Int J Pharm Bio Sci2012 July;3(3): (P)598- 610

Research Article Pharmacognosy

International Journal of Pharma and Bio Sciences ISSN 0975-6299

RADIOPROTECTIVE EFFECT OF ALCOHOLIC EXTRACT OF *MENTHA PIPERITA* (LINN) ON SWISS ALBINO MICE EXPOSED TO WHOLE BODY GAMMA IRRADIATION: A PRELIMINARY STUDY

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ABSTRACT

Natural Products offer an alternative to synthetic radioprotectors being less toxic. In this study 50% alcoholic extract of *Mentha piperita* (ALM) was tested for its radioprotective ability in terms of radiation sickness and survival of Swiss albino mice. This drug was well tolerated at highest dose of 1000mg/kg b.wt./day for three consecutive days. All doses of drug provided significant protection against radiation sickness and mortality, however the highest protection was observed at 100mg/kg. The optimum dose of 100mg/kg b.wt./day was determined on the basis of maximum survival and biochemical analysis of lowest lipid peroxidation and highest reduced glutathione levels. To determine the dose reduction factor (DRF) the optimum dose was administered for three consecutive days before 6,8,10 Gy gamma irradiation and 30 day survival was studied simultaneously with radiation sickness. The $LD_{50/30}$ value of experimental (ALM + irradiation) was found to be considerably higher (8.052 $\pm$0.115) than irradiation alone (5.598$\pm$0.09) group. On the basis of $LD_{50/30}$ survivability, ALM pretreatment produced a dose reduction factor (DRF) of 1.44.

KEYWORDS: Radioprotective, Morbidity ,*Mentha piperita,* Dose reduction factor

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INTRODUCTION

The science of radiation protection is a fundamental outgrowth of peaceful and military applications of ionizing radiation. Natural radioprotectors include use of plant extracts. Several chemical agents/synthetic radioprotectors have been tried against the hazardous effects of ionizing radiation in experimental studies with success. However, the practical applicability of the majority of these synthetic compounds remains limited, owing to their high toxicity at their optimum protective doses[1].

Herbal drugs offer an alternative to synthetic compounds and are considered either non-toxic or less toxic than their synthetic counterparts. A large number of plants contain antioxidant phytochemicals reported to be radioprotective in various model systems. These include Chinese herbal medicines, Ayurvedic preparations, cruciferous vegetables, green tea, Shigoka extract, *Spirulina platensis*, soy products, venoruton, bixin, *Mentha arvensis* (mint), triphala plant extract, curcumin, chlorogenic acid, quercetin, grape seed, *Aspalathus linearis*, etc. Most of these botanical or alterative medicines could be considered as dietary supplements[2]. *Mentha piperita* L. (Peppermint) is a perennial, glabrous and strongly scented herb belonging to family Labiatae. *Mentha piperita* posses a number of pharmacological properties as antioxidant and antiperoxidants properties[3,4,5,6,7], antiallergic effect[8,9], virucidal property[10], Antifungal activity[11], antimicrobial antispasmodic[9],antitumorogenic[9],anticarcinogenic[12,13,14], etc. The radiomodulatory effect of Mentha oil on serum phosphatases, haematological parameters in mice against whole-body gamma irradiation has been earlier studied in our laboratory[9,16]. The present study aims at evaluating the radioprotective effect of alcoholic extract of *Mentha piperita*(ALM) on radiation induced mortality and morbidity.

MATERIAL AND METHODS

Animals

Six-eight week old female Swiss albino mice (*Mus musculus*) weighing 25±2 gm (procured from Hamdard University, Delhi) were bred in an animal house under control condition of temperature (25±2°C) and light (14 hrs. light and 10 hrs. darkness) were used for the present study. These animals were given pelleted standard mice feed (obtained from Hindustan Lever Ltd., Delhi) and water *ad libitum*.

Irradiation

The cobalt teletherapy unit (ATC-C9) in the Cancer Treatment Center, radiotherapy department S.M.S. Medical College and hospital, Jaipur was used for irradiation.

Unanaesthetized animals were restrained in well-ventilated Perspex boxes and the whole body exposed to different doses (6, 8, 10 Gy) of gamma radiation at a distance of 77.5 from the source, to deliver the dose rate of 1.64 Gy/min.

Preparation of Alcoholic Extract of Mentha (ALM)

Mentha piperita collected locally was identified and specimen was placed at Herbarium, Department of Botany, University of Rajasthan, Jaipur (voucher number is RUBL-19443). Fresh leaves of *Mentha piperita* (Linn.) were washed, air dried, powdered and extracted with 1500 ml of 50% ethanolic solution in double distilled water (DDW) and by refluxing for 36h (3x12½) at 60°C. The extract thus obtained was vacuum evaporated andpowdered. The extract was suspended in DDW and 0.1 ml of ALM suspension was given to each mouse by oral gavage in various doses.

EXPERIMENTAL DESIGN

Drug Tolerance Study

Swiss albino mice were divided into 6 groups(10 animals each) first group was control which were given DDW (0.1 ml) and the second group was drug alone (five groups) which were given50,100,200,400, 600, 800 and 1000 mg/Kg b.wt./day of ALM for 3 consecutive days. All these animals were observed daily for 30 days for any sign of morbidity, mortality and behavioral changes.

Determination of Optimum Dose of Alcoholic Extract of Mentha (ALM) against Radiation

The animals (30 animals each) were given 50, 100, 200 and 400 mg/Kg b.wt./day for three consecutive days. Thirty minutes after last administration, these animals were exposed to 8 Gy gamma radiations. All these animals were observed daily for 30 days for any sign of sickness, morbidity, mortality and behavioral changes. The reduced glutathione (GSH) and lipid peroxidation (LPO) levels in liver were estimated after 30 days of radiation exposure.

Determination of dose reduction factor (DRF)

The Dose Reduction Factor (DRF) was calculated on the basis of $LD_{50/30}$ survivability experiments. To calculate the $LD_{50/30}$ values, the animals were divided into four groups:

Group I (normal): The animals (n=10) were given DDW (0.1 ml)

Group II (drug alone): The animals (n=10) were given ALM drug dose of 100 mg/kg b.wt./day for 3 consecutive days.

Group III (control) were further divided into 3 subgroups (30 animals in each)

Subgroup IIIa: DDW (0.1 ml) + 6 Gy

Subgroup IIIb: DDW (0.1 ml) + 8 Gy

Subgroup IIIc: DDW (0.1 ml) + 10 Gy

Group IV (experimental), were further divided into 3 subgroups (30 animals in each) were given ALM drug dose 100 mg/kg b.wt./day for 3 consecutive days

Subgroup IVa: ALM + 6 Gy

Subgroup IVb: ALM + 8 Gy

SubgroupIVc: ALM + 10 Gy

The survival-dose-response curves were constructed by using the percentage of surviving animals upto day 30 after exposure.

Regression analysis was done to obtain $LD_{50/30}$ values and to determine dose reduction factor. DRF was computed by the following formula:

$$\mathrm{DRF} = \frac{\mathrm{LD}_{50/30}\,[\mathrm{Experimental\ animals}]}{\mathrm{LD}_{50/30}\,[\mathrm{Control\ animals}]}$$

BIOCHEMICAL ESTIMATION

a. Hepatic reduced glutathione (GSH) assay[17]

The reduced Glutathione in liver reacts with DTNB and forms a yellow coloured complex with DTNB that absorbs at 412 nm using a UV-VIS systronics spectrophotometer. GSH purchased from Sisco Research Laboratories Pvt. Ltd., Bombay was used as a standard to calculate nmole GSH/mg tissue.

b. Hepatic lipid peroxidation (LPO) assay[18]

Lipid peroxidation level in liver was estimated as thiobarbituric acid reactive substances (TBARS). The concentration of TBARS was expressed as nmoles of malondialdehyde per mg of tissue using 1, 1, 3, 3-tetramethoxy propane (TMP) as the standard (Lancaster, England).Peroxidation of lipids generates MDA, which reacts with thiobarbituric acid to give a red species absorbing at 532 nm using a UV-VIS systronics spectrophotometer.

STATISTICAL ANALYSIS

a. *Student's 't' test*

The results obtained from the present study were expressed as mean ± S.E. *Student's 't'* test[19] was used to make a statistical comparison between the groups. The significance level was obtained from the table of significance provided for the Student's distribution. The significant levels were set at P<0.05, P<0.01 and P<0.001. The statistical comparisons were done between control (irradiation alone) vs experimental (ALM + Irradiation).

b. *Regression analysis*

Linear regression analysis was done to obtain $LD_{50/30}$ values and to determine dose reduction factor (DRF).

RESULTS

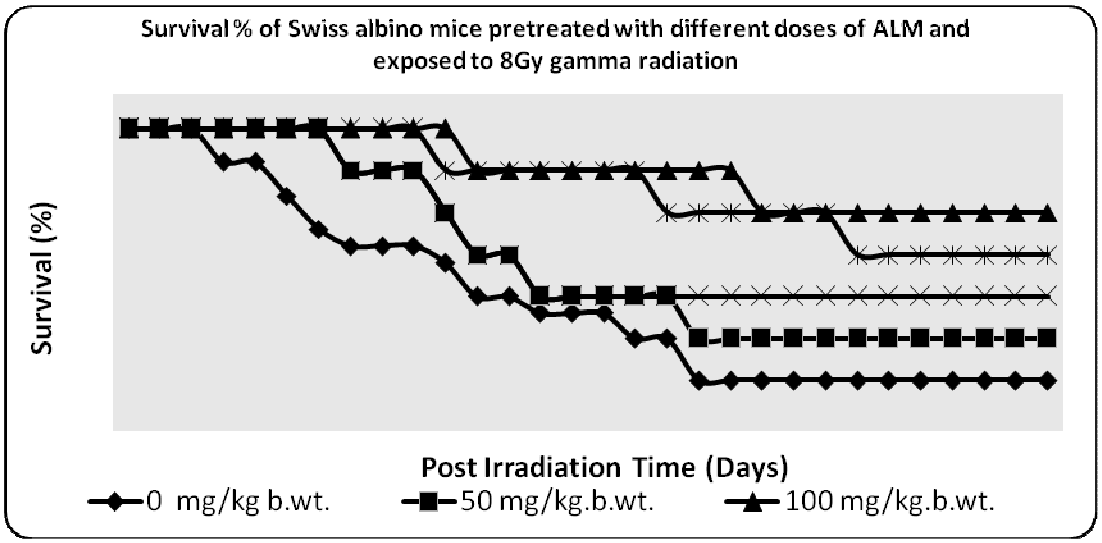
Drug Tolerance Study

The mice treated with different concentrations of ALM (50, 100, 200, 400, 600, 800, 1000 mg/kg b.wt./day) for 3 consecutive days showed no signs of sickness, toxicity, abnormalities and mortality during 30 days observation period.

Optimum Dose of Alcoholic Extract of Mentha (ALM) against Radiation

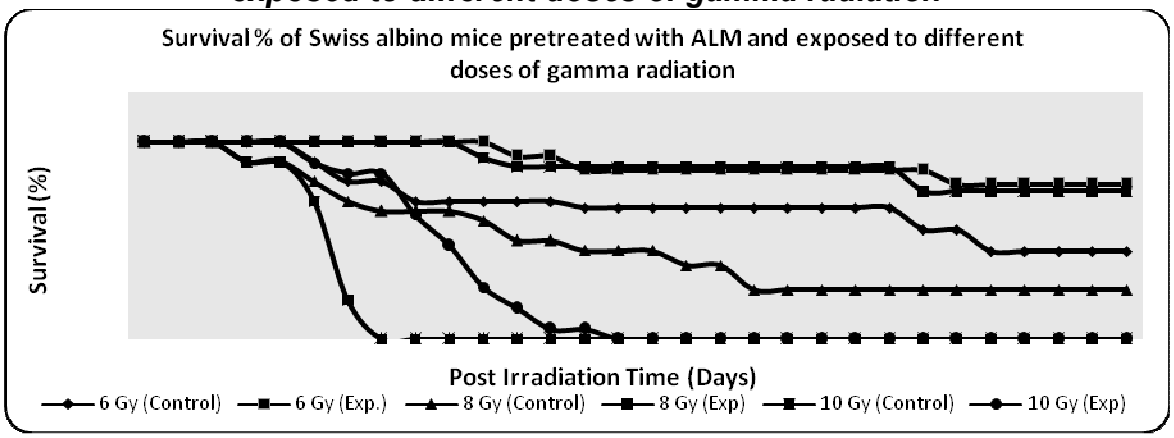
Graph 1

Survival % of Swiss albino mice pretreated with different doses of ALM and exposed to 8Gy gamma radiation



Graph 2

Survival % of Swiss albino mice pretreated with ALM (100 mg/Kg body weight/day) and exposed to different doses of gamma radiation



Maximum radioprotection in terms of highest survival percentage (75%) was observed with 100 mg/kg b.wt/day (optimum dose) for three consecutive days before irradiation at 8 Gy. At other doses of ALM viz. 50, 200 and 400 mg/kg b.wt./day 30 days survival percentage was 37.50%, 50% and 62.50 respectively. No radiation sickness was observed with drug (ALM) dose of 100 and 400 mg/kg b.wt/day, whereas mild radiation sickness (general lethargy and loss of appetite) was observed in animals treated with 50 and 200 mg/kg b.wt./day before 8 Gy gamma irradiation. The animals control group exhibited minimum survival (25%) and severe radiation sickness (lethargy, diarrhoea, loss of body weight and appetite, ruffled hair, epilation and facial edema).

Dose reduction factor (DRF)

The LD $_{50/30}$ value of experimental (ALM + irradiation) was considerably higher (8.052 ±0.115) than control (5.598±0.09) group. On the basis of LD $_{50/30}$ survivability, ALM pretreatment produced a dose reduction factor (DRF) of 1.44.

Table 1

Body weight change in Swiss albino mice till day 30 after exposure to 6, 8 and 10 Gy of gamma rays with (experimental) and without (control) pretreatment of ALM

Day	Control 6 Gy	Experimental 6 Gy	Control 8 Gy	Experimental 8 Gy	Control 10 Gy	Experimental 10 Gy	Normal	Drug alone
0	25.26 ± 1.42	26.42 ± 1.42	26.12 ± 1.20	25.87 ± 1.02	22.76 ± 1.46	23.96 ± 1.89	24.26 ± 0.42	24.5 ± 1.7
1	24.24 ± 1.16	26.22 ± 1.92	23.62 ± 1.30	24.62 ± 1.56	22.25 ± 1.18	23.16 ± 1.42	24.18 ± 0.82	25.6 ± 1.84
2	24.14 ± 0.56	25.46 ± 1.54	22.37 ± 1.25	25.50 ± 1.98	20.04 ± 1.06[a]	22.42 ± 1.26[a]	24.84 ± 1.48	26.08 ± 2.36
3	23.42 ± 1.28	25.22 ± 1.84	22.25 ± 1.25	26.00 ± 1.11	19.12 ± 0.40[b]	21.84 ± 2.25[b]	24.92 ± 1.02	26.17 ± 2.1
4	23.14 ± 0.26[a]	24.42 ± 1.46	22.62 ± 0.61[b]	24.75 ± 0.90	17.42 ± 1.3[c]	21.46 ± 2.85	25.2 ± 0.46	26.28 ± 1.28
5	21.32 ± 1.18[b]	24.42 ± 1.46	21.00 ± 1.41[c]	25.37 ± 1.23	15.94 ± 1.76[c]	20.92 ± 2.62	25.96 ± 1.24	27.32 ± 1.56
6	21.48 ± 0.82c	23.89 ± 2.32	21.35 ± 0.53[c]	27.25 ± 1.20	13.29 ± 2.40[c]	20.82 ± 3.24	25.96 ± 1.24	27.58 ± 1.42
7	20.68 ± 0.46[c]	23.42 ± 1.65	20.28 ± 0.65[c]	27.62 ± 1.05	13.29 ± 2.40[c]	19.78 ± 2.16	26.2 ± 0.42	27.69 ± 1.86

8	20.44 ± 0.76[c]	24.64 ± 1.25	20.28 ± 0.65[c]	28.37 ± 1.36	-	19.25 ± 1.84	26.4 ± 0.8	27.82 ± 1.11
9	19.86 ± 0.26[c]	24.24 ± 1.25[a]	20.00 ± 0.32[c]	28.50 ± 1.37[a]	-	18.28 ± 1.46	26.72 ± 0.96	28.07 ± 1.28
10	19.22 ± 1.26[c]	24.14 ± 1.70[a]	19.00 ± 1.37[c]	27.25 ± 1.20	-	17.82 ± 1.33	27.24 ± 0.25	28.33 ± 1.55
11	19.22 ± 0.26[c]	25.00 ± 1.84[a]	19.00 ± 1.37[c]	25.0 ± 1.19	-	17.12 ± 1.46	27.44 ± 1.46	28.85 ± 1.56
12	19.14 ± 0.46[c]	25.00 ± 1.84[a]	19.80 ± 1.12[c]	22.71 ± 1.40	-	16.92 ± 2.32	27.82 ± 0.82	29.35 ± 1.84
13	14.22 ± 0.38[c]	25.48 ± 1.25[a]	19.00 ± 1.29[c]	24.00 ± 1.15[a]	-	16.71 ± 1.81	28.28 ± 0.25	29.49 ± 1.55
14	18.46 ± 0.98[c]	25.96 ± 1.54[a]	18.50 ± 1.25[c]	24.85 ± 1.45[b]	-	15.18 ± 1.24	28.6 ± 0.30	29.49 ± 1.25
15	18.96 ± 1.24[c]	24.64 ± 1.26[a]	17.75 ± 1.54[c]	25.14 ± 1.22[b]	-	15.18 ± 1.24	28.72 ± 1.46	29.68 ± 0.8
16	19.25 ± 0.72[c]	24.42 ± 1.64	19.50 ± 0.70[c]	25.00 ± 1.48[a]	-	-	28.72 ± 1.46	29.69 ± 0.9
17	19.56 ± 1.25[c]	26.17 ± 1.4 [b]	19.75 ± 1.54[c]	24.33 ± 1.4	-	-	29.26 ± 0.58	29.16 ± 1.24
18	20.42 ± 1.54[b]	26.84 ± 1.42[a]	19.50 ± 0.65[c]	23.83 ± 1.68	-	-	29.43 ± 1.24	29.76 ± 1.46
19	20.94 ± 1.65[b]	26.96 ± 1.46[a]	21.50 ± 2.36[b]	26.50 ± 1.66	-	-	29.43 ± 1.24	29.84 ± 1.4
20	21.87 ± 1.46[b]	26.52 ± 2.56	21.75 ± 1.93[b]	26.66 ± 1.58	-	-	21.76 ± 1.32	29.84 ± 1.22
21	21.87 ± 1.46[b]	26.48 ± 2.42	21.75 ± 2.32[b]	27.50 ± 1.52	-	-	29.76 ± 1.16	30.18 ± 1.7
22	21.44 ± 2.32[a]	26.96 ± 1.12	22.0 ± 1.82[b]	28.50 ± 1.6	-	-	30.14 ± 1.46	30.28 ± 1.25
23	21.64 ± 1.01[b]	26.96 ± 1.12b	22.50 ± 2.17[b]	28.60 ± 1.32[a]	-	-	30.14 ± 1.68	30.34 ± 1.32
24	21.46 ± 1.26[b]	27.42 ± 1.84[a]	21.25 ± 1.65[b]	28.60 ± 1.12[a]	-	-	30.28 ± 1.4	30.51 ± 1.68
25	22.24 ± 1.8[b]	27.22 ± 1.25	21.50 ± 1.70[b]	28.20 ± 1.15	-	-	30.42 ± 1.22	30.63 ± 1.48
26	22.84 ± 1.26[b]	27.84 ± 2.34	22.25 ± 1.95[a]	28.12 ± 1.00	-	-	30.48 ± 1.70	30.77 ± 1.19
27	23.16 ± 1.84[b]	28.21 ± 1.46	23.50 ± 2.36[a]	28.37 ± 1.05	-	-	30.61 ± 0.75	31.84 ± 1.20
28	24.42 ± 2.34[a]	28.22 ± 1.72	24.66 ± 1.45[a]	28.50 ± 1.26	-	-	30.68 ± 1.65	31.89 ± 1.11
29	24.42 ± 2.34[a]	28.24 ± 0.57	24.62 ± 1.75[a]	29.27 ± 1.24	-	-	30.86 ± 1.54	31.89 ± 1.25
30	25.64 ± 1.84[a]	28.48 ± 1.42	25.80 ± 1.75[a]	29.29 ± 1.24	-	-	30.86 ± 1.25	31.96 ± 1.53

Graph 3

Survival dose - response curves for the determination of $LD_{50/30}$ (survival data collected for four radiation doses and calculated by regression analysis

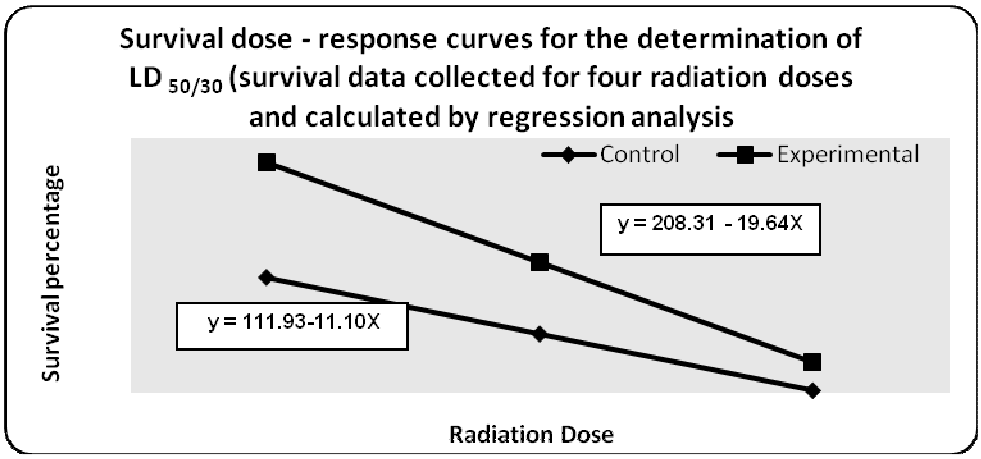


Table 2

Survival percentage (30 days post irradiation) of Swiss albino mice with or without pre-treatment of ALM and exposed to different doses of gamma radiation.

RADIATION DOSE (Gy)	CONTROL SURVIVAL (%)		EXPERIMENTAL SURVIVAL (%)	
	OBSERVED	AFTER REGRESSION y = 111.93 - 11.10 x (r = 0.64)	OBSERVED	AFTER REGRESSION y = 208.31 - 19.64 x (r = 0.69)
6	44.40	45.33	78.57	90.47
8	25.00	23.13	75.00	51.19
10	0.00	0.93	0.00	11.91

Control = Radiation alone
Experimental = ALM+ Radiation
DRF = $LD_{50/30}$ Experimental / $LD_{50/30}$ Control
Control $LD_{50/30}$ = 5.598 ± 0.09
Experimental $LD_{50/30}$ = 8.052 ± 0.115
DRF = 1.438

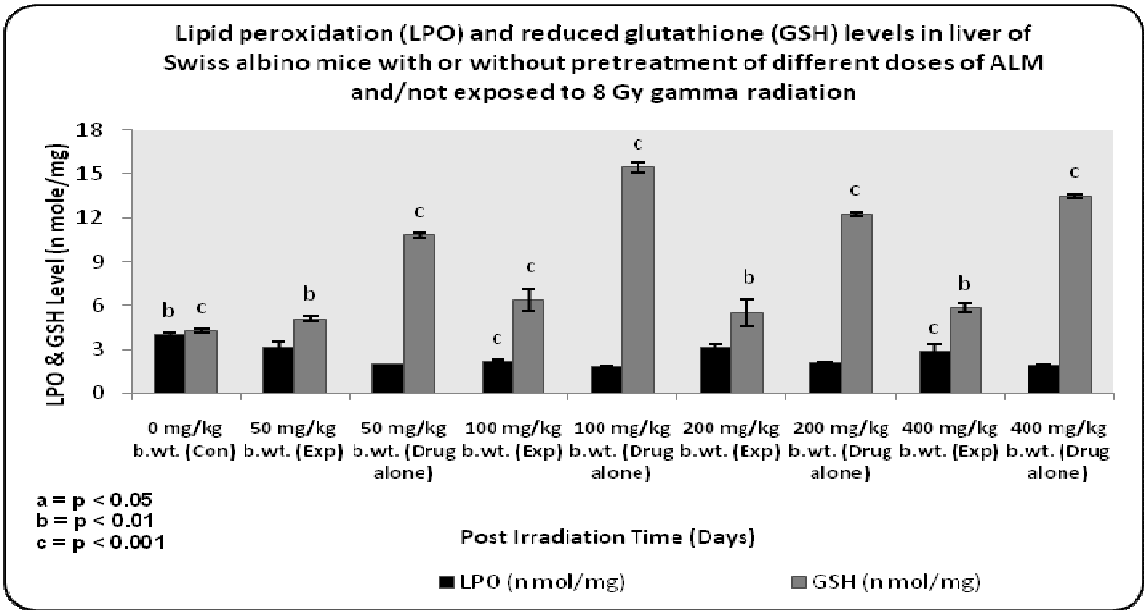
The animals group I (normal) and group II (drug alone) animals showed a consistent weight gain till day 30, which was 27.20 and 30.44 percent higher than their initial weight (day 1). The signs of radiation sickness such as lethargy, diarrhoea, loss in body weight, loss of appetite, ruffled hair, epilation, facial edema was observed in animals exposed to 6, 8 and 10 Gy irradiation although the severity was dose dependent. In 6 and 8 Gy exposed animals maximum weight loss and mortality occurred within first ten days. 100 percent mortality was observed during the first week at 10 Gy exposures as well as showed severe

radiation sickness with significant ($p<0.01$) weight loss of 41.61 percent. Occasionally excessive watering of eyes with continuous blinking, “Duncing" behaviour was also exhibited by some animals with 8 and10 Gy exposure in which animals sit immobile facing the wall of the cage with bowed head rocking sideways, some mice showed movement with rolling gait. Most of the animals showed swelling on either side of the mouth.

Pre treatment with 100 mg/kg b.wt./day for 3 consecutive days afforded considerable radioprotection at 6, 8 and 10 Gy radiation doses. No, mild and less severe radiation sickness was observed at 6, 8 and 10 Gy irradiation + ALM treated group respectively. As compared to control 34.14% and 25% higher survival was observed with ALM pre-treatment at 6 and 8 Gy exposure. The body weight loss also showed considerable arrest at all the radiation doses. In the experimental group (group IV) some animals survived till day 15 which was significantly ($p<0.001$) higher as compared to their respective control group (subgroup IIIc) in which no animal survived after day 7.

Graph 4

Lipid peroxidation (LPO) and reduced glutathione (GSH) levels in liver of Swiss albino mice with or without pretreatment of different doses of ALM and/not exposed to 8 Gy gamma radiation



Highly significant ($p<0.001$) elevation in liver GSH level in drug alone (ALM) group was observed at all concentration (50, 100, 200, 400 mg/kg b.wt./day) as compared to normal animals (without any treatment). However, a significant ($p<0.001$) decrease in GSH was observed in control (0 mg/kg b.wt./day) animals exposed to 8 Gy gamma radiation as compared to normal. Maximum GSH level (6.4±0.714 n mole/mg) was observed in animals treated with 100 mg/kg b.wt./day of ALM, which was significantly ($p<0.001$) higher than the respective control.

Lipid peroxidation (LPO) assay (Fig. 4)

In the drug alone group, there was non significant variation in LPO levels with normal however the level increased after radiation exposure and these values were below normal at all the drug doses. The minimum lipid peroxidation level was observed in the group administered with 100 mg/kg b.wt./day, which

was significantly ($p<0.001$) lower than respective control.

DISCUSSION

These results suggest that the drug is well tolerated up to the concentration of 1000 mg/kg body weight/day by Swiss albino mice for 3 days. Radiation exposure (6, 8 and 10 Gy) in control animals showed qualitatively similar kind of signs of radiation sickness such as weight loss, anorexia, diarrhoea, lethargy, ruffled hair, epilation, watering eyes , facial edema, and "Duncing " behavior but the severity of these signs and symptoms was dose dependent. These observations are in good agreement with the finding of other workers[20,21,22,23,24,25,26]. Causes of diarrhoea may be either due to the loss of the ability of bowel to absorb fluid and electrolytes[27] or due to changes in the permeability[28], malabsorption of bile salts and carbohydrates[29,30] and bloody diarrhoea may be due to loss of epithelial barrier[31]. In mice, death within 10 days post-irradiation is due to gastrointestinal damage[39,40,41] and from 11 to 30 days is due to hemopoietic damage inflicted by radiation[20,42,41]. The characteristic symptoms such as irritability, epilation, weight loss, emaciation, lethargy and ruffling of hairs were in consonance with earlier reports[20,40,42,41].

The inflammation of mice skin following high doses of radiation can be attributed to nitric oxide production[32]. The weight loss in the initial phase may be probably due to the gastrointestinal damage following irradiation[33,34]. The second phase of weight loss may be due to reduced water intake[35]. Radiation induced gastrointestinal syndrome results in marked loss of water and electrolytes which may also contribute to weight loss[36,37]. The early death of animals following irradiation can be attributed to functional failure of gastrointestinal tract (gastro-intestinal syndrome), whereas the later deaths appear to bone marrow damage (hemopoietic syndrome) and bacteremia[38]. Bacteremia has also been studied[43,44,45] in irradiated rodents as a cause of mortality secondary to hematopoietic and gastrointestinal radiation damage as antibiotic treatment has been shown to increase survival of mice irradiated in the $LD_{50/30}$ range[46]. In fact, death is associated with widespread damage to many organs and it is virtually impossible to single out or characterize a precise cause of death in any individual mortality.

The radioprotective activity of ALM has been demonstrated in the present study in form of reduced mortality and radiation sickness. The reduction in radiation induced sickness can be attributed to the antiemetic property of *Mentha piperita*[47,48]. The antiemetic effect can partly be attributed by its action on 5-HT (3) receptor of ion–channel complex probably by binding to a modulatory site distinct from the serotonin binding site[49]. Peppermint oil has also been reported to relieve the symptoms of irritable bowel syndrome, relaxing intestinal smooth muscle by reducing the availability of calcium[50]. Animal model studies demonstrate a relaxation effect of the herb on gastrointestinal (GI) tissue, analgesic and anesthetic effects in the central and peripheral nervous system[51]. The antimicrobial property of *Mentha*[52,6] may protect gastrointestinal injury and suppress diarrhoea.

Other symptoms like swelling and watering of eyes, along with swollen edges of mouth are possibly prevented by antiallergic[8] and anti-inflammatory[53] property of *Mentha piperita*. Flavonoid glycosides which are present in *Mentha* like eriocitrin, narirutin, hesperidin, luteolin-7-O-rutinoside, isorhoifolin, diosmin, rosmarinic acid and 5,7-dihydroxycremone-7-O-rutinoside are potent inhibitor of histamine release has been reported to exhibit antiallergic property[8]. The anti-inflammatory property of *Mentha piperita* is because of limonene[53,54]. Maximum radioprotection was observed at 100 mg/kg b.wt./day of ALM before irradiation (8 Gy) whereas, at higher concentrations (200 and 400 mg/kg b.wt./day) the protection was less. A similar observation has been made earlier with herbal preparations like Triphala and Abana[41,55], antioxidant aminothiol protector, 2-mercaptopropionyl glycine[56], Menthol[57], Ageratum conyzoides[55], *Mentha piperita*[58].

The pattern of survival in the ALM treated group was similar to that of the irradiated control group except that the mortality was delayed. This clearly indicates the effectiveness of ALM in arresting death caused by gastrointestinal destruction up to 10 days. Similarly, pretreatment of mice with ALM considerably reduced bone marrow death and bacteremia after day 10, which was observed as increased survival up to day 30. This increase in 30 day survival may be owing to the protection affected by ALM to the stem cell compartment, which continued to supply the requisite number of cells in the survivors[59]. A similar effect has been reported for compound formulation such as Liv 52[61,62], Triphala[41], various rasayanas[62], ayurvedic preparation[60], plant extracts like *Emblica officinalis*[64,65], *Phyllanthus niruri*[66], Abana[55] and *Panax ginseng*[67]. ALM may have prevented the localization of the pathogenic microbes in the GI tract and the bacteremia, owing to its antimicrobial property[68,52]. This property is conferred by menthol and menthone present in *Mentha piperita* essential oil[52].

A number of antioxidants, antiperoxidants have been reported in *Mentha piperita* viz., β-carotene, α-tocopherol[7], tannins, rutin, menthone and isomenthone, selenium, zinc, geranial, caryophyllene[6], caffeic acid, eugenol, rosmarinic acid[3,4,5]. ALM is also found to elevate the level of liver GSH which is necessary for the proliferation of cells including lymphocytes[69]. In addition GSH is essential for the activation of T-lymphocytes and polymorphonuclear leucocytes as well as cytokine production and therefore mounting successful immune responses when the host is immunologically challenged[70]. The exact mechanism of action of ALM against radiation induced damage to Swiss albino mice is not known. However, it may scavenge free radical induced damage to the cellular DNA which can be related to its antioxidant activity.

CONCLUSION

The Antitumorogenic, anticarcinogenic and radioprotective activity of *Mentha piperita* oil and *Mentha piperita* aquoeus extract has well been documented. The present study demonstrated the effectiveness of alcoholic extract against radiation induced morbidity and mortality using the optimum dose of 100 mg/kg b.wt./day ALM for 3 consecutive days.

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