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Exposure to noise augments behavioral deficits in mice: Protective effect of banana peel extract

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Abstract: The study is aimed to evaluate the protective impact of banana peel extract (BPE) following noise induce behavioral deficits in male mice. Animals were separated into two groups (control and test, 12 in each). Control mice were given drinking water, at the same time test group was given BPE (400 mg/kg; oral administration). Animals have received their respective treatment for 14 days. Mice were subdivided (n=6) into unstressed and stressed groups on day 15. Noise stress was given to the respective group for 4-h. Behavioral activities were monitored 24-h after the 4-h noise stress. Forced-swim-test, Elevated-plus-maze and light-dark-activity-box tests were performed for depression/anxiety-like behaviors respectively. Morris-water-maze assessment was used for memory. After behavioral tests animals were sacrificed and brain was detached for biochemical estimations and histopathological studies. In the present study, BPE produced anxiolytic and antidepressant-like effects and enhanced memory. Activity of antioxidant enzymes increased while levels of AChE and MDA decreased in BPE treated animals. Histopathological alterations induced by noise stress were also normalized by BPE. It is concluded that supplementation/administration of banana peel has preventive effects against anxiety, depression and memory impairment via its strong antioxidant potential following NS.

Keywords: Banana peel extract, noise stress, oxidative stress, antioxidant enzyme, behavioral deficits, memory.

INTRODUCTION

Environmental noise is a widespread dilemma experienced in metropolitan life, a cause of stress (Hahad *et al.* 2019). Stress-instigated effects are involved in hyperactivity of the hypothalamic pituitary adrenal axis (HPA-axis) resulting in secretion hormone and neurotransmitter (Juruena *et al.* 2020). Noise exposure affects learning, memory and induces behavioral alteration. High noise volume has been linked with decreases in memory in children (Percy-Smith *et al.* 2020), an outcome that has been similar in rats (Samad *et al.* 2020). High noise can strictly affect sleeping, working ability, performance, and communication competence (Javanbakht *et al.* 2021). Long-term experience to unavoidable noise stress (NS) induces behavioral alterations (Samad *et al*. 2020).

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Oxidative stress (OS) is the situation occurring from the unevenness between toxic reactive oxygen species (ROS) and the mechanism of antioxidant (Poprac *et al.* 2017). Extensive reported ROS are distributed in the body in many ways, with utilization of antioxidant enzymes (e.g., superoxide dismutase (SOD) that changes $O^{2-\bullet}$ to H_2O_2, which is then transformed into water by glutathione per oxidase (GPx) and catalase (CAT) (Hritcu and Ciobica 2013). It has been documented that unevenness between oxidant and the antioxidant system is involved in the progression of various diseases (Xie *et al.* 2016). Studies have shown that stress can produce adverse effects on the antioxidant system and cause the induction of lipid per oxidation (LPO) at central level (Samad *et al*. 2020).

Plants have a major role in the prevention of various diseases related to OS. The fame and accessibility of the traditional medication have to lead to concerns about the protection, usefulness and the liability of practitioners using traditional remedies (Pedraza-Alva *et al.* 2019). Banana is one such plant that has acquired fame in the cure of various illnesses, belongs to *Musaceae* family (Sarkiyayi and Aileru 2016). Banana, commonly recognized as *Musa sapientum*, is a familiar tropical fruit in the world. Every part of the banana plant has a medicinal relevance (Liu et al. 2003). Banana peel, a waste product of banana (Sarkiyayi and Aileru 2016) has medicinal properties (Samad *et al.* 2020; Shadma *et al.* 2014). It contains compounds such as flavonoids, tannins, phlobatannins, alkaloids, glycosides, and terpenoids. These biologically active compounds exert pharmacological effects, especially by reducing oxidative stress, treating diabetes, inflammatory and microbial infections (Imam and Akter 2011). Presently, it is assumed that supplementation of banana peel extract

(BPE) helps to cope up with NS induced behavioral changes, memory impairments and OS damage in the brain of mice.

MATERIALS AND METHODS

Animals

Albino male mice (BALB/c) (20-25 g) had admittance to diet and drinking water for 4 days before the beginning of the experiment. The mice were placed alone to evade societal activity under 12-hrs dark and light timings and at fixed temperature (21±2°C) with independent intake of diet and water. Animals were purchased from the University of Lahore, Lahore-Pakistan. All experiments were approved by Departmental Bio-ethical Committee (D-1691/52- Biochem; Dated: June 19, 2019) and performed with guidelines of NIH for care and use of laboratory animals.

Plant material and preparation of the extract

The banana was obtained from collected from the proximate of Multan, Punjab-Pakistan and recognized as *Musa sapientum* by the taxonomist (Dr. Zafar Ullah Zafar, Department of Botany, Bahauddin Zakariya University, Multan) and voucher (rjp-559) was booked in an herbarium. Peels of the fresh banana extract were extracted; 600 g of peel heated in 1000 ml of distilled water (80°C) for 120 sec. 70% acetone was used for homogenization of peel using an electric blender at room temperature. After that, at 6000 rpm this mixture was centrifuged 10 min. The mixture was then filtered and concentrated to 0.3 L at 50°C using rotary evaporator. Then, the extract was allowed to dry overnight in an oven (50°C) as described previously by Tee and Hassan (2011).

Experimental protocol

This experiment is comprised of two phases. In the first phase various doses (0.0, 50.0, 100.0, 200.0, 400.0, 800.0mg/kg body weight) of BPE were used and the exploratory activity in open field and home cage was monitored. The exploratory activity was conducted to select a dose which may possibly protects from behavioral, biochemical and histopathological modification following noise exposure. Mice (5 in each group) received BPE orally, once daily (at 9:00-10:00 am) for 14 days. Exploratory activities were conducted right after 14 days for 5 minutes for each animal.

In the second phase twenty-four mice were randomly separated into two groups (12 animals in each group). Group 1 is named as control which received drinking water while group 2 called as test group which received selected dose of BPE (400 mg/kg body weight) orally (once daily; at 9:00-10:00 am). All mice received their respective treatment for 14 days. After 14 days animals were again divided into two more groups (i) control +unstressed (ii) control +stressed (iii) BPE +unstressed (iv) BPE +stressed. Stressed groups were exposed with the noise on acute basis for 4-hrs on day 15. Twenty-four hours after the exposure of noise stress behavioral tests [forced-swim-test (FST), light-dark-activity-test (LDA)', 'elevated-plus-maze-test (EPM)' and 'Morris-water-maze-test (1MWM)] of all four groups were performed. After behavioral tests animals were decapitated and their brains were collected and frozen at a set temperature of -20°C for biochemical and histopathological analysis.

Noise exposure

Recorded noise by generator amplified with speakers. Mice exposed to intensified noise to induce a noise stress model. The method of Naqvi *et al*. (2012) was used in the study.

Behavioral Analysis

Anxiety like behaviors was evaluated by EPM (Naqvi *et al.* 2012) and LDA (Samad *et al.* 2020) as described previously. Depression like symptoms were monitored by FST as reported earlier (Naqvi *et al.* 2015). MWM assessment was performed to evaluate the cognitive effect as described earlier (Haider *et al.* 2011).

Biochemical analysis

Brain homogenate prepared in phosphate buffer after reported procedure used for biochemical estimation. The methods of Chow and Tappel (1972), Pari and Latha (2004), Naskar *et al.* (2001), Flohe and Gunzler (1984) and Ellman *et al.* (1961) used for MDA, CAT, SOD, GPx and AChE estimations in brain tissues of the mice.

Histopathological studies

Hematoxylin and eosin (H & E) stain was used for brain tissue staining. Brain slices were dipped in formalin for histopathological studies as mentioned by Thenmozhi *et al.* (2015). Stained slides were visualized at 200X under the light microscope.

STATISTICAL ANALYSIS

Statistics were done by using SPSS (V. 20) by following 2-way anova. p less than 0.05 was used as significant.

RESULTS

Exploratory activity of BPE treated unstressed and stressed mice

Data on exploratory activity of BPE treated is presented in fig. 1. One-way anova of square crossed in open field activity [$F_{(5,24)}$=70.65, $p<0.05$] and cage crossing in home cage [$F_{(5,24)}$=60.55, $p<0.05$] exhibits significant effect of BPE. Post hoc analysis showed that gradual increase in BPE dose enhanced exploratory activity in both open field and home cage.

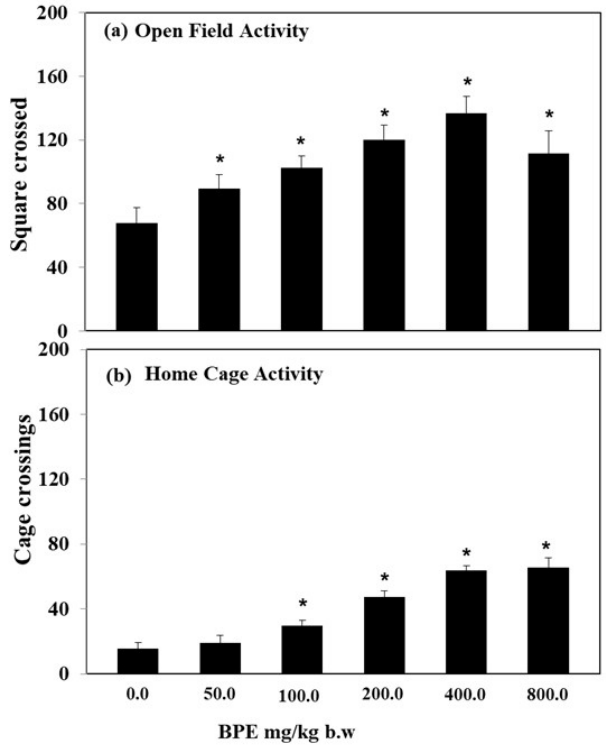

Fig. 1: Effect on various doses of BPE on exploratory activity in an open field and home cage. Values are means ± SD (n=5). Data was analyzed by Tukey's test following one-way ANOVA. Statistical difference is expressed as *p<0.01 versus respective control mice.

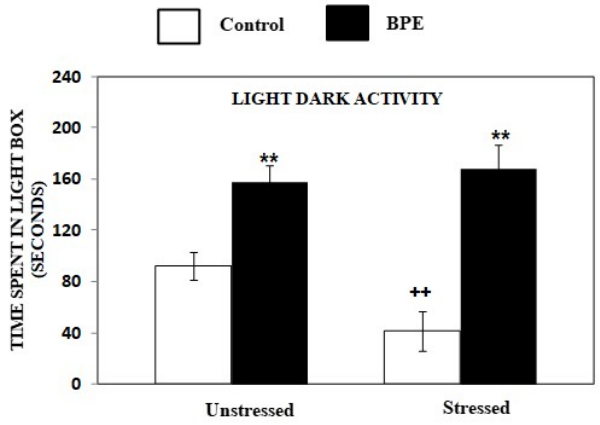

Fig. 2: Effects of BPE on time spent in light compartment in LDA following 4-h NS. Values are mean ± SD (n = 6). Data was analyzed by Tukey's test following two-way ANOVA. Statistical difference is expressed as *p<0.01 versus respective control and +p<0.01 versus unstressed mice.

Anxiety profile in light dark activity box of BPE treated unstressed and stressed mice

Data of the time spent in light compartment of LDA test (fig. 2) in the follow up effect of BPE analyzed by 2-way anova (df 1,20) and exhibited significant effects of NS [F = 10.85 p<0.001], BPE [F= 254.33 p<0.001] and NS× BPE [F=26.52 p<0.001]. Tukey's test shown that 4-hrs NS reduced, time consumed in a light-box in control+stressed mice. Time consumed in light-box is higher in BPE treated unstressed and stressed animals than control +stressed group.

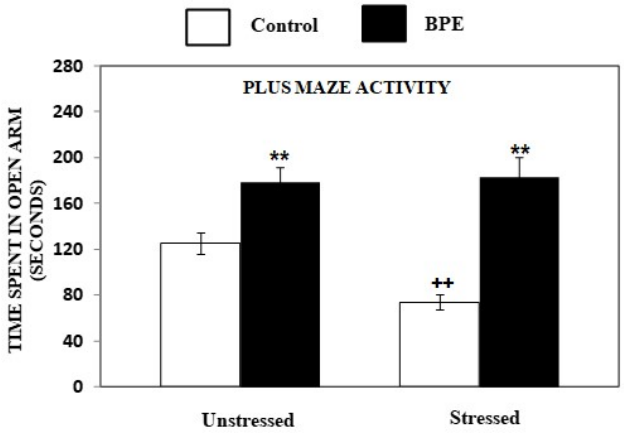

Fig. 3: Effects of BPE on time spent in open arm in EPM following 4-h NS. Values are mean ± SD (n=6). Data was analyzed by Tukey's test following two-way ANOVA. Statistical difference is expressed as *p<0.01 versus respective control and +p<0.01 versus unstressed mice.

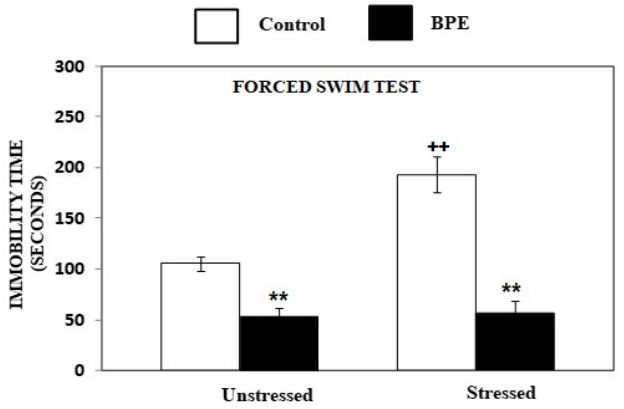

Fig. 4: Effect of BPE on depression like symptoms assessed by FST in terms of immobility time (s) following 4-hrs Noise stress. Values are mean ± SD (n = 6). Data was analyzed by Tukey's test following two-way ANOVA. Statistical difference is expressed as *p<0.01 versus respective control and +p<0.01 versus unstressed mice.

Anxiety profile in elevated plus maze activity of BPE treated unstressed and stressed mice

Data of the time spent in open arm of EPM test (fig. 3) in the follow up effect of BPE analyzed by 2-way anova (df 1,20) and exhibited significant effects of NS [F= 20.96 p <0.001], BPE [F = 251.55p<0.001] and NS× BPE [F= 29.15 p<0.001]. Tukey's test shown that 4-hrs NS reduced time consumed in open arm in control+stressed mice. Time consumed in open arm is greater in BPE+

unstressed and BPE+ stressed than their respective control.

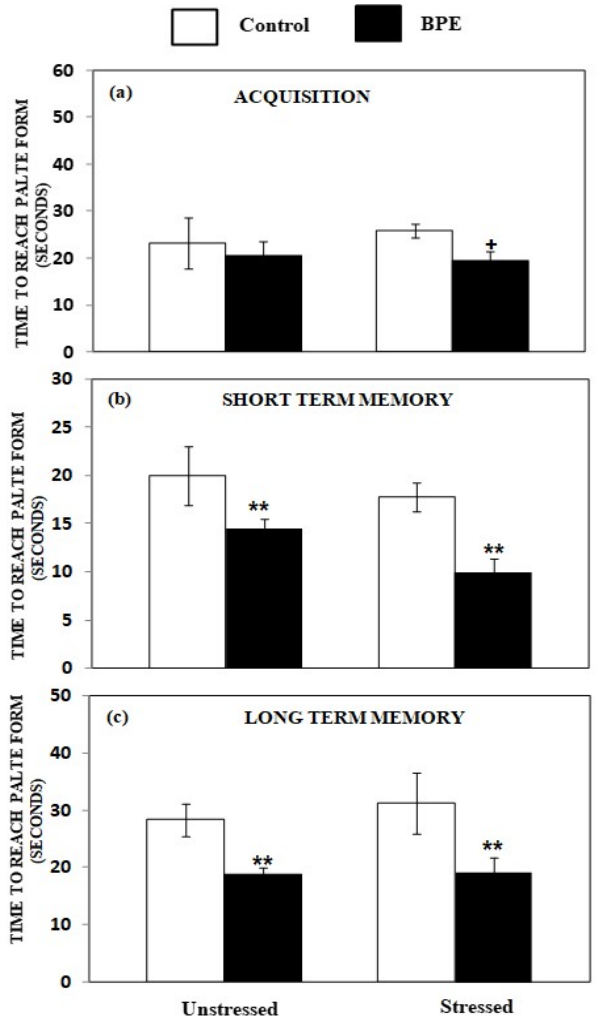

Fig. 5: Effect of BPE administration following 4-hrs NS on acquisition (a) STM (b) and LTM (c) in terms of escape latency (s) assessed by MWM. Values are mean ± SD (n = 6). Data was analyzed by Tukey's test following two-way ANOVA. Statistical difference is expressed as*p < 0.01 versus respective control and +p<0.01 versus unstressed mice.

Depression-like behavior in forced swim test of BPE treated unstressed and stressed mice

Data of the immobility time in FST (fig. 4) in the follow up effect of BPE analyzed by 2-way anova (df 1,20) and exhibited significant effects of NS [F= 89.98 p<0.001], BPE [F=381.99 p<0.001] and NS× BPE [F=78.53 p< 0.001] . Tukey's test shown that BPE reduced immobility time in unstressed and stressed animals. Immobility time in FST was greater in water treated stressed than unstressed.

Cognitive behavior in Morris water maze test of BPE treated unstressed and stressed mice

Data on memory function evaluated in MWM test (fig. 5) in the follow up effect of BPE analyzed by 2-way anova (df 1, 20). In acquisition phase, significant effects of BPE [F= 10.42 p<0.001] observed. Effects of NS [F = 0.30 p= p>0.001] and BPF x NS [F=1.96 p=p>0.001] were not significant. Anova for STM shown that significant effects of NS [F= 17.93 p<0.01], BPE [F= 34.27 p<0.001], while BPF x NS [F= 2.19 p>0.01] was not significant. Anova for LTM shown substantial effect of BPE [F= 60.96 p <0.001]. Effects of NS [F=1.16 p=p>0.01] and interaction [F=0.92 p>0.01]. Tukey's test shown that during acquisition BPE reduced the time to attain the platform in stressed mice. Whereas analysis of STM and LTM revealed that BPE considerably reduced the duration to attain the platform in stressed as well as unstressed mice. It was also observed memory was improved in BPE treated stressed animals than unstressed during STM.

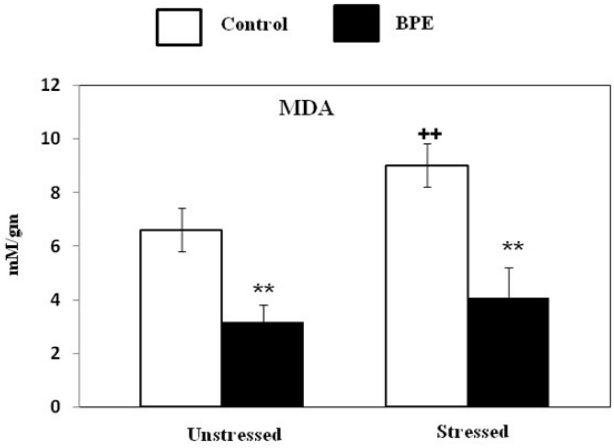

Fig. 6: Effect of BPE administration following single 4-hrs NS on brain MDA levels. Values are mean ± SD (n = 6). Data was analyzed by Tukey's test following two-way ANOVA. Statistical difference is expressed as*p < 0.01 versus respective mice.

Oxidative stress profiling of BPE treated unstressed and stressed mice

Data on effect of BPE following acute NS on MDA levels is shown in fig. 6. Statistics by Anova (2-way, df 1,20) exhibited significant effect of NS [F= 22.02p < 0.001] and BPE [F=141.09 p<0.001]. Whereas NS x BPE [F = 0.007 p>0.05] was not substantial. Tukey's test shown that NS increased MDA levels in control stressed animals. Whereas administration of BPE reducing peroxide formation in unstressed and stressed than control animals.

Antioxidant enzymes profiling of BPE treated unstressed and stressed mice

Data on effect of BPE on antioxidant enzymes following acute NS is shown in fig 7. The activity of SOD was evaluated by anova (2-way df 1,20) exhibited substantial property of BPE [F=71.39 p<0.001], NS [F=5.07p<0.05] and NS x BPE [F=22.39 p<0.001]. Tukey's test shown that stress reduced the action of SOD in water treated animals. Whereas, administration of BPE enhancing the activity of SOD in stressed than control animals.

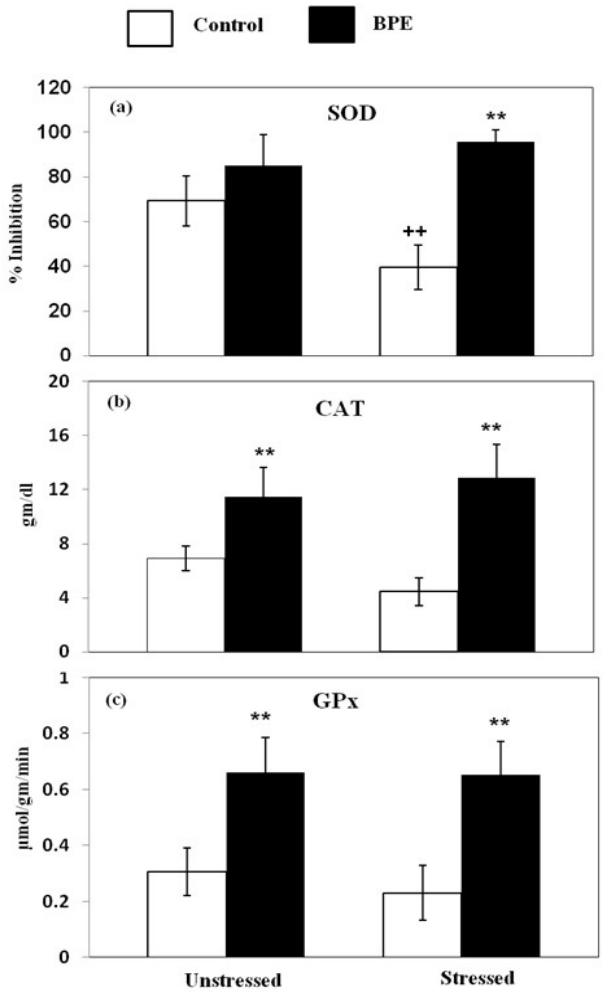

Fig. 7: Effect of BPE administration following single 4-hrs NS on brain SOD (a), CAT (b) and GPx(c) activity. Values are mean ± SD (n = 6). Data was analyzed by Tukey's test following two-way ANOVA. Statistical difference isexpressed as *p<0.01 versus respective control and +p < 0.01 versus unstressed mice.

Data on the action of CAT was evaluated by anova (2-way df 1,20) exhibited substantial property of BPE [F =81.42 p<0.001], and NS x BPE interaction [F=7.20 p< 0.05]. Effect of NS [F=0.52 p>0.05] was not significant. Tukey's test revealed BPE elevated the activity of CAT in unstressed and stressed than control mice.

Data on the activity of GPx was evaluated by anova (2-way df 1,20) gave the substantial property of BPE [F=88.58 p<0.001]. NS [F=1.05 p>0.05] and NS x BPE [F=0.68 p>0.05] exhibited non-significant effects. Tukey's test revealed that BPE elevated the activity of GPx in a notable manner in stressed and unstressed than their counterparts.

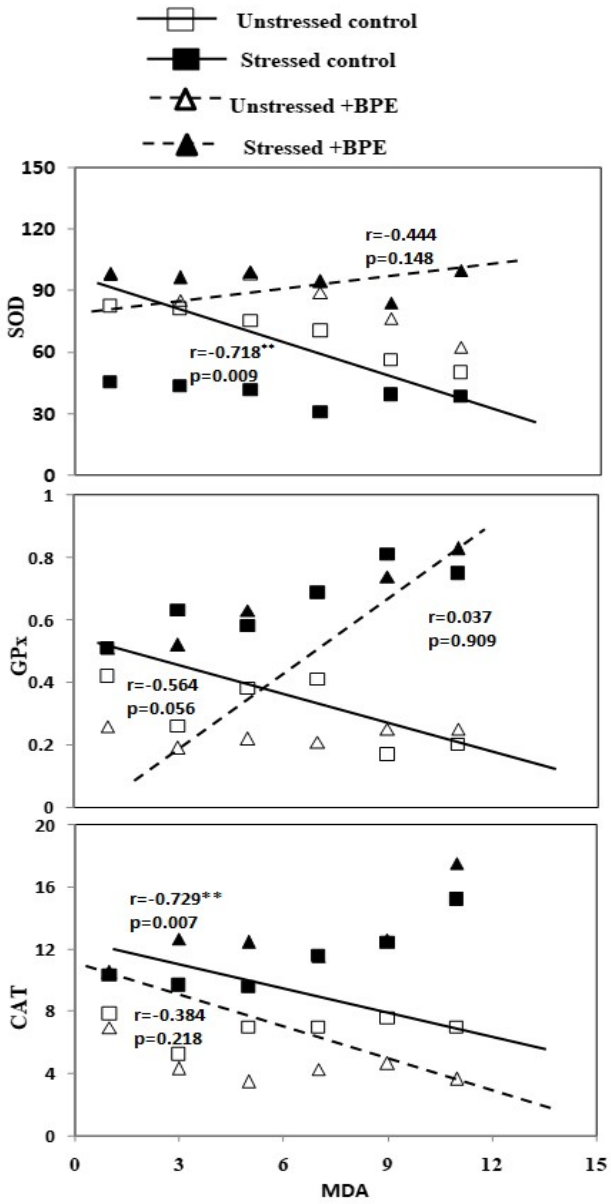

Fig. 8: Statistical correlation was used to identify the relation between LPO and antioxidant enzyme activities. Correlations between MDA levels and SOD activity (a), CAT activity (b), GPx activity (c) were determined using Pearson correlation test. In all cases, regular line and the values represent the correlation for control unstressed and stressedmice whereas dotted line and values represent correlation obtained for the BPE unstressed and stressed mice.

Correlation of oxidative stress and antioxidant profiling of BPE treated unstressed and stressed mice

Effect of BPE on oxidative stress, for evaluation a Bivariate Pearson's correlation test is shown in fig. 8. Data on SOD and lipid peroxidation showed a substantial relationship between the control group (unstressed and stressed, r= -0.71, p<0.01), while a non-substantial

relationship was observed between BPE treated groups (unstressed and stressed, r = 0.44, p=NSIG). Statistic on lipid peroxidation and CAT activity revealed a substantial relationship between control group (unstressed and stressed, r= -0.72, p<0.01), while non-substantial relationship was noticed between BPE treated groups (stressed and unstressed, (r= -0.38, p =0.21). Data on GPx and lipid per oxidation showed a non-substantial relationship between control group (r= -0.56, p=NSIG) and BPE treated group (stressed and unstressed, r = 0.03, p=NSIG).

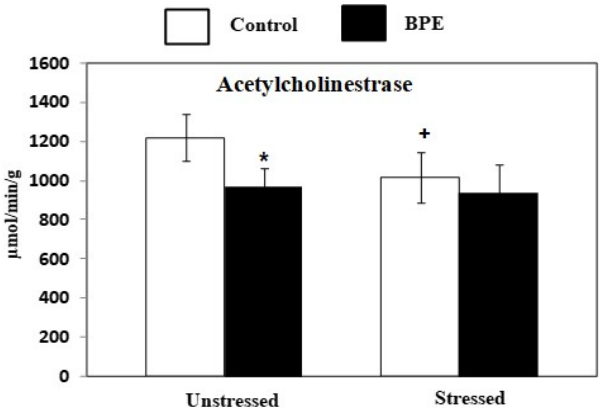

Fig. 9: Effect of BPE administration following single 4-hrs NS on brain AChE activity. Values are mean ± SD (n = 6). Data was analyzed by Tukey's test following two-way ANOVA. Statistical difference is expressed as*p < 0.01 versus respective control mice.

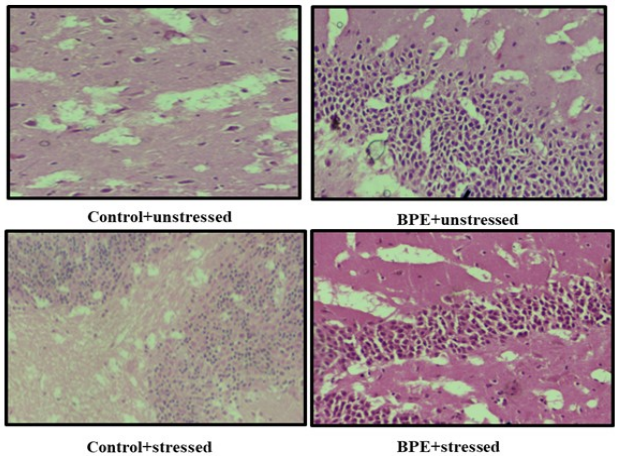

Fig. 10: Photomicrographs showing histopathological alterations in the brain of control + unstressed, control + stressed, BPE + unstressed, BPE + stressed mice.

Acetylcholinesterase activity of BPE treated unstressed and stressed mice

Effect of BPE on the activity of brain AChE activity following NS is shown in fig. 9. ANOVA (2-way, df 1,20) for the obtained data substantiated a notable property of BPE [F = 10.82 p< 0.01] and NS [F= 5.67 p<0.05]. Interaction between BPE x NS [F= 2.97 p=NSIG] revealed a substantial effect. Tukey's test shown BPE diminished the AChE activity in unstressed than control. The activity of AChE was also decreased in control stressed than unstressed animals.

Histopathological studies of BPE treated unstressed and stressed mice

Histopathological analysis of brain in all groups is shown in fig. 10. In control +unstressed mice normal basophilic staining was observed. Histology of control +stressed mice showed unclear basophilic staining of purkinje cells, and degeneration of pyknotic nuclei at some places. Slide of BPE +unstressed showed normal arrangement of purkinje cells with vacuolation at few places. BPE +stressed animals showed rare damage of purkinje cells which indicating slight damage of brain cells.

DISCUSSION

Noise exposure can noticeably induce behavioral and biochemical changes in mammals including humans and rats. Stress dysregulate the HPA axis and can induce mood disorders, such as depression and anxiety (Dwyer *et al.* 2020). Particularly, high levels of environmental noise correlate with the psychological symptoms and the incidence of psychiatric disorders (Hegewald *et al.* 2020). NS can enhance stress hormones such as catecholamine and glucocorticoids (Stansfield and Matheson 2003). Exposure to the stress involved in the induction of anxiety (Juruena *et al*. 2020). The result of the present study showed that acute NS produced anxiety (fig. 1 &2) that was accompanied by an enhanced immobility time (fig. 3) exhibited an animal model of depression. Conversely, administration of BPE attenuated the NS induced anxiety- and depression-like behaviors.

The stress-related behavioral alteration occurs may be due to increased OS in mice exposed to the NS that has a crucial role in the succession of neurological ailments (Salim 2017). In the brain, stress induces oxidative harm and noticeably impairs the equilibrium between pro-oxidant and antioxidant substances (Millington *et al.* 2014). The concentration of MDA (fig. 5) was elevated in stressed than unstressed mice. Consequently, the behavioral deficits exhibited by stressed animals may be due to the production of ROS (Fontella *et al.* 2005).

In a living system antioxidant enzyme have ROS hunting activity (Alkadi 2020). The present work demonstrated the significant decrease of SOD activity (fig. 6) while a non-significant decrease in CAT and GPx (fig. 6) was observed in stress as compared to unstressed animals. A reduction in antioxidant defense system causes oxidative deterioration by altering the homeostasis between redox and cellular defensive system and producing ROS (Millington *et al.* 2014). It is indicated that the activity of antioxidant enzymes was reversed by the administration

of BPE in stressed than unstressed. Consequently, it is indicated that reduced content of MDA and enhanced SOD with CAT and GPx activities could be due to the antioxidant potential of bioactive compounds present in BPE. The relationship between the activity of the antioxidant enzyme and the levels of MDA was not observed in BPE-administered unstressed and stressed mice (fig. 7). Correlations exhibited by water + unstressed and water + stressed mice might be ascribed to the NS induced change of cellular activities to a degree which causes OS. OS can modify the functioning of the nervous system by harming the cell membrane of neuron due to augmented oxidation of fatty acid that is a major structural part of the membrane (Blake *et al*. 1987). Banana peel has antioxidant properties and shown to decline OS whichever by hunting the ROS or by retrieving the antioxidant defense mechanism (Bouayed *et al.* 2009). BPE attenuates the NS-generated behavioral deficits by regularizing the SOD activity and altering the negative role of stress on CAT, consequential in normal GPx activity while no association was found between the enzyme activities and MDA levels in BPE treated stressed and unstressed mice. The abovementioned role of BPE may be ascribed due to the reduced LPO that cause a reversal of harmful effects of NS on behaviors. These findings show that BPE could be useful for the attenuation of stress-instigated alterations in the antioxidant mechanism.

Histological results are very much important in the present study which showed that due to noise induced oxidative stress brain cell faced oxygen deprivation. Conversely BPE due to its antioxidant potential normalizes the all worse conditions with no damaging appearance.

The activity of AChE (fig. 8) is substantially decreased following acute NS. Acetylcholine is involved in the formation and encoding of new memories (Adewoye *et al.* 2009). Das *et al*. (2011) reported that AChE activity in male rats was decreased and increased the transfer latency time in passive avoidance test following acute immobilization stress than control and chronically stressed groups. Our data is shown that decreased AChE activity produced no pronounced effect on short and long-term- memory (fig. 4) following acute noise stress. BPE, conversely, improving the short term and long-term-memory training sessions (fig. 4), which may be ascribed to the decreased AChE activity in unstressed and stressed mice. Previously it has been reported that banana increases the cognitive function (Kumar *et al.* 2012) by phenolic phytochemicals and reduce the risk of Alzheimer's disease (Das *et al*. 2000). Hence a decrease in AChE activity in the brain could increase the levels of acetylcholine and improve the cognitive ability (fig. 4 & 9). BPE and single stress enhance the cognitive ability, which is also a vital part of our work; however, an important finding is that BPE may improve-induced increase in cognitive function. It is therefore suggested that BPE may possess inhibitory functions on AChE and increase the availability at the synapse for binding on receptor sites due to its potential bioactive compounds that having antioxidant effects (Jing *et al.* 2011).

CONCLUSION

In conclusion, acute noise stress exhibited a reduction in activities of antioxidant enzymes; decrease in the activity of acetylcholinesterase, normalization of histo-pathological alterations followed by behavioral deficits and impaired cognitive functions. The present finding may have inferences for new curative strategies for the treatment or prevention of neurological diseases via antioxidant potential. Intake of banana peel extract possibly will help to avert the development of disorders like anxiety, depression, dementia, Alzheimer's disease, motor disabilities. In future more, studies should be done to evaluate the effect of banana peel extract with proteomics and genomic aspects.

REFERENCES

Adewoye EO, Taiwo VO and Olayioye FA (2009). Antioxidant and anti-hyperglycemic activities of *Musasapientum* root extracts in alloxan-induced diabetic rats. *Afr. J. Med. Sci.,* **38**(2): 109-117.

Alkadi H (2020). A review on free radicals and antioxidants. *Infect. Disord. Drug Targets.,* **20**(1): 16-26.

Blake DR, Allen RE and Lunee J (1987). Free radicals in biological systems: A review oriented to the inflammatory process. *Br. Med. Bull.,* **43**(2): 371-385.

Bouayed J and Rammal H, Soulimani R (2009). Oxidative stress and anxiety: Relation-ship and cellular pathways. *Oxid. Med. Cell. Longev.,* **2**(2): 63-67.

Chabuck ZAK, Al-Charrakh AH, Hindi NKK, Hindi SKK (2013). Antimicrobial effect of aqueous banana peel extract, Iraq. *Res. Gate. Pharm. Sci.,* **1**: 73-75.

Chow CK and Tappel A (1972). An enzymatic protective mechanism against lipid peroxidation damage to lungs of ozone-exposed rats. Lipids., **7**(8): 518-524.

Cohen S (1980). After effects of stress on human performance and social behavior: A review of research and theory. *Psychol. Bull.,* **88**(1): 82-108.

Das A, Kapoor K, Sayeepriyadarshini A, Dikshit M, Palit G and Nath C (2000). Immobilization stress-induced changes in brain acetylcholinesterase activity and cognitive function in mice. *Pharmacol. Res.,* **42**(3): 213-217.

Dwyer JB, Aftab A, Radhakrishnan R, Widge A, Rodriguez CI, Carpenter LL, Nemeroff CB, McDonald WM and Kalin NH (2020). Traffic noise and mental health: a systematic review and meta-analysis. *Int. J. Environ. Res. Public Health,* **17**(17): 6175.

Ellman Gl, Courtney KD, Andres V and Featherstone RM (1961). A new and rapid colorimetric determination of acetylcholinesterase activity. *Biochem. Pharmacol.,* **7**(2): 88-95.

Flohe L and Gunzler WA (1984). Assays of glutathione peroxidase. *Methods Enzymol.,* **105**: 114-121.

Fontella FU, Siqueira IR, Vasconcellos AP, Tabajara AS, Netto CA and Dalmaz C (2005). Repeated restraint stress induces oxidative damage in rat hippocampus. *Neurochem. Res.,* **30**(1): 105-111.

Haider S, Tabassum S, Perveen T, Ali S, Saleem S, Khan AK and Haleem DJ (2011). Age-related decrease in striatal DA produces cognitive deficits in male rats. *J. Pharm. Nutr. Sci.,* **1**: 20-27.

Hahad O, Prochaska JH, Daiber A and Muenzel T (2019). Environmental noise-induced effects on stress hormones, oxidative stress and vascular dysfunction: key factors in the relationship between cerebrocardiovascular and psychological disorders. *Oxid. Med. Cell Longev.,* 4623109.

Hritcu L, Ciobica A, Stefan M, Mihasan M, Palamiuc L and Nabeshima T (2011). Spatial memory deficits and oxidative stress damage following exposure to lipopolysaccharide in a rodent model of Parkinson's disease. *Neurosci. Res.,* **71**(1): 35-43.

Javanbakht M, Moosavi MB and Vahedi M (2021). The importance of working memory capacity for improving speech in noise comprehension in children with hearing aid. *Int. J. Pediatr. Otorhinolaryngol.,* **147**: 110774.

Juruena MF, Eror F, Cleare AJ and Young AH (2020). The role of early life stress in hpa axis and anxiety. *Adv. Exp. Med. Biol*., **1191**: 141-153.

Kumar KPS, Bhowmik D, Duraivel S and Umadevi M (2012). Traditional and medicinal uses of banana. *J. Pharmacog. Phytochem.,* **1**(3): 51-63.

Liu S, Tang YF, Zhao QL, Li Y, Chen J, Li ML, Zhao H and Zhou Y (2009). Extraction of polyphenols from banana peel and anti-fungal effect research. *Hu Nan Sheng Chang Sha Shi Xian Jia Hu Hu Nan Shi Fan Da Xue Yi Xue.,* **6**: 12-14.

Millington C, Sonego S, Karunaweera N, Rangel A, Aldrich-Wright Jr and Campbell IL (2014). Chronic neuroinflammation in Alzheimer's disease: new perspectives on animal models and promising candidate drugs. *Biomed. Res. Int.,* 309129.

Naskar S, Islam A, Mazumder UK, Saha P, Haldar PK and Gupta M (2011). *In Vitro* and *In Vivo* antioxidant potential of hydromethanolic extract of *Phoenix dactylifera* fruits. *J. Sci. Res.,* **2**: 144-157.

Pari L and Latha M (2001). Protective role of *Scorparia dulcis* plant extract on brain antioxidant status and lipid per oxidation in STZ diabetic male Wistar rats. *BMC Complement Alternat. Med.* **4**: 16.

Pedraza-Alva G, Ramírez-Serrano CE, Pedraza F, Flores-Vallejo RDC, Villarreal ML and Pérez-Martínez L (2019). From traditional remedies to cutting-edge medicine: Using ancient mesoamerican knowledge to address complex disorders relevant to psychoneuroimmunology. *Brain Behav. Immun.,* **79**: 3-5.

Percy-Smith L, Wischmann S, Josvassen JL, Hallstrøm M, Laplante-Lévesque A, Sorgenfrei MG and Caye-Thomasen P (2020). Evaluation of a sentence test in noise in children with hearing impairment. *Dan. Med. J.,* **67**(1): A06190358.

Poprac P, Jomova K, Simunkova M, Kollar V, Rhodes CJ and Valko M (2017). Targeting free radicals in oxidative stress-related human diseases. *Trends Pharmacol. Sci.* **38**(7): 592-607.

Porsolt RD (1981). Behavioral despair. In Antidepressants: Neurochemical, Behavioral and Clinical Perspectives,'' eds. Enna SJ, Malick JB, Richelson E, Raven Press, New York, pp.121-139.

Salim S (2017). Oxidative Stress and the Central Nervous System. *J. Pharmacol. Exp. Ther.,* **360**(1): 201-205.

Samad N, Yasmin F, Khaliq S, Ahmad S, Azizuddin and Mustafa S (2020). Diet supplements of banana fruit pulp mitigates repeated noise stress induced behavioral deficits and oxidative stress. *Pak. J. Pharm. Sci.,* **33**(5 Suppl.): 2293-2300.

Samad N and Haleem DJ (2017). Antioxidant effects of rice bran oil mitigate repeated haloperidol-induced tardive dyskinesia in male rats. *Met. Brain Dis.,* **32**(4): 1099-1107.

Sarkiyayi S and Aileru AE (2016). Effect of methanol leaf extract of anogeissusleio carpus on gentamicin induced biochemical derangement in rats. *J. Health Pharmacol.,* **4**(1): 1-7.

Shadma A, Sundaram S and Rai G (2014). Nutraceutical application and value addition of banana peel: A review. *Int. J. Pharm. Pharm. Sci.,* **6**(10): 81-85

Stansfeld SA and Matheson MP (2003). Noise pollution: non-auditory effects on health. *Br. Med. Bull.,* **68**: 243-257.

Tee TP and Hassan HA (2011). Antidepressant-like activity of banana peel extract in mice. *Am. Med. J.,* **2**(2): 59-64.

Thenmozhi AJ, Raja TR, Janakiraman U and Manivasagam T (2015). Neuroprotective effect of hesperidin on aluminium chloride induced Alzheimer's disease in Wistar rats. *Neurochem. Res.,* **40**(4):767-76.

Xie ZZ, Liu Y and Bian JS (2016). Hydrogen Sulfide and Cellular Redox Homeostasis. *Oxid. Med. Cell Longev.,* 6043038.