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Neuromodulatory effects of aqueous extract of *Coriandrum sativum* seeds against acrylamide induced toxicity in *Drosophila melanogaster*

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ABSTRACT

Acrylamide (ACR) exposure leads to neuronal damage in both experimental animals and humans and has been established as a neurotoxin. The primary focus of this study was to assess the potential ameliorative effect of aqueous extract of coriander seeds against ACR-induced neurotoxicity in a Drosophila model. In this co-exposure study, adult male flies (8–10 days) were exposed (7 days) to ACR (5 mM) with or without aqueous extract of coriander seeds (0.005% and 0.01%) in the medium. The incidence of mortality among flies fed with ACR and extract was significantly reduced (40-60%). The ACR fed flies showed improvement in negative geotaxis assay when co-exposed with coriander extract (50-60%). Further, a significant attenuation in the ACR induced oxidative stress parameter such as Reactive Oxygen Species (ROS), and malondialdehyde (MDA) was evident. Although the effect of ACR with or without extract showed a differential effect on the activities of superoxide dismutase (SOD), catalase (CAT) and glutathione –S – transferase (GST), the reduced levels of Thioredoxin Reductase (TRR) activity was robustly enhanced with extract supplement. Further, the cholinergic and dopaminergic function was assessed among all flies. While ACR induced elevation of acetylcholine esterase (AChE) activity remained unaltered with coriander supplement, a significant improvement was evident in the ACR induced reduction of dopamine levels. While the underlying mechanism of action needs further investigation, the protective effects may be at least in part related to the antioxidant capacity of the phytoconstituents of coriander.

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INTRODUCTION

Spices are in use since time immemorial as food adjuncts and in traditional medicinal preparations of Ayurveda. Commonly used spices are clove, cinnamon, coriander, cardamom, bay leaf, cumin, turmeric, etc. Extensive research over a decade has indicated that bioactive derived from spices such as turmeric (Curcumin), pepper (Piperine), clove (Eugenol), coriander (Linalool) and cinnamon (Cinnamaldehyde) target oxidative stress and inflammatory pathways that are common to many pathophysiological conditions. Hence spices are indeed a 'basket of nutraceuticals' with pleiotropic properties (Kannappan *et al.,* 2011; Sortibran *et al.,* 2015). Further, spices are consumed in our daily diet and may be contributing *unknown* benefits for the maintenance of good health. The other advantage of spices is that they do not result in adverse effects in a population at large.

Coriander (*Coriandrum sativum* L., Family Apiaceae), is an important and common spice in India. Both the fresh leaves and its seeds are widely used in culinary purposes. In addition to its culinary use, it is widely used for its medicinal benefits (Srinivasan, 2011). It has the ability to prevent nausea, vomiting and other gastrointestinal complaints such as anorexia, dyspepsia, flatulence and griping pain (Deepa and Anuradha, 2011). In addition, fresh coriander leaves are excellent appetizers to the bowels. It aids in digestion, liver function and also reduces diarrhea (Samojlik *et al.,* 2010). It has been shown to possess anti-diabetic action among streptozotocin-induced diabetes mice as well as among high-fat diet-induced diabetic rats (Grover *et al.,* 2002; Srinivasan, 2011). In addition, coriander has anti-edemic, antiseptic and antimicrobial activity. It has been well documented to possess anti-diabetic effect both *in vitro* and *in vivo* studies carried out with a different experimental approach (Grover *et al.,* 2002; Srinivasan, 2011; Perera and Wijetunge, 2015).

Acrylamide (ACR), a well-known human neurotoxin, is formed naturally during heat processing of carbohydrate-rich foods such as cookies, French fries, chips as well as during roasting of coffee beans (Reviewed by Yener and Kalipci, 2009). Because of its feasible chemical nature, it has applications in various industries such as the production of plastics, dyes, and paper, in the treatment of drinking water, wastewater and sewage (Pennisi *et al.,* 2013; Erkekoglu and Baydar, 2014). Being water soluble, ACR has a high risk of contamination into surface and groundwater (Tepe and Cebi, 2017). Although, included under the list of 'Probable Carcinogen', its monomeric form is known to be toxic to both central and peripheral nervous system (Ling *et al.,* 2005; LoPachin and Gavin, 2008; Prasad and Muralidhara, 2013; Prasad and Muralidhara, 2014a). Several experiments in various models such as rat, mice as well as study in Drosophila from our lab have shown the development of neuropathic signs due to ACR. The development of oxidative stress, inflammatory reactions and alterations in neurotransmission contribute to its neurotoxic effects (Tareke *et al.,* 2009; Lyn-Cook Jr *et al.,* 2011; Prasad and Muralidhara, 2013; Prasad and Muralidhara, 2014a).

Drosophila melanogaster has been extensively used as a model to study neurodegenerative disorders (NDD) such as Parkinson's disease, Alzheimer's disease and others (Botella, 2009; Feany, 2010; Chandran and Muralidhara, 2012). It is an excellent platform to understand the pathophysiology and genetics of several human neurodegenerative diseases due to its amazing similarity with respect to the nervous physiology/ function (Feany, 2010; Ambegaokar *et al.,* 2010; Chandran and Muralidhara, 2012). In addition, it provides several advantages in terms of rapid generation time, high fecundity and low cost for maintenance and culture. It serves as a convenient tool to screen the potential candidates for therapeutics against NDD (Marsh and Thompson, 2006; Whitworth *et al.,* 2006; Hirth, 2010). Employing the Drosophila model, we have demonstrated the neurotoxic effects of ACR (Prasad and Muralidhara, 2012). We have reported from our lab the neuromodulatory effects of spice actives and extracts of *Bacopa monnieri* and *Selaginella delicatula* against model neurotoxicants such as rotenone and paraquat as well as ACR (Hosamani and Muralidhara, 2009, 2010; Girish and Muralidhara, 2012; Prasad and Muralidhara, 2012, 2014b).

In continuation to our neuro-research in Drosophila, we examined the hypothesis that ACR induced oxidative stress and neurotoxicity can be ameliorated by commonly consumed spice – coriander. Different types of extracts of coriander have been reported to exhibit antioxidant properties. Studies for the assessment of antioxidant action have been carried out in different experimental models earlier (Satyanarayana *et al.,* 2004; Deepa and Anuradha, 2011; Sortibran *et al.,* 2015). Here we report the findings of the neuroprotective effect of aqueous extracts of coriander against ACR employing a co-exposure paradigm.

MATERIALS AND METHODS

Chemicals: Acrylamide, Thiobarbituric acid (TBA), 1,1,3,3-tetramethoxypropane, 2',7'–Dichlorofluorescein (DCF), 2',7'–dichlorofluorescein diacetate (DCFH–DA), 1,1,3,3–tetramethoxy propane (TMP), reduced Glutathione and dopamine were procured from Sigma Chemical Co., St. Louis, USA. 2,4–Dinitrophenylhydrazine (DNPH), 5,5-dithiobis 2- nitrobenzoic acid (DTNB), 1–chloro 2,4–dinitrobenzene (CDNB) and all other chemicals were of analytical grade and procured from Sisco Research Laboratory chemicals, India. Coriander seeds were bought from a local market.

Drosophila culture and husbandry: *Drosophila melanogaster*, wild (Oregon K) (originally procured from the National Stock Facility, Manasagangothri, University of Mysore, Karnataka, India) maintained and cultured at the fly laboratory of our research Institute under standard conditions (22±1°C, 70–80% relative humidity) on a standard wheat flour–agar diet with yeast granules as the protein source (Hosamani and Muralidhara, 2009). For all the studies, age synchronized adult (9–10 d old) male flies (50 per replicate; 3 replicates per group) were introduced into glass vials with 2 mL medium.

Experimental procedure

Preparation of aqueous extract of coriander seeds

Coriander seeds were purchased in a local supermarket and ground in a household mixer to a fine powder. Aqueous extracts were prepared and reconstituted as and when required for the experiments as per cent solution.

Modulatory effects of aqueous extract of coriander seeds

In a preliminary study, flies were exposed to different concentrations of aqueous extract (0 – 0.2%) in the diet for 7 days to determine the per se effect if any. Our data on prophylaxis study (Unpublished) revealed that 0.01% concentration rendered maximal protection against ACR induced neurotoxicity. Hence for co-exposure with ACR (5 mM), the concentrations of the extract used were 0.005% and 0.01% for 7 days.

Measurement of locomotor dysfunction by negative geotaxis assay

All the groups of flies were subjected to negative geotaxis assay (days 3 and 7) to assess the extent of locomotor deficits (Feany and Bender, 2000; Prasad and Muralidhara, 2012). Briefly, flies were observed for the climbing activity for a min in a graduated vertical glass column (25 flies/ trial; 3 trials/ replicate). The flies that remained at the bottom were counted. Locomotor behaviour was expressed as per cent flies that could not escape beyond a minimum distance of 10 cm.

Effect of aqueous extract of coriander seeds on ACR induced mortality

Adult male flies were exposed to ACR in a diet with or without extract (0.005% and 0.01%) for 7 days. Flies were checked for mortality on all days of the experiment. At the end of 7 days, the flies from each group were subjected to biochemical analysis (See below).

Biochemical investigations

Sample preparation: Flies from control and various treatment groups were mildly anaesthetised using diethyl ether. They were homogenized using 0.1 M sodium–phosphate buffer, pH 7.4. Following homogenization, samples were centrifuged at 2500 x g for 10 min at 4^{o}C; the supernatant was filtered through a sieve with nylon mesh (pore size, 10 µm) and used for biochemical assays (Hosamani and Muralidhara, 2009).

Measurement of ROS generation

ROS generation was assayed using 2',7'–dichlorofluorescein diacetate (DCFH–DA) as described previously (Chandrashekar and Muralidhara, 2008). Briefly, an aliquot was incubated in Locke's buffer (pH 7.4) containing DCFH-DA (5µM) for 30 min at room temperature. The fluorescent product DCF was measured using a spectrofluorimeter (Excitation: 480 nm and emission at 530 nm). The ROS generation was calculated using a standard curve for DCF and data has been expressed as ρmol DCF/ min/ mg protein.

Measurement of lipid peroxidation

Lipid peroxidation was measured by employing thiobarbituric acid (TBA) as described previously (Ohkawa *et al.,* 1979). Briefly, the reaction mixture containing an aliquot of homogenate, 1.5 mL acetic acid (pH 3.5, 20%), 1.5 mL of TBA (0.8% w/v), 200 µL sodium lauryl sulphate (SDS) (8% w/v) was heated in a boiling water bath for 45 min and adducts formed were extracted with butanol. The absorbance was measured at 532 nm and quantified as malondialdehyde (MDA) equivalents using 1,1,3,3-tetramethoxypropane as the standard. Data has been expressed as nmol malondialdehyde/mg protein.

Measurement of hydroperoxides (HP)

HP levels were measured according to a previously described method using FOX 1 reagent with minor modifications (Wolf, 1994). An aliquot of homogenate (100 µg protein) was added to 1 mL FOX reagent (xylenol orange, 100 µM; ferrous ammonium sulphate, 250µM; sorbitol, 100µM; H_2SO_4, 25mM). The colour developed after 30 min incubation was read at 560 nm in a spectrophotometer. The concentration of HP was calculated using the MEC (ε) of 2.2×10^5 M^{-1} cm^{-1} and expressed as nmol hydroperoxides/ mg protein.

Estimation of reduced glutathione (GSH)

GSH content was quantified employing o-phthalaldehyde based on a method described previously (Mokrasch and Teschke, 1984). Briefly, an aliquot of homogenate was added to formic acid (0.1 M) and centrifuged at 10,000 × g for 10 min. O-phthalaldehyde (100 µg/ mL) was added to an aliquot of supernatant (de-proteinized) taken in tubes containing buffered formaldehyde (1: 4 (v/v) 37% formalin: 0.1 M Na_2HPO_4). The reaction mixture was incubated for 45 min at room temperature, and fluorescence was measured (Excitation: 345 nm and Emission: 425 nm). A concentration of GSH was calculated from a standard curve and values were expressed as µmol GSH /mg protein.

Estimation of Total thiols (TSH)

TSH in the homogenate was estimated as described previously (Ellman, 1959). Briefly, an aliquot of the sample was added to 0.375 mL of Tris–HCl buffer (0.2 M, pH 8.2) containing di-thiobis-nitrobenzoic acid (DTNB, 10 mM) and 1.975 mL of methanol.

Following incubation for 30 min at room temperature, the samples were centrifuged at 3000 x g for 10 min. The absorbance of the supernatant was measured at 412 nm and expressed as µmol TSH/ mg protein ($\varepsilon = 13.6\ mM^{-1}cm^{-1}$).

Activities of antioxidant enzymes

Catalase (CAT) activity was determined according to a previously described method (Aebi, 1984). To 1 mL reaction mixture containing 8.8 mM H_2O_2 (3%) and 0.1mM sodium–phosphate buffer (pH 7.0), an aliquot of the sample was added to initiate the reaction. A decrease in H_2O_2 was monitored for 3 min at 240 nm and expressed as ηmol of H_2O_2 decomposed/ min/ mg protein (ε = 43.6 mM-1cm-1).

Superoxide dismutase (SOD) activity was determined by monitoring the inhibition of quercetin auto-oxidation. Total volume of 1 mL reaction mixture containing 3–5 mg protein; 0.016M sodium phosphate buffer (pH 7.8), 8 mM N, N, N, N tetramethylethylenediamine (TEMED) and 0.08 mM ethylenediaminetetraacetic acid (EDTA), and reaction was started by adding quercetin (1.5 mg in 1 mL dimethylformamide). The reaction was monitored for 3 min at 406 nm, expressed as the amount of protein required to inhibit 50% of quercetin auto-oxidation (Kostyuk and Potapovich, 1989).

The activity of Glutathione-S-transferase (GST) was determined according to the method of Guthenberg *et al.,* 1985 with minor modifications. Briefly, the conjugation of GSH to 1-Chloro-2,4-dinitrobenzene (CDNB) was monitored at 340 nm by adding an aliquot of the sample. The increase in the optical density at 340 nm was recorded for 3 min, and the activity expressed as nmol conjugate formed/min/mg protein ($\varepsilon = 9.6\ m\ M^{-1}\ cm^{-1}$).

Thioredoxin Reductase (TRR) activity was measured by monitoring the reduction of DTNB at 412 nm, in a potassium phosphate buffer (0.1 M, pH 7.0, containing 10 mM EDTA, 0.2 mM NADPH) as described previously (Luthman and Holmgern, 1982). The activity was expressed as nmol substrate reduced/min/mg protein ($\varepsilon = 13.6\ mM^{-1}\ cm^{-1}$).

Activity of Acetylcholinesterase (AChE)

The activity of AChE was determined according to the method of Ellmann et al. (1961). Briefly, the reaction mixture containing phosphate buffer (0.1 M, pH 8.0), 5,5-dithiobis 2- nitrobenzoic acid (DTNB, 10 mM), an aliquot of homogenate (100 µg protein) and acetylthiocholine iodide (150 mM), was monitored at 412 nm for 3 min for change in absorbance. The enzyme activity was expressed as ηmol of substrate hydrolyzed/ min/ mg protein.

Estimation of dopamine (DA) by HPLC analysis

DA levels in the whole body homogenate were analysed by injecting the sample into HPLC column (Discovery C- 18, 25 cm x 4.6 mm, 5 mm, Supelco Sigma–Aldrich) equipped with an ultraviolet detector set at 280 nm (Dalpiaz *et al.,* 2007). Samples were run at a flow rate of 1 mL/ min in a mobile phase containing 0.2% aqueous trifluoroacetic acid and methanol (70:30 v/v). DA levels were calculated by running a standard and expressed as µg DA/ mg protein.

Determination of protein

The amount of protein in test samples was determined by spectrophotometric method (Lowry *et al.,* 1951). An aliquot of the sample was incubated with Folin – Ciocalteau's phenol in an alkaline medium (30 min) and measuring the optical density at 750 nm using a UV-Visible spectrophotometer. The amount of protein was quantified using bovine serum albumin as the standard.

Statistical analysis

Results are represented as mean ± standard error (SE) for each experimental group. The data were analysed by one-way ANOVA followed by a post hoc 'Tukey' test to compare the control and treatment groups; p-values ≤ 0.05 were considered as statistically significant. All statistical analysis was performed using SPSS statistical software package version 17.0.

RESULTS AND DISCUSSION

Spices are known to contain various bio-actives in addition to varying quantities of essential oils, proteins, sugars, fibres, minerals and pigments (Srinivasan, 2011; Kannappan *et al.,* 2011). Essentially the phytochemicals give the potential therapeutic benefits of these spices. Previous researchers have investigated the constituents of Coriander- whole plant (fresh leaves) and dried seeds. Various types of extracts have been proved to be beneficial in different experimental models. With ACR getting attention due to its formation in food, naturally, we are now aware that we are consuming ACR albeit minute quantities through our diet daily. Our findings in Drosophila model of ACR neurotoxicity and its modulation by coriander seeds extract has been stated below.

Modulatory effect on ACR induced mortality and locomotor function

Both the concentrations of aqueous extract of coriander seeds reduced the mortality induced by ACR by 40-60% at the end of 7 days of co-exposure (Fig. 1A). A comparative rescuing effect was evident with respect to locomotor function by the extract against ACR induced locomotor deficits (Fig. 1B).

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Hence the phytochemicals present in the aqueous extract were interfering with the pathophysiological alterations induced by ACR and rendering protection against it. The role of coriander phytochemicals in the vital mechanisms of sustaining life/ extending life span was evident by this study. Further, the inclusion of coriander extracts in the diet did act on the nervous tissue and probably rendered protection to minimize the damage causing effects of ACR, as the flies performed better in the negative geotaxis assay.

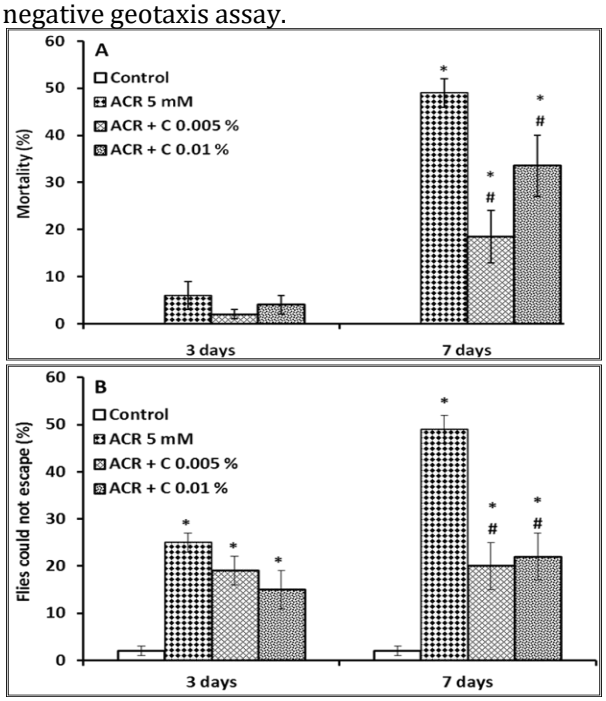

Figure 1: Effect of aqueous extract of coriander seeds on ACR induced mortality (A) and locomotor deficits (B) among male adult *Drosophila melanogaster;* Values are mean ± SE (n = 50 flies/replicate, three such replication used for assay). Data analysed by one-way analysis of variance (ANOVA) followed by Tukey's test for comparison of means. *Significant against control at p ≤ 0.05; # significant against ACR at p ≤ 0.05.

Modulatory effect against ACR induced alterations in oxidative markers

At the end of 7-day exposure, ACR elevated the levels of oxidative markers such as ROS, MDA and HP among flies. While the extract reduced the levels of ROS and MDA at both concentrations significantly, the HP levels remained high (Fig. 2). The reduction of oxidative markers such as ROS and MDA indicates clearly that the antioxidant potential of coriander extracts (Fig. 2A and Fig. 2B) as reported earlier in other models (Satyanarayana *et al.,* 2004; Deepa and Anuradha, 2011; Sortibran *et al.,* 2015). This may signify that the ameliorative effect of coriander phytochemicals on total ROS burden of the cell as well as the peroxidation of lipid contents. However, the HP levels remained unaltered (Fig. 2C), and this was in parallel to the enhanced activity of CAT enzyme (see below).

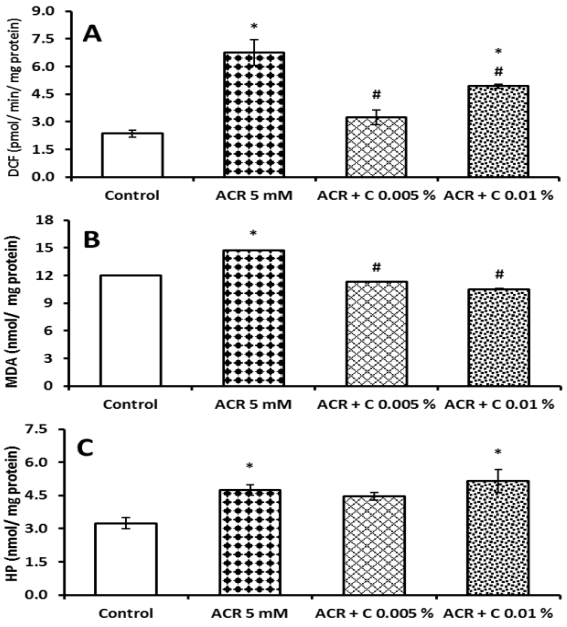

Figure 2: Effect of aqueous extract of coriander seeds on ACR induced Reactive Oxygen Species (A), lipid peroxidation (B) and Hydroperoxides (C) among adult male *Drosophila melanogaster;* Values are mean ± SE (n = 50 flies/replicate, three such replication used for assay). Data analysed by one-way analysis of variance (ANOVA) followed by Tukey's test for comparison of means. *Significant against control at p ≤ 0.05; # significant against ACR at p ≤ 0.05.

Effect on enzymatic and non-enzymatic antioxidants

Table 1: Effect of aqueous extract of coriander seeds on ACR induced alterations in the activities of some of the antioxidant enzymes among adult male *Drosophila melanogaster*

Group	SOD[1]	CAT[2]	GST[3]	TRR[4]
Control	221.1 ±9.6	145.5 ±8.8	187.9 ±4.4	34.1 ±1.53
ACR	321.0 ±18.1*	214.0 ±13.7*	250.1 ±13.0*	9.51 ± 0.78*
ACR + C 0.005%	254.9 ±15.1#	215.2 ±2.3*	229.3 ±2.9*	44.05 ±4.13#
ACR + C 0.01%	260.0 ±23.1#	216.7 ±11.8	260.1 ± 4.0*	51.25 ±2.74*#

Values are mean ± SE (n = 50 flies/replicate, three such replication used for assay). Data analysed by one-way analysis of variance (ANOVA) followed by Tukey's test for comparison of means. *Significant against control at p ≤ 0.05; # significant against ACR at p ≤ 0.05. [1] – Superoxide dismutase, U/ mg protein; [2] – Catalase, ηmol of hydrogen peroxide decomposed/ min/ mg protein; [3] – Glutathione S

transferase, ηmol conjugate formed/ min/ mg protein; [4] – Thioredoxin reductase, nmol NADPH oxidized/ min/ mg protein

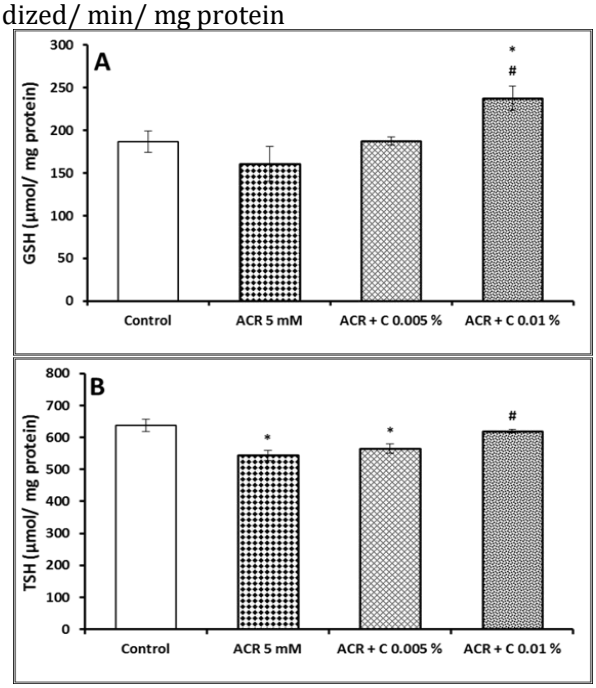

Figure 3: Effect of aqueous extract of coriander seeds co-exposed with ACR on reduced Glutathione (A) and Total thiols (B) among adult male *Drosophila melanogaster;* Values are mean ± SE (n = 50 flies/replicate, three such replication used for assay). Data analysed by one-way analysis of variance (ANOVA) followed by Tukey's test for comparison of means. *Significant against control at $p \leq 0.05$; # significant against ACR at $p \leq 0.05$.

Although ACR induced a moderate reduction in the levels of TSH, no significant reduction was evident with respect to GSH levels among the adult flies (Fig. 3). However, the higher concentration of coriander seeds extract (0.01%) enhanced the levels of both GSH and TSH significantly when co-exposed with ACR for 7 days. The assessment of the activities of SOD, CAT and GST indicated an increase with ACR exposure; however, the TRR activity was significantly reduced (Table 1). With coriander extract, the activities of CAT and GST remained elevated on co-exposure with ACR, while the activity of SOD was reduced. Thence, ACR with or without extract, the activities of CAT and GST were elevated unlike the activity of SOD. The ambiguous result may emphasize on the oxidative mechanisms that are getting altered with ACR are further interfered with in the presence of coriander extract. However, the current experimental design fails to explain these alterations in the whole-body homogenates of the adult flies. Further, the elevation in the activity of TRR by the extract was robust (Table 1); this is suggestive of the ability of coriander constituent phytochemicals to interfere with the vitagenes of the antioxidant defence system. The TRR is one of the major players in the maintenance of redox balance (Cho *et al.,* 2003; Halliwell, 2006; Calabrese *et al.,* 2010). Since oxidative stress has a key role in ACR induced neurotoxicity, the neuroprotective effect of coriander extract may be largely due to its effect on TRR activity. It would be interesting to investigate further if coriander is enhancing the activity of TRR enzyme molecules or up-regulating its gene expression. Earlier we have reported the neuroprotective effects of geraniol, one of the constituents of coriander essential oil, in ACR induced neurotoxicity in Drosophila and rat model (Prasad and Muralidhara, 2014a; 2014b).

Effect on activity of AChE and DA levels

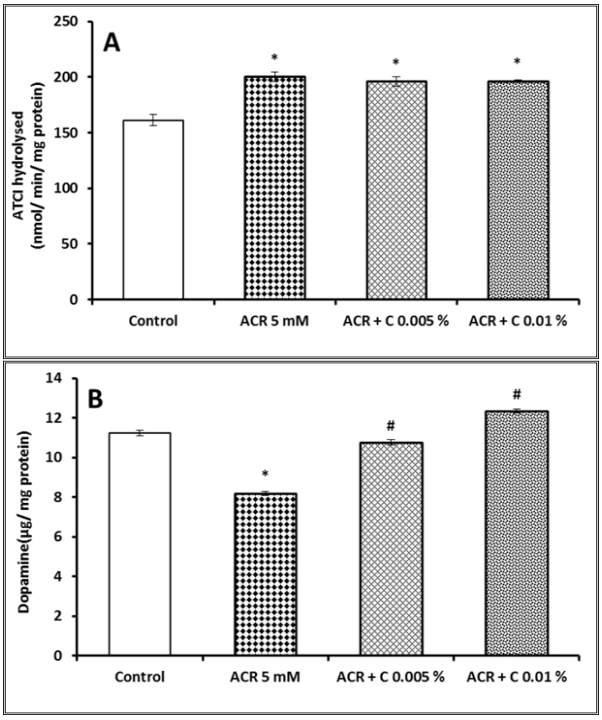

Figure 4: Effect of aqueous extract of coriander seeds co-exposed with ACR on acetylcholinesterase activity (A) and dopamine levels (B) among adult male *Drosophila melanogaster;* Values are mean ± SE (n = 50 flies/replicate, three such replication used for assay). Data analysed by one-way analysis of variance (ANOVA) followed by Tukey's test for comparison of means. *Significant against control at $p \leq 0.05$; # significant against ACR at $p \leq 0.05$.

The cholinergic function was assessed by determining the activity of AChE among ACR fed flies and was found to be enhanced (Fig. 4A). This is in correlation with the previous reports in Drosophila and rodent models (Prasad and Muralidhara, 2012; Krishna and Muralidhara, 2015). Overactivation of AChE leads to faster acetylcholine degradation and consequently lowered stimulation of acetylcholine receptors, which causes a reduction of diverse cholinergic functions (Chacon *et al.,*

2003; Schmatz *et al.,* 2009). Contrary to our anticipation, co-exposing the flies with extracts did not reduce the activity of AChE (Fig. 4A), which implies that the phytochemicals of the extract do not have any effect on cholinergic function *via* AChE activity. Further, dopaminergic neurotransmission was assessed by determining the DA levels. Dopaminergic neurotransmission is affected by ACR as evidenced by many researchers in different models (Coulom and Birman, 2004; Ling *et al.,* 2005; LoPachin *et al.,* 2006; Tareke *et al.,* 2009; Prasad and Muralidhara, 2014; 2014b). Interestingly, the ACR and extract co-exposed flies (at both concentrations) elevated the levels of DA (Fig. 4B). This is perhaps one of the early findings which show the modulatory effect of aqueous extract of coriander on dopaminergic function among adult flies. An elevation in the DA levels should be an important feature that contributes to the improvement in the locomotor function as evidenced by the negative geotaxis assay. Many studies have shown the role of dopamine in motor functions in different models earlier (Tareke *et al.,* 2009; Hosamani *et al.,* 2010; Prasad and Muralidhara, 2014a; 2014b).

CONCLUSION

ACR, a well-known neurotoxin, interferes with the redox system, inflammatory reactions and neurotransmission in humans and experimental animals. We were the first ones to report the effects of ACR in the Drosophila model (Prasad and Muralidhara, 2012). In continuation of our screening work for therapeutic candidates against neurotoxicity and NDD, the present study assessed the beneficial aspects of coriander seed extract. The extract was found not only to reduce oxidative impairments and elevate DA levels but also reduce ACR induced mortality (*per cent*) and locomotor deficits. Hence our study proposes the potential benefits of the extract against neurotoxicity and the associated pathophysiology.

CONFLICT OF INTEREST

The authors declare no conflict of interest

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