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Influence of Fruits Extract & Fractions of *Terminalia Chebula* on Chemical Induced Memory Impairments in Rats

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ABSTRACT

AIM- the aim of the present investigation is to study the Influence of Fruits Extract & Fractions of *Terminalia Chebula* on Chemical Induced Memory Impairments in Rats.

MATERIAL & METHODS- The dried fruits of *Terminalia chebula* were extracted by successive solvent extraction method with the help of soxhlet apparatus. The plant material first extracted with petroleum ether then chloroform, acetone, methanol and ethanol. Fixed dose method as in Annex 2d: Test procedure with a starting dose of 2000 mg/Kg body weight was adopted. Memory impairment, the most important component of dementia, was induced in mice by intraperitoneal administration of scopolamine. At the end of experiment, the experimental animals were sacrificed by cervical dislocation and brains were taken out. They were rinsed thoroughly with ice-chilled 0.9% NaCl and weighed. A 10% (w/v) tissue homogenate was prepared in 0.1 M phosphate buffer (pH 7.4). The post nuclear fraction was obtained by centrifugation (Remi - C-30, Remi Industries Ltd, Mumbai, India) of the homogenate at 12000g for 60 min at 4ºC.

RESULTS- Spatial learning in the water maze was analysed during acquisition trial in term of escape latencies. The mean latencies spent to reach the platform and time spent in the target quadrant in vehicle control group was 130.7 ± 0.6146 and 64.00 ± 1.033 respectively. In a scopolamine treated group animals the total protein level significantly decreased to the extent of 4.602 mg/dl as compared to normal vehicle control group 8.012 mg/dl. The reference standard Piracetam (PC) treated animals showed marked significant increase in brain tissue Reduced glutathione level 1.739 nm/mg as compared to disease control animals to the extent of 0.7233 nm/mg.

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CONCLUSION- On the basis of the preliminary screening of the *T. chebula* fruit extracts (Ethanol, Methanol, Acetone and Chloroform extracts) we concluded that ethanolic extracts of *T. chebula* significantly improved learning memory in several exteroceptive and interoceptive behavioural models of scopolamine induced memory deficit activity.

KEYWORDS- Extract & Fractions, *Terminalia Chebula,* Chemical Induced, Memory Impairments, Acetone and Chloroform extracts

INTRODUCTION

Learning is defined as acquisition of information and skills and subsequent retention of this information is called as memory. In Ayurveda, there are three aspects of mental ability eg. Dhi (process of acquisitions / learning), Dhuti (process of retentions) and Smriti (process of recalling). Any disturbance in these aspects resulted in the loss of mental ability.[1]

Memory is the process by which organisms are able to record their experiences and retain them over short or long periods of time and recall the same at a later time when needed.[2] Memory plays a vital role in human life, as without it, one cannot lead a normal life.[3] Memory is classified into two - long term memory and short term memory. As per long term memories that we can recall days or months or years after they were originally stored. Short term memories are last seconds to hours and are vulnerable to disruption.[5] Memory can be devided into declarative and non-declarative memory. Memory of facts and verbal knowledge are examples of declarative memory. [6]

There are several drugs available in modern system of medicine to treat memory and cognition disorders but all synthetic modern medicines available in market having variety of side effects and slow action. Ayurvedic drugs including Harad (*Terminalia chebula)* are more reliable and effective in complete treatment of digestion, git, mood and many other problems of body basically due to more potent presence of antioxidants.

On the basis of literature review, it was decided to investigate and explore role of some phytofractions of fruit of *Terminalia chebula* in memory related disorders.

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MATERIALS AND METHODS

Collection of Plant Material:

The dried fruits of *Terminalia chebula* was purchased from authorized herbal supplier of local market.

Extraction & Fractionization:

The dried fruits of *Terminalia chebula* were extracted by successive solvent extraction method with the help of soxhlet apparatus. The plant material first extracted with petroleum ether then chloroform, acetone, methanol and ethanol.

Fractionization of best extract: The ethanolic extract of dried fruits of *Terminalia chebula* was selected for further fractionization on the basis of biological memory activity. The ethanolic extract was mixed in water and then fractionized with ethyl acetate and butanol respectively.

Qualitative chemical examination:[7]

Qualitative test for the presence of various active phytoconstituents i.e. alkaloids, terpenoids, protein, flavonoids, phenolic compounds etc were identified by the method described by the Kokate & Khandelwal.

Animals:

Swiss albino mice of either sex (young, age 8 weeks, 18-20 g and aged, age 32 weeks, 35-40 g) were used for the study. Animals were housed in polypropylene cages and maintained under the standard laboratory environmental conditions; temperature 25 ± 2ºC, 12 h light: 12 h dark cycle and 50 ± 5% relative humidity with free access to food and water *ad libitum*. Animals were acclimatized to laboratory conditions before the test. Each group consisted of six (n = 6) animals. All the experiments were carried out during the light period (08:00-16:00 h). The studies were carried out in accordance with the guidelines

Acute oral toxicity Studies:

The acute toxicity study was carried out in adult female albino rats by “fix dose” method of OECD (Organization for Economic Co-operation and Development) Guideline No.420. Fixed

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dose method as in Annex 2d: Test procedure with a starting dose of 2000 mg/Kg body weight was adopted. [8,9]

Experimental models of memory impairment (Scopolamine induced memory impairment in mice)

Memory impairment, the most important component of dementia, was induced in mice by intraperitoneal administration of scopolamineand. Scopolamine (3 mg/kg), a muscarinic receptor antagonist, was dissolved in normal saline (0.9 % NaCl) and administered intraperitoneally in a volume of 1 ml/kg body weight. Rats were subjected to behavioural testing 5 min after scopolamine injection.[10]

Morris water maze test

The Morris water maze consists of a circular pool (60 cm in diameter, 26 cm in height), filled with water (26 ± 1oC) to the depth of 20 cm and made opaque white color. The pool was divided into four hypothetical quadrants. An escape platform was placed 1 cm below from the water surface. Four different starting points were placed around the perimeter of the pool. On each of the five training days all four start points were used once in a pseudorandom sequence. The water maze was located on a large room with a number of extra maze visual cues. The trial began by placing the animal in the water facing the wall of the pool at one of the starting points. If the animals failed to locate the platform within 120 s (for rats) or 60 s (for mice), it was gently placed there by researcher and allowed to stay for 30 s. Each animal was subjected to a daily session of four trials per day for rats and three trials per session in case of mice for five consecutive days. Escape latency time (ELT) to reach the hidden platform in water maze was noted as an index of learning.[11]

Experimental Treatment Groups: For *Terminalia chebula* fruit extract treated Morris water maze test model:

1. Group-1 (NC): Normal Control, animals received 0.1% NaCMC solution as a vehicle
2. Group-2 (DC): Diseased Control, Scopolamine (3 mg/kg i.p)
3. Group-3 (TC-ETOH): T. Chebula ethanolic extract at the doses of 100 mg/kg of body weight respectively p.o. + scopolamine (3mg/kg i.p)

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4. Group-4 (TC-ACT): T. Chebula acetone extract at the doses of 100 mg/kg of body weight respectively p.o. + scopolamine (3 mg/kg i.p)
5. Group-5 (TC-MEOH): T. Chebula methanolic extract at the doses of 100 mg/kg of body weight respectively p.o. + scopolamine (3 mg/kg i.p)
6. Group-6 (TC-CHCl3): T. Chebula chloroform extract at the doses of 100 mg/kg of body weight respectively p.o. + scopolamine (3 mg/kg i.p)
7. Group-7 (PC): Positive Control, Piracetam (100 mg/kg p.o) + scopolamine (3 mg/kg i.p)

Experimental Treatment Groups: For fractions of ethanolic extract of *Terminalia chebula* fruits treated Morris water maze test model:

1. Group-1 (NC): Normal Control, animals received 0.1% NaCMC solution as a vehicle
2. Group-2 (DC): Diseased Control, Scopolamine (3 mg/kg i.p)
3. Group-3 (TC-EA): ethyl acetate soluble fraction of ethanolic extract of dried fruits of *Terminalia chebula* at the doses of 100 mg/kg of body weight respectively p.o. + scopolamine (3mg/kg i.p)
4. Group-4 (TC-BUT): Butanol soluble fraction of ethanolic extract of dried fruits of *Terminalia chebula* at the doses of 100 mg/kg of body weight respectively p.o. + scopolamine (3 mg/kg i.p)
5. Group-5 (TC-Water): Water soluble fraction of ethanolic extract of dried fruits of *Terminalia chebula* at the doses of 100 mg/kg of body weight respectively p.o. + scopolamine (3 mg/kg i.p)
6. Group-6 (PC): Positive Control, Piracetam (100 mg/kg p.o) + scopolamine (3 mg/kg i.p)

At the end of experiment, the experimental animals were sacrificed by cervical dislocation and brains were taken out. They were rinsed thoroughly with ice-chilled 0.9% NaCl and weighed. A 10% (w/v) tissue homogenate was prepared in 0.1 M phosphate buffer (pH 7.4). The post nuclear fraction was obtained by centrifugation (Remi - C-30, Remi Industries Ltd, Mumbai, India) of the homogenate at 12000g for 60 min at 4ºC.

Estimation of Total Protein:

Homogenize 100mg of tissue in 2.5ml of saline. To the homogenate added 2.5ml of 10% TCA. Centrifuge for 20 minutes at 2500 rpm. To the decandate added 5ml of 0.1N Sodium hydroxide

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and shake well. Take 8 ml of the working solution in three test tubes marked 'T' 'S' and 'B' for the test standard and blank. To the test added 0.4 ml of the tissue extract, to the standard 0.4ml of standard protein solution and to the blank 0.4ml of distilled water. Reagent is best added to the solution in a stream preferably with acromatic pipette. Mix well and wait for 10 minutes. Added 0.8ml of phenol reagent. Mix well. Read the extinction at 578nm against water after 30 minutes and not later 60 to 90 minutes after mixing. The values were expressed as gm/gm fresh tissue weight. [12, 13]

Estimation of markers of oxidative stress:

Catalase (CAT): The incubation mixture of brain homogenate contained in a final volume of 2.0ml, 0.1ml of Thonda et al., IJPSR, 2014; Vol. 5(3): 829-838. E-ISSN: 0975-8232; P-ISSN: 2320-5148 International Journal of Pharmaceutical Sciences and Research 833 diluted homogenate, 1.0ml of phosphate buffer and 0.4ml of distilled water to which 0.5ml of H2O2 solution was added to initiate the reaction, while the H2O2 solution was left out in control tubes. After incubating for 1 min at 37oC the reaction was stopped by addition of 2 ml of potassium dichromate acetic acid reagent. The samples were kept in boiling water bath for 15 minutes, finally cooled and the absorbance measured at 570 nm against control. The catalase content was calculated by using molar extinction coefficient = 58.03 x 10-3 M -1 cm-1 and the values are expressed as nmoles/mg protein.[14]

Lipid peroxidation (LPO): Briefly, the reaction mixture contained 0.1 ml of brain regions homogenate/ mitochondria (1mg protein), 1.5 ml of 20% acetic acid (pH 3.5), 1.5 ml of 0.8% thiobarbituric acid (0.8% w/v) and 0.2 ml SDS. Following these additions, tubes were mixed and heated at 95 °C for one hour on a water bath and cooled under tap water before mixing 1 ml of distilled water and 5ml mixture of n-butanol and pyridine (15:1). The mixture was centrifuged at 2200g for 10 min. The amount of MDA/TBARS formed was measured by the absorbance of upper organic layer at a wave length of 532 nm. The results are expressed as nmol MDA/mg protein. The absorbance of the clear pink color supernatant was measured at 532 nm against appropriate blank. The amount of lipid peroxidation was determined by using molar extinction coefficient 1.56 x 105 M - 1 cm-1 and the results were expressed as nmoles MDA/g of protein.[15]

Reduced Glutathione (GSH): The assay is based on the principle of Ellman's reaction. The sulfhydryl group of glutathione reacts with DTNB (5, 5'-dithiobis-2-nitrobenzoic acid) and

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produces a yellow colored 5-thio- 2-nitrobenzoic acid (TNB). Measurement of the absorbance of TNB at 412 nm provides an accurate estimation of glutathione in a sample. Briefly, 0.5 ml of homogenate is mixed with 0.1 ml of 25% TCA to precipitate proteins and centrifuged at 4000 rpm for 5 min. Then, 0.3 ml of the supernatant was mixed with 0.5 ml of 0.1M phosphate buffer (pH 7.4) and 0.2 ml of 10 mM DTNB. This mixture was incubated for 10 min and the absorbance was measured at 412 nm against appropriate blanks. The glutathione content was calculated by using extension coefficient 13.6 x 103.[16]

RESULTS

Qualitative chemical examination of different extracts of *T. chebula* fruit

On qualitative phytochemical examination of different extracts of *Terminalia chebula* fruits the test for carbohydrate was found positive in ethanolic, methanolic, and chloroform extract. Proteins were found in ethanolic, methanolic, and chloroform extract of *T. chebula* fruits. The steroidal test was positive in acetone and petroleum ether extracts. Triterpenoids test was found positive in ethanolic, methanolic and chloroform extract of *Terminalia chebula* fruits. Glycosides were present in ethanolic, methanolic, and chloroform extract of *T. chebula* fruits. No extract was given positive test for presence of alkaloids. Test for flavonoids was found positive in ethanolic and methanolic extract of *T. chebula* fruits. The test of phenolic and tannin compounds was positive in ethanolic, methanolic and chloroform extracts but highest in ethanolic extract of *T. chebula* fruits. The ethanolic and methanolic extract of *T. chebula* fruits also showed presence of coumarin compounds.

Acute toxicity studies of different extracts of *Terminalia chebula* fruits

The acute toxicity test was performed for both topical (Dermal) and oral administration of extracts of *Terminalia chebula* fruits. All extracts were found safe for administration of extract by oral as well as dermal (Topical) route.

Effect of *Terminalia chebula* extracts on the scopolamine induced spatial learning and memory deficit using Morris water maze test

Spatial learning in the water maze was analysed during acquisition trial in term of escape latencies. The mean latencies spent to reach the platform and time spent in the target quadrant in

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vehicle control group was 130.7 ± 0.6146 and 64.00 ± 1.033 respectively. Animals treated with TC-ETOH at 100 mg/kg showed an acquisition and retention profile reduction in mean latencies and time spent as 148.5 ± 0.3416 and 52.50 ± 0.5627 respectively significant as compared to scopolamine control group. Reference standard piracetam group demonstrated significant decreased (to the extent of 135.5 ± 0.4282) in the mean latencies spent to reach the platform and time spent in the target quadrant (retention trial) increased significantly to the extent of 56.67 ± 0.4944 as compared to scopolamine control group. *T. chebula* acetone, methanol, and chloroform extract treated animals also showed significant decreased mean latencies spent to reach the platform 176.5 ± 0.7188, 157.0 ± 0.7303 and 163.2 ± 0.7923 respectively.=

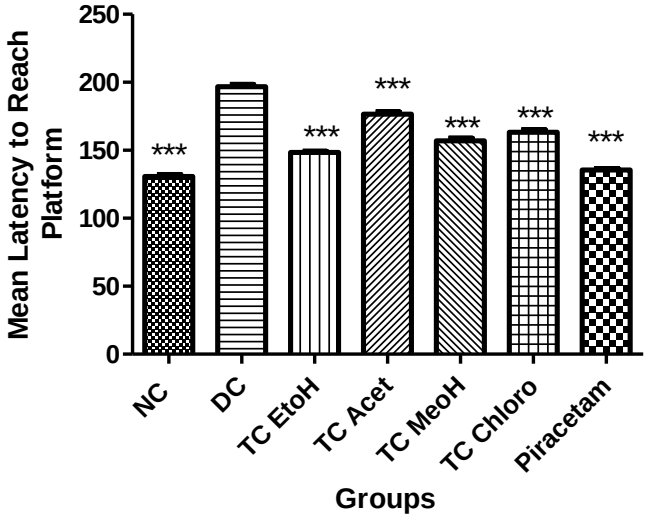

Figure No. 1: Effect of *T. chebula* extracts in Morris water maze test on mean latencies

Data are expressed as Mean ± SEM and analyzed statistically by One way ANOVA followed by Dunnett's Multiple Comparison Test, using Graph Pad Prism Software trial version. IN Dunnett's Multiple Comparison Test, Group DC was compared with NC and other treated groups were compared with DC. P value considered as P<0.05 Significant (*), P<0.01 Very Significant (**), P<0.001 Highly Significant (***).

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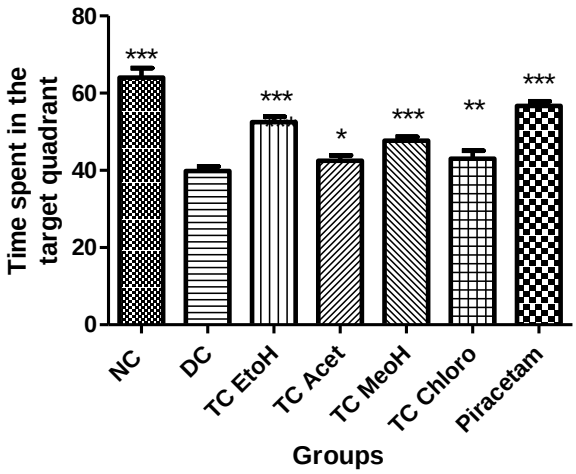

Figure No. 2: Effect of *T. chebula* extracts in Morris water maze test on Time spent in the target quadrant

Data are expressed as Mean ± SEM and analyzed statistically by One way ANOVA followed by Dunnett's Multiple Comparison Test, using Graph Pad Prism Software trial version. IN Dunnett's Multiple Comparison Test, Group DC was compared with NC and other treated groups were compared with DC. P value considered as P<0.05 Significant (*), P<0.01 Very Significant (**), P<0.001 Highly Significant (***).

Effect of fraction of *T. chebula* Ethanol extract on the total protein level in the scopolamine induced amnesiac rats

In a scopolamine treated group animals the total protein level significantly decreased to the extent of 4.602 mg/dl as compared to normal vehicle control group 8.012 mg/dl. Ethylacetate fraction of *T. chebula* Ethanol extract treated groups animals showed significant increase in total protein level 8.575 mg/dl as compared to disease control animals to the extent of 5.275 mg/dl, thus suggested marked improvement in memory. The reference standard Piracetam (PC) treated animals showed marked significant increase in total protein level 8.435 mg/dl as compared to disease control animals to the extent of 5.275 mg/dl.

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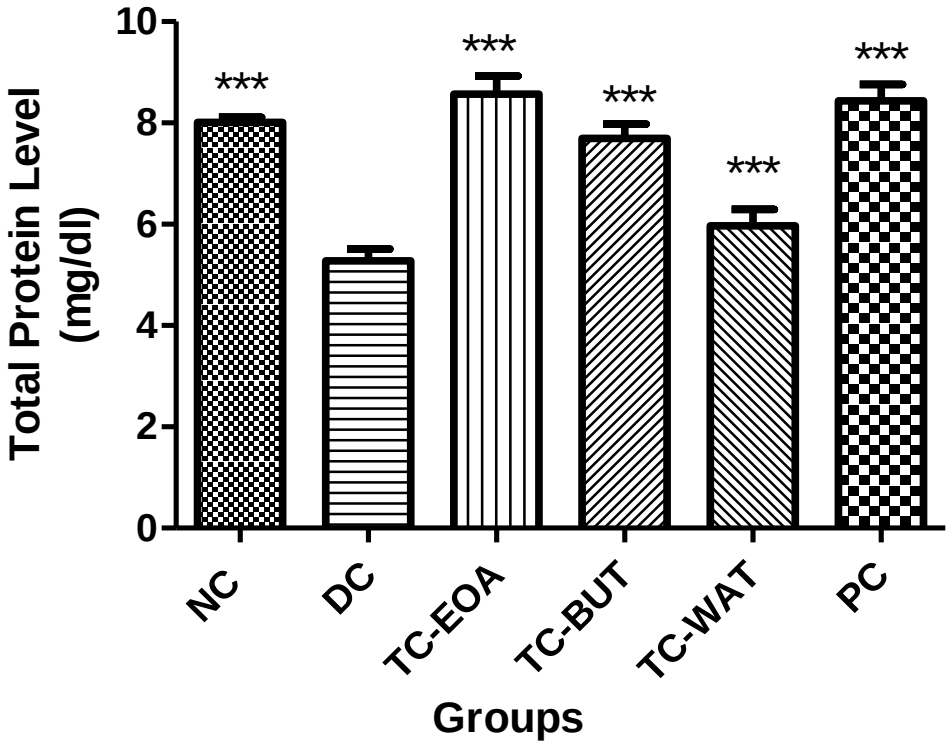

Figure No. 3: Effect of fraction of *T. chebula* Ethanol extract on the total protein level in the scopolamine induced amnesiac rats

Data are expressed as Mean ± SEM and analyzed statistically by One way ANOVA followed by Dunnett's Multiple Comparison Test, using Graph Pad Prism Software trial version.

Effect of fraction of *T. chebula* Ethanol extract on the markers of oxidative stress Catalase (CAT) level in the scopolamine induced amnesiac rats

In a scopolamine treated group animals the brain tissue catalase level significantly decreased to the extent of 35.10 nm/mg protein as compared to normal vehicle control group 64.04 nm/mg protein. *T. chebula* Ethanol extract (TC-ETOH) treated groups animals showed significant increase in brain tissue catalase level 69.67 nm/mg protein as compared to disease control animals to the extent of 35.10 nm/mg protein, thus suggested marked improvement in memory.

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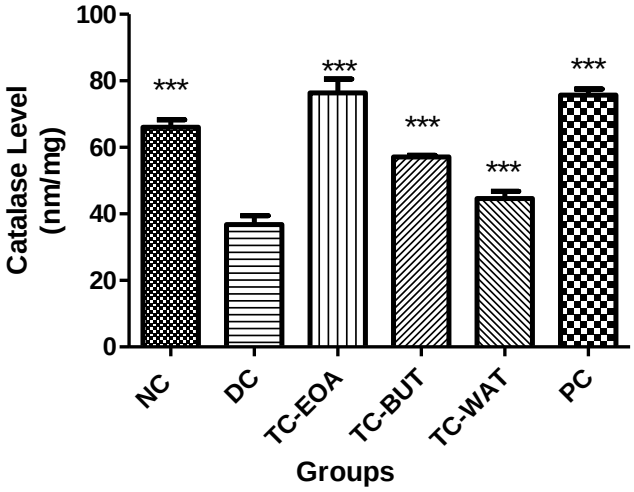

Figure No. 4: Effect of fraction of *T. chebula* Ethanol extract on the markers of oxidative stress Catalase (CAT) level in the scopolamine induced amnesiac rats

Data are expressed as Mean ± SEM and analyzed statistically by One way ANOVA followed by Dunnett's Multiple Comparison Test, using Graph Pad Prism Software trial version.

Effect of fraction of *T. chebula* Ethanol extract on the markers of oxidative stress Lipid peroxidation (MDA) level in the scopolamine induced amnesiac rats

Ethylacetate fraction of *T. chebula* Ethanol extract (TC-EOA) treated group animals showed significant decreased in brain tissue Lipid peroxidation (MDA) level 262.9 nm/gm as compared to disease control animals to the extent of 635.8 nm/gm, thus suggested marked improvement in memory.

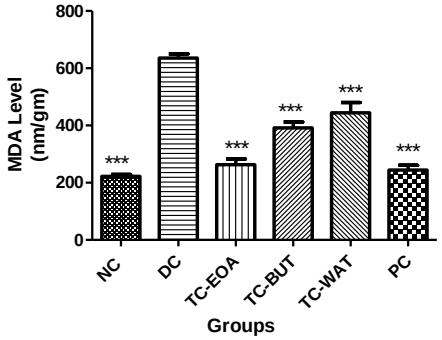

Figure No. 5: Effect of fraction of *T. chebula* Ethanol extract on the markers of oxidative stress Lipid peroxidation (MDA) level in the scopolamine induced amnesiac rats

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Data are expressed as Mean ± SEM and analyzed statistically by One way ANOVA followed by Dunnett's Multiple Comparison Test, using Graph Pad Prism Software trial version.

Effect of fraction of *T. chebula* Ethanol extract on the markers of oxidative stress Reduced Glutathione (GSH) level in the scopolamine induced amnesiac rats

In a scopolamine treated group animals the brain tissue Reduced glutathione level significantly decreased to the extent of 0.7233 nm/mg as compared to normal vehicle control group 1.748 nm/mg protein. The reference standard Piracetam (PC) treated animals showed marked significant increase in brain tissue Reduced glutathione level 1.739 nm/mg as compared to disease control animals to the extent of 0.7233 nm/mg.

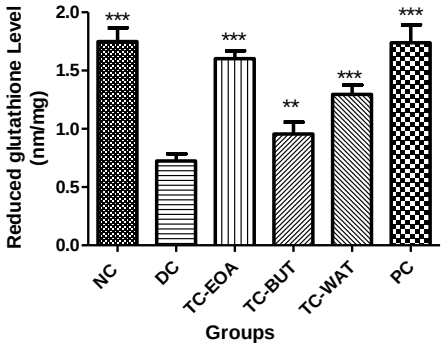

Figure No. 6: Effect of fraction of *T. chebula* Ethanol extract on the markers of oxidative stress Reduced Glutathione (GSH) level in the scopolamine induced amnesiac rats

Data are expressed as Mean ± SEM and analyzed statistically by One way ANOVA followed by Dunnett's Multiple Comparison Test, using Graph Pad Prism Software trial version.

DISCUSSION

A number of different forms of learning and memory involving diverse neural systems are currently recognized. Rather than a single entity there are at least two major memory forms: a capacity for conscious recollection of facts and events (declarative memory) and a collection of non-conscious learning capacities (non-declarative memory).[17] Poor memory, lower retention and slow recall are common problems in today's stressful and competitive world. Age, stress, emotions are conditions that may led to memory loss, amnesia, anxiety, high blood pressure, dementia, to more ominous threat like schizophrenia and Alzheimer's diseases. Neuropsychiatric

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symptoms are common in dementia. Some plant extracts which occur as a complex mixture of components, such as *T. Chebula*. extract, have demonstrated relevant biological activities in relation to metabolism, cardiovascular, diabetes, disinfection, antimicrobial and antioxidant potential, but the compounds responsible for the observed effects or the mechanisms of action have not been well characterized. Therefore, scopolamine was used to study effect of *T. Chebula* on memory impairment function.

The Morris water maze is a behavioral procedure widely used in behavioral neuroscience to study spatial learning and memory. In this paradigm, animal is placed into a small pool of water which contains an escape platform hidden below the water surface. Visual cues, such as colored shapes, are placed around the pool in plain sight of the animal. This improvement in behavioral performance occurs presumably as a result of learning and memory for where the hidden platform is located relative to the conspicuous visual cues.[18]

Scopolamine was administered 5 min before the acquisition trial to induce memory impairment and retention was tested. Administration of scopolamine caused memory impairment in rats as indicated by significant increase in transfer latency time in elevated plus maze and a significant change in dips as well as exploration time in hole board. Further, in light or dark model and pole climbing teat, rats treated with scopolamine had significantly lower % avoidance response to reach light or dark chamber and pole climbing latency, respectively.

In Morris water maze study we directly examined the effect of *T. chebula* fruit extracts and fractions of ethanolic extract on mean latencies during the acquisition trial and time spent in the target quadrant (memory trial). Scopolamine treated disease control group significantly increased mean latencies to the extent as compared to normal vehicle control group. Animals orally treated with *T. chebula* fruit extracts and fraction significant decreased the mean latencies of the acquisition trial as compared to scopolamine disease control group. The Significant decrease in transfer latency by ethanolic extract and ethylacetate soluble fraction of *T. chebula* fruit as compared to scopolamine disease control group suggests improved beneficial effect on learning and memory process. While in the acquisition trial treatment with *T. chebula* fruit plant extracts and fractions there were significant increased the time spent in the target quadrant was observed as compared to scopolamine control group. Thus *T. chebula* extracts and fractions improved basal as well as scopolamine-impaired performance comparable with reference standard

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piracetam with respect memory claiming their nootropic potential. A catalase is one of the crucial antioxidant enzymes that mitigates oxidative stress to a considerable extent by destroying cellular hydrogen peroxide to produce water and oxygen. Deficiency or malfunction of catalase is postulated to be related to the pathogenesis of many age-associated degenerative diseases like diabetes mellitus, hypertension, anemia, vitiligo, Alzheimer's disease, Parkinson's disease, bipolar disorder, cancer, and schizophrenia.[19]

All extracts and fractions including ethanolic extract and ethylacetate soluble fraction of ethanolic extract of *Terminalia chebula* fruit showed catalase scavenging activity as evident higher in nm/mg tissue weight clearly demonstrating the difference in potential of the different extracts as well as fractions. These increase value of catalase in treatment groups proved the ability of extracts and fractions with more potential scavenging activity by ethylacetate soluble fraction of ethanolic extract of *T. chebula* fruit.

ROS can easily initiate the lipid peroxidation of the membrane lipids, causing damage of the cell membrane of phospholipids, lipoprotein by propagating a chain reaction cycle.[201] Oxide indirectly initiates lipid peroxidation because oxide anion acts as a precursor of singlet oxygen and 0H-. Hydroxyl radicals eliminate hydrogen atoms from the membrane lipid, which results in lipid peroxidation. [20]

The extracts and fractions of *T. chebula* proved to inhibit the *in vitro* lipid peroxidation of microsomal membranes and increase the protein level in brain and body tissue. The ethanolic extract and ethylacetate soluble fraction of ethanolic extract of *Terminalia chebula* fruit showed protein scavenging activity as evident higher in mg/dl tissue homogenate clearly demonstrating the difference in potential of the different extracts as well as fractions.

Reduced glutathione or GSH is endogenous antioxidants. It reacts with free radicals by donating the hydrogen ions and decreases the oxidative stress. Protein carbonyl is produced through the oxidation of proteins in the membrane.

The ethanolic extract and ethylacetate soluble fraction of ethanolic extract of *Terminalia chebula* fruit showed Reduced glutathione or GSH scavenging activity as evident higher in tissue homogenate clearly demonstrating the difference in potential of the different extracts as well as fractions. These increase value of protein and Reduced glutathione or GSH in treatment groups

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proved the ability of extracts and fractions with more potential free radical scavenging activity by ethylacetate soluble fraction of ethanolic extract of T. *chebula* fruit.

In this study the preliminary pharmacological *in vivo* studies correlates well to demonstrate the memory ameliorating, anti-amnesic property of the plant extracts in the presence *or* the absence of amnestic agent suggests the nootropic activity of the plant extracts.

CONCLUSION

Lack of satisfactory treatment of the cognitive deficits usually accompanying stress, depression, anxiety, ageing, and associated mental problems presents a constant challenge for Psychopharmacological research. On the basis of the preliminary screening of the *T. chebula* fruit extracts (Ethanol, Methanol, Acetone and Chloroform extracts) we concluded that ethanolic extracts of *T. chebula* significantly improved learning memory in several exteroceptive and interoceptive behavioural models of scopolamine induced memory deficit activity, antioxidant activity and by attenuating the biochemical perturbations caused by cognitive impairments.

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