC (Wintrobe et al., 1961). Differential count of WBC was carried out from Leishmen stained blood smears (Dacie & Lewis, 1958). Serum biochemical parameters like serum glutamate oxaloacetate transaminase (SGOT) serum glutamate pyruvate transaminase (SGPT) (Bergmeyer et al., 1978), serum alkaline phosphatase (SALP) (King, 1965), serum bilirubin (Malloy & Evelyn, 1937) and total proteins (Lowry et al., 1951) were also estimated.

Estimation of lipid peroxidation (TBARS)

The thiobarbituric acid reactive substances (TBARS) in the liver tissue were measured as per the method reported by Ohkawa et al. (1979). Lipid peroxides (TBARS) levels were expressed as μmoles of malondialdehyde (MDA)/g of liver tissue.

Estimation of reduced glutathione

The GSH level of liver tissue was determined as per the method of Ellman (1959) and expressed as μg/g of liver tissue.

Estimation of superoxide dismutase and catalase

The SOD and CAT activity in liver tissue were assayed as per the method of Kakkar et al. (1984) and Aebi (1974), respectively. The SOD activity was expressed as unit/mg of liver tissue and CAT was expressed in terms of μmol of hydrogen peroxide decomposed/min/mg of liver tissue.

Statistical analysis

The experimental results were expressed as mean ± standard error of mean (SEM). Statistical significance was analyzed by one-way ANOVA followed by Dunnett's post hoc test of significance. P values of <0.001 and <0.05 were considered as statistically significant.

Results

Acute toxicity

The oral LD_{50} value of the hydroalcoholic extract of *S. roxburghiana* in mice was 500 mg/kg body weight.

Tumor growth and survival parameters

HASR at 50 and 100 mg/kg body weight significantly reduced the body weight, tumor volume, packed cell volume and viable tumor cell count in a dose-dependent manner as compared to EAC control ($p < 0.001$). Furthermore, HASR increased non-viable tumor cell counts and decreased viable tumor cell counts as compared with the EAC control ($p < 0.001$). In the EAC control group, the median survival time was 20.56 ± 1.13 days, whereas in the HASR-treated groups these were 29.83 ± 1.19 (50 mg/kg) and 36.08 ± 1.75 (100 mg/kg) days, respectively. The reference drug 5-fluorouracil (20 mg/ kg) showed 41.43 ± 1.74 days (Table 1).

Hematological parameters

Hematological parameters of tumor bearing mice were found to be significantly altered compared to those of the normal saline group. The total WBC count was found to be increased in EAC control animals ($p < 0.001$) when compared with the normal saline group. Treatment with HASR at 50 ($p < 0.05$) and 100 mg/kg ($p < 0.001$) significantly ($p < 0.001$) increased the hemoglobin content and RBC count towards the normal levels. In the differential count, lymphocytes and monocytes were found to be decreased and the neutrophils were increased in the EAC control group when compared with the normal saline group. HASR treatment significantly ($p < 0.001$) brought them towards the normal counts (Table 2).

Serum biochemical parameters

Biochemical parameters like SGOT, SGPT, SALP and serum bilirubin in the EAC control group were significantly ($p < 0.001$) elevated as compared to the normal saline group. Treatment with HASR at the dose of 50 and 100 mg/kg significantly ($p < 0.001$) reduced the SGOT, SGPT, SALP and serum bilirubin levels towards the normal values in a dose-dependent manner. The total protein was found to be significantly decreased in the EAC control group as compared with the normal saline group ($p < 0.001$). Administration of HASR at the dose of 50 mg/kg ($p < 0.05$)

Table 1. Effect of HASR on body weight, tumor volume, packed cell volume, cell count, median survival time (MST) and life-span (%ILS) in EAC bearing mice.

Groups	Body weight (g)	Tumor volume (mL)	Packed cell volume (mL)	Viable cell count (cells × 10^6/mL)	Non-viable cell count (cells × 10^6/mL)	Median survival time (days)	ILS (%)
Normal saline (5 mL/kg)	21.16 ± 0.47	-	-	-	-	-	-
EAC control (2 × 10^6 cells/mouse)	26.46 ± 0.66$^{\#a}$	4.26 ± 0.28	2.37 ± 0.08	8.15 ± 0.07	0.63 ± 0.04	20.56 ± 1.13	-
EAC+HASR (50 mg/kg)	24.34 ± 0.49^{*a}	2.48 ± 0.1^{*a}	0.83 ± 0.02^{*a}	3.26 ± 0.05^{*a}	1.24 ± 0.07^{*a}	29.83 ± 1.19^{*a}	45.23
EAC+HASR (100 mg/kg)	21.7 ± 0.42^{*a}	1.34 ± 0.04^{*a}	0.22 ± 0.01^{*a}	1.36 ± 0.05^{*a}	2.96 ± 0.05^{*a}	36.08 ± 1.75^{*a}	72.04
EAC+5-F uracil (20 mg/kg)	19.79 ± 0.7^{*a}	0.35 ± 0.01^{*a}	-	0.84 ± 0.03^{*a}	3.46 ± 0.04^{*a}	41.43 ± 1.74^{*a}	103.82

Values are mean ± SEM (n = 6); $^{\#}$EAC control group versus normal saline group; *All treated groups versus EAC control group; $^{a}p < 0.001$.

Table 2. Effect of HASR on hematological parameters in EAC bearing mice.

				Differential count		
Groups	Hb content (g%)	RBC (cells × 10^6/mm^3)	WBC (cells × 10^3/mm^3)	Monocyte (%)	Lymphocyte (%)	Neutrophil (%)
Normal saline (5 mL/kg)	11.22 ± 0.47	4.58 ± 0.45	3.88 ± 0.31	1.93 ± 0.06	76.5 ± 1.17	18.0 ± 0.96
EAC control (2 × 10^6 cells/mouse)	7.11 ± 0.24$^{\#a}$	2.15 ± 0.13$^{\#a}$	5.57 ± 1.16$^{\#a}$	1.33 ± 0.11$^{\#a}$	32.66 ± 0.71$^{\#a}$	66.83 ± 1.22$^{\#a}$
EAC + HASR (50 mg/kg)	8.97 ± 0.63^{*b}	2.97 ± 1.06^{*b}	4.42 ± 1.28^{*a}	1.75 ± 0.04^{*b}	59.16 ± 2.52^{*a}	38.33 ± 1.05^{*a}
EAC + HASR (100 mg/kg)	9.84 ± 0.36^{*a}	3.76 ± 0.84^{*a}	3.5 ± 0.49^{*a}	1.9 ± 0.07^{*a}	72.0 ± 2.93^{*a}	21.16 ± 1.07^{*a}
EAC + 5-F uracil (20 mg/kg)	10.71 ± 0.84^{*a}	3.95 ± 0.43^{*a}	3.93 ± 0.31^{*a}	1.91 ± 0.08^{*a}	75.83 ± 1.53^{*a}	20.5 ± 0.88^{*a}

Values are mean ± SEM (n = 6), $^{\#}$EAC control group versus normal saline group; *all treated groups versus EAC control group; $^{a}p < 0.001$; $^{b}p < 0.05$.

and 100 mg/kg ($p < 0.001$) in EAC bearing mice significantly increased the total protein content as compared with the EAC control (Table 3).

Lipid peroxidation

The levels of TBARS represented as MDA were significantly ($p < 0.001$) increased in EAC control animals as compared to the normal control group. Treatment with HASR at 50 and 100 mg/kg significantly ($p < 0.001$) reduced the MDA levels when compared with EAC control animals (Table 4).

Reduced glutathione

The level of reduced GSH was significantly depleted in the EAC control group ($p < 0.001$) as compared with the normal control group. Reduced GSH level was found to be significantly elevated towards the normal level on administration of HASR at 50 ($p < 0.05$) and 100 mg/kg ($p < 0.001$) as compared with the EAC control group (Table 5).

Superoxide dismutase and catalase

There was significant ($p < 0.001$) reduction in superoxide dismutase and catalase activities in the EAC control groups compared with the normal group. Administration of HASR at 50 ($p < 0.05$) and 100 mg/kg significantly ($p < 0.001$) recovered SOD and CAT levels towards normal values when compared with EAC control animals (Tables 6 and 7).

Discussion

The present work was aimed to study the antitumor activity of hydroalcoholic extract of *Sansevieria roxburghiana* rhizome in EAC tumor bearing mice. The results of this study revealed that HASR at the doses of 50 and 100 mg/kg significantly reduced the tumor volume, packed cell volume, tumor cell count (viable and non-viable) and restored the hematological and serum biochemical parameters towards normal values. The HASR also significantly restored the hepatic lipid peroxidation, reduced glutathione level and antioxidant enzyme activities such as SOD and CAT in tumor bearing mice towards normal levels.

In EAC tumor bearing hosts, a drastic increase in ascitic fluid volume was observed. Treatment with HASR reduced intraperitoneal tumor burden, thereby reducing the tumor volume, viable tumor cell count, and increased the life span of the tumor bearing mice. The results demonstrated that the viable cell count decreased with increased count of non-viable cells. This implies that the antitumor action of HASR had a direct relationship with the tumor cells, indicating loss of viability of the HASR treated cells.

The reliable criterion for judging the value of any anticancer drug is the prolongation of life-span of the tumor bearing animal (Clarkson & Burchneal, 1965). It can therefore be inferred that HASR increased the life- span of EAC bearing mice may be due to the prevention of tumor progression. Usually in cancer chemotherapy the major problems that are encountered are myelosuppression and anemia (Price & Greenfield, 1958). Results of the present study indicate that HASR dose-dependently and significantly increased the erythrocyte count and hemoglobin level when compared to those of EAC control mice. The WBC count was reduced as compared with that of EAC control mice. These indicating parameters revealed that HASR exerted less toxic effect to the hemopoietic system and plausibly had selective affinity to the tumor cell and thereby it could maintain the normal hematological profile.

Elevated levels of serum parameters, i.e., SGPT, SGOT, SALP, serum bilirubin, serum protein are indicative of impaired liver functions due to cancer as observed in the EAC control group (Moss & Butterworth, 1974; Dortman & Lawhorn, 1978). Treatment with HASR restored the above mentioned parameters towards the normal level in a dose-dependent manner. Reactive oxygen species (ROS) formed in cancer tissues result in lipid peroxidation and subsequently increase in MDA and other TBARS levels. MDA, the end product of lipid peroxidation, a biomarker of oxidative stress, was reported to be higher in cancer tissues than in the non-diseased organ (Yagi, 1991; Neilson et al., 1997). The present study showed that TBARS levels measured as MDA in the EAC bearing liver tissues were higher than those in normal saline treated

Table 3. Effect of HASR on serum biochemical parameters in EAC bearing mice.

Groups	SGOT (IU/L)	SGPT (IU/L)	SALP (IU/L)	Total protein (mg/dL)	Bilirubin (mg/dL)
Normal saline (5 mL/kg)	37.16 ± 2.44	27.5 ± 2.23	78.0 ± 5.87	8.78 ± 0.49	0.88 ± 0.09
EAC control (2×10^6 cells/mouse)	72.0 ± 2.92$^{\#a}$	65.0 ± 3.5$^{\#a}$	122.0 ± 2.98$^{\#a}$	5.65 ± 0.11$^{\#a}$	2.6 ± 0.12$^{\#a}$
EAC + HASR (50 mg/kg)	41.0 ± 4.06^{*a}	37.06 ± 2.73^{*a}	92.0 ± 3.32^{*a}	6.94 ± 0.01^{*b}	1.8 ± 0.08^{*a}
EAC + HASR (100 mg/kg)	32.35 ± 2.17^{*a}	37.38 ± 1.62^{*a}	81.0 ± 3.31^{*a}	8.39 ± 0.15^{*a}	1.42 ± 0.09^{*a}
EAC + 5-F uracil (20 mg/kg)	32.66 ± 2.34^{*a}	33.66 ± 3.28^{*a}	72.0 ± 2.52^{*a}	8.56 ± 0.2^{*a}	0.96 ± 0.06^{*a}

Values are mean ± SEM (n = 6); $^{\#}$EAC control group versus normal saline group; *all treated groups versus EAC control group; $^{a}p < 0.001$; $^{b}p < 0.05$.

Table 4. Effect of HASR on lipid peroxidation in EAC bearing mice.

Treatment	MDA (μM/g of wet liver tissue)
Normal saline (5 mL/kg)	165 ± 0.03
EAC control (2×10^6 cells/mouse)	502 ± 0.06 $^{\#, a}$
EAC + HASR (50 mg/kg)	157 ± 0.01$^{*, a}$
EAC + HASR (100 mg/kg)	145 ± 0.04$^{*, a}$
EAC + 5-FU (20 mg/kg)	279 ± 0.03$^{*, a}$

Values are mean ± SEM (n = 6); $^{\#}$EAC control group versus normal saline group; *all treated groups versus EAC control group; $^{a}p < 0.001$.

Table 5. Effect of HASR on reduced glutathione (GSH) level in EAC bearing mice.

Treatment	GSH (μg/g of wet liver tissue)
Normal saline (5 mL/kg)	29 ± 0.56
EAC control (2×10^6 cells/mouse)	8 ± 0.64$^{\#a}$
EAC + HASR (50 mg/kg)	13 ± 0.26^{*b}
EAC + HASR (100 mg/kg)	26.5 ± 0.73^{*a}
EAC + 5-FU (20 mg/kg)	26.5 ± 0.16^{*a}

Values are mean ± SEM (n = 6), $^{\#}$EAC control group versus normal group; *all treated groups versus EAC control group; $^{a}p < 0.001$; $^{b}p < 0.05$.

Table 6. Effect of HASR on superoxide dismutase (SOD) activity in EAC bearing mice.

Treatment	SOD (IU/mg of wet liver tissue)
Normal saline (5 mL/kg)	7.9 ± 0.27
EAC control (2×10^6 cells/mouse)	3.7 ± 0.2$^{\#a}$
EAC + HASR (50 mg/kg)	5.2 ± 0.34^{*b}
EAC + HASR (100 mg/kg)	6.2 ± 0.52^{*a}
EAC + 5-FU (20 mg/kg)	6.4 ± 0.68^{*a}

Values are mean ± SEM (n = 6); $^{\#}$EAC control group versus normal group; *all treated groups versus EAC control group; $^{a}p < 0.001$; $^{b}p < 0.05$.

Table 7. Effect of HASR on catalase (CAT) activity in EAC bearing mice.

Treatment	CAT (IU/min/mg of wet tissue)
Normal saline (5 mL/kg)	36.5 ± 0.11
EAC control (2×10^6 cells/mouse)	8.5 ± 0.17$^{\#a}$
EAC + HASR (50 mg/kg)	16 ± 0.33^{*b}
EAC + HASR (100 mg/kg)	29 ± 0.25^{*a}
EAC + 5-FU (20 mg/kg)	29 ± 0.12$^{*, a}$

Values are mean ± SEM (n = 6), $^{\#}$EAC control group versus normal group; *all treated groups versus EAC control group; $^{a}p < 0.001$; $^{b}p < 0.05$.

liver tissues. Treatment with HASR inhibited hepatic lipid peroxidation as revealed by reduction of MDA levels towards normal levels. This indicated the reduction in free radical generation (ROS) by HASR in tumor bearing mice.

Glutathione, the most abundant tripeptide thiol, exists as GSH (reduced form) and GSSG (oxidized form) in cells. Glutathione, a potent inhibitor of the neoplastic process, plays an important role in the endogenous non-enzymatic antioxidant system. Primarily it acts as a reducing agent and detoxifies hydrogen peroxide in the presence of an enzyme glutathione peroxidase (Arias & Jakoby, 1976). Virtually all the non-protein sulfhydryl groups of liver tissues remain in the form of reduced glutathione. HASR significantly elevated the reduced hepatic glutathione levels in EAC bearing mice. The results showed that the antitumor activity of HASR was accompanied with the enhancement in non-enzymatic antioxidant protection. These findings suggest that the HASR may exert its antitumor role through the enhancement of the cellular antioxidant system.

Cells are also equipped with enzymatic antioxidant mechanisms that play an important role in the elimination of free radicals (ROS). Superoxide dismutase and catalase are involved in the clearance of superoxide and hydrogen peroxide. The inhibition of SOD and CAT activities as a result of tumor growth was reported (Jiau-Jian & Larry, 1977) and similar findings were observed in our present results in EAC bearing mice. The administration of HASR at both doses significantly recovered the SOD and CAT levels towards normal in a dose-dependent manner.

In the present study it was noted that HASR significantly reduced tumor growth and viability of tumor cells, and normalized the hematological and serum biochemical profiles, raising life span as compared with those of EAC control mice. Also, HASR treatment improved the endogenous non-enzymatic and enzymatic antioxidant systems. The lowering of lipid peroxidation and elevation of GSH, SOD and CAT in HASR-treated mice indicated its potential as an inhibitor of EAC-induced intracellular oxidative stress. Therefore, it can be concluded that the hydroalcoholic extract of *Sansevieria roxburghiana* rhizome demonstrated remarkable antitumor activity against Ehrlich ascites carcinoma in mice plausibly by modulating lipid peroxidation and augmenting endogenous antioxidant defense systems.

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Declaration of interest

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