Vol. 1/1 (2001) 33 - 41

JOURNAL OF NATURAL REMEDIES

Effect of *Butea monosperma* on memory and behaviour mediated *via* monoamine neurotransmitters in laboratory animals

N. S. Gawale, S. C. Pal, V. S. Kasture, S. B. Kasture*

N.D.M.V.P. Samaj's College of Pharmacy, NASHIK - 422 002.

Received 25 July 2000; Revised and accepted 14 October 2000

Abstract

Objective: To identify the fraction responsible for the nootropic activity of *Butea monosperma* and to correlate nootropic activity with monoamine and acetyl choline mediated behaviour. Materials and methods: The acetone soluble part of petroleum ether and ethanolic extracts of dried flowers of *Butea monosperma* exhibited nootropic activity in the elevated plus maze paradigm and active avoidance learning. The effect of active fraction was observed on clonidine-induced hypothermia (noradrenaline mediated behaviour), haloperidol-induced catalepsy (dopamine mediated behaviour), lithium-induced head twitches (serotonin mediated behaviour) and sodium nitrate induce respiratory arrest (acetylcholine mediated behaviour). Results: The elevated plus maze paradigm indicated that the nootropic activity resides in the ethyl acetate (PEF) fraction of petroleum ether extract and ethyl acetate fraction (AEF) and methanolic fraction (AMF) of alcoholic extract. These fractions reversed scopolamine-induced amnesia in mice. The fractions influenced the monoamine-mediated behavior differentially. The approximate LD_{50} of PEF, AEF and AMF were estimated as 0.3g/kg, >5.0g/kg and 3g/kg i.p. respectively. Conclusion: The PEF, AEF and AMF exhibited significant nootropic activity had differential effect on the monoamine mediated behaviour indicating different modes of their nootropic activity. These fractions need to be investigated further to understand mechanism of their action.

Key words: *Butea monosperma*, nootropic, elevated plus maze, hypothermia, catalepsy, head twitches

1. Introduction

In the Ayurvedic system of medicine, flowers of *Butea monosperma*, (Lam) Kuntze (Family: Fabaceae) are used as tonic, astringent, aphrodisiac and diuretic [1].

Roots are reported to be useful in the treatment of filariasis, night blindness, helminthiasis, piles, ulcers and tumors [2]. Flowers are reported to have astringent, diuretic, and anti-inflammatory activity. Alcoholic concentrate of petals exhibits anti-estrogenic and anti-implantation activity and decoction of flowers is used in diarrhoea [3]. This laboratory has recently reported antistress and anti-convulsant activity of flowers of *B. monosperma* [4, 5].

* Corresponding Author
E-mail: kasture_sb@hotmail.com

During phytochemical studies on the flowers of *B. monosperma*, we noted presence of saponins. Since previous studies from this laboratory has shown that saponins obtained from *Albizzia lebbeck* (Unpublished data), *Bacopa monnieri* [6], and *Panax ginseng* [7], possess nootropic activity, we investigated nootropic activity of flowers of *B. monosperma.*

Several mediators like acetyl choline, noradrenaline, dopamine, serotonin, gamma-aminobutyric acid, glutamate, nitric oxide, and peptides [8] influence the cognitive behaviour of the animal. The animal behaviour mediated by these mediators may be a simple way of studying the neurochemical correlates of learning and memory. Therefore, in the present study we have tried to correlate the nootropic activity with the monoamine-mediated behaviour.

2. Materials and methods

2.1 Plant material

The flowers of *B. monosperma* (Voucher specimen No. 165413) were collected in May and were deposited at the Botanical Survey of India, Pune, and were also identified by comparison with herbarium specimens at the Department of Botany, Nagpur University, Nagpur, India.

2.2 Extraction

Petals of *B. monosperma* (0.5 kg) were shed dried and extracted successively with petroleum ether (pet ether) and ethanol (70 % V/V). The extracts were concentrated under reduced pressure. The dried pet ether extract (8.08g) and ethanolic extract (205g) were fractionated into acetone soluble and insoluble parts. The acetone soluble part of both the pet ether extract (4.96g) and ethanolic extract (4.3g) exhibited nootropic activity, hence these parts were fractionated further using column chromatography with silica gel as a stationary phase and organic solvents of varying polarity like benzene, ethyl acetate and methanol as mobile phase.

The acetone soluble part of pet ether extract yielded benzene fraction (PBF, 2.5g), ethyl acetate fraction (PEF, 2.0g) and methanol fraction (PMF, 0.3 g) whereas, the acetone soluble part of ethanolic extract yielded ethyl acetate fraction (AEF, 2.2g) and methanolic fraction (AMF, 2.0g). All fractions were tested for nootropic activity using elevated plus maze. The effect of these fractions was also studied on monoamine mediated behaviour as a simple way to study their probable mode of nootropic action.

2.3 Animals

Sprague-Dawley rats (200-225g) and Swiss mice (25-30g) were used in this study. They were housed into groups of six, under standard laboratory conditions of temperature (23° ± 1°C), relative humidity (55 ± 5 %), lighting (from 08-20 h) with

Table 1
Effect of acetone soluble part of pet ether and ethanolic extract and their fractions on the transfer latency on elevated plus maze in mice.

Treatment	Dose mg/kg	Inflexion ratio (mean ± SEM) on the second day
Vehicle	-	1.26 ± 0.32
ASP	100	2.84 ± 0.46*
ASE	100	2.86 ± 0.38*
AIP	100	1.35 ± 0.22
AIE	100	1.33 ± 0.45
PBF	50	1.08 ± 0.31
PEF	10	11.37 ± 1.7**
	25	6.85 ± 2.46**
	50	5.51 ± 0.66**
AEF	10	4.62 ± 0.76**
	25	3.41 ± 2.14
	50	0.62 ± 0.22
AMF	10	1.18 ± 0.52
	25	1.12 ± 0.39
	50	2.77 ± 0.55*
Piracetam	100	1.92 ± 0.18

n = 6; The transfer latency is represented as the inflexion ratio. *P<0.05, **P<0.01 compared to vehicle treated group (ANOVA followed by Dunnett's test).
ASP= Acetone soluble part of pet ether extract. ASE = Acetone soluble part of ethanollic extract, AIP = Acetone insoluble part of pet ether extract, AIE = Acetone insoluble part of ethanolic extract. PBF = Benzene fraction of acetone soluble part of pet ether extract. PEF= Ethyl acetate fraction of acetone soluble part of pet ether extract, AEF = Ethyl acetate fraction of acetone soluble part of ethanolic extract and AMF = methanolic fraction of acetone soluble part of ethanolic extract.

food (Lipton India Ltd., pellets) and water freely available. They were transferred to the laboratory at least 1 h before the start of experiment. The experiments were performed during the light portion (08 - 16 h).

2.4 Drugs and chemicals

Gift samples of piracetam (Uni-Ucb, India), scopolamine and clonidine (German Remedies, India), haloperidol (Searle, India), and lithium sulphate (Glenmark, India) were used in this study. Pet ether (60-80°C), ethanol, acetone, ethyl acetate, benzene, methanol were of laboratory grade. These drugs and fractions were dissolved in water and polyethylene glycol 400 (PEG 400) and administered intraperitoneally 30min before behavioural testing.

2.5 Acute toxicity

The PEF, AEF and AMF fractions which possessed nootropic activity were administered orally in varying doses (0.1-5g/kg i.p.) to groups of mice (n = 6) and percent mortality was observed 24 h later.

Table 2
Effect of piracetam, PEF, AEF and AMF on scopolamine-induced alteration in the transfer latency on elevated plus maze in mice.

Treatment	Dose mg/kg	Inflexion ratio(mean± SEM) on the second day
Vehicle	-	-0.24 ± 0.06
Piracetam	100	3.20 ± 1.62*
PEF	10	2.21 ± 0.53**
	25	0.33 ± 0.07***
	50	0.63 ± 0.22**
AEF	10	1.37 ± 0.3**
	25	3.78 ± 1.35**
	50	3.87 ± 2.39
AMF	10	3.14 ± 0.62**
	25	5.10 ± 2.05*
	50	1.27 ± 0.44**

n = 6; Scopolamine (0.3mg/kg i.p.) was administered 30min after drug treatment; *P<0.05, **P<0.01 and ***P<0.005 compared to vehicle treated group (ANOVA followed by Dunnett's test).
PEF= Ethyl acetate fraction of acetone soluble part of pet ether extract; AEF = Ethyl acetate fraction of acetone soluble part of ethanolic extract and AMF = methanolic fraction of acetone soluble part of ethanolic extract.

2.6 Nootropic activity

The nootropic activity was assessed using elevated plus maze. The plus maze consisted of two open arms (35 x 6cm) and two enclosed arms (35 x 6 x 15cm). The maze was elevated to the height of 25cm. Mice were gently placed individually at the end of an open arm facing away from the central platform and the time it took to move from the end of the arm to the center of the maze (transfer latency, TL) was recorded.

On the first day, mice were allowed to explore plus maze after the measurement of TL. On 2nd day, mice were treated with the test compounds and after 30 min placed on the maze and TL was recorded for each animal. The inflexion ratio was calculated as described by Jaiswal and Bhattacharya [9] using the following formula

Inflexion ratio = $(L_1-L_0)/L_0$

Where L_1 is the initial TL in sec and L_0 is the TL in sec on the second day.

In another set of experiments, the animals received, before the first trial, vehicle, PEF, AEF, AMF, (10,25 or 50mg/kg), or piracetam (100mg/kg) either alone or 30 min before scopolamine (0.3mg/kg).

2.7 Active avoidance learning

Sidman jumping box was used to study the active avoidance learning and retention as describe by Jaiswal and Bhattacharya [9]. Rats were placed individally in one of the two chambers of the Sidman box and after 5 seconds the buzzer (conditioned stimlus, CS) was sounded for 2 sec, followed by an electric shock (unconditioned stimuls, UCS 30V, 0.5 sec) through the grid. If the rat jumped to another chamber to avoid UCS it was allowed to take rest.

Otherwise the animal was again placed after 3 min for the next trial. The rats were given 10 trials daily until they exhibited 100% active avoidance response. The animals received, vehicle, PER, AEF, AMF (10, 25 or 50mg/kg), or piracetam (100mg/kg) 30 min before the behavioral testing. The number of trials required to learn active avoidance was counted.

Table 3
Effect of piracetam, PEF, AEF and AMF on clonidine induced hypothermia in rats

Treatment Dose mg/kg		Rectal temperature° C (mean ±SEM) at 0	60	120	150	180 min.
Vehicle	-	36.0±0.2	33.8±0.2	33.5±0.2	33.5±0.3	33.4±0.3
Piracetam	100	36.1±0.2	32.7±0.2	33.6±0.2	34.1±0.3	34.3±0.3
PEF	10	37.0±0.1	34.3±0.1	34.6±0.1	34.6±0.2	34.6±0.1
	25	35.5±0.2	34.1±0.1	33.6±0.1	33.6±0.1	33.1±0.1
	50	36.0±0.3	33.3±0.3	33.6±0.3	33.8±0.4	33.5±0.4
AEF	10	36.2±0.1	34.2±0.1	33.7±0.1	33.7±0.1	33.8±0.2
	25	36.0±0.2	33.8±0.1	33.5±0.2	33.8±0.1	33.7±0.3
	50	36.0±0.2	34.7±0.2	33.9±0.3	33.9±0.2	34.0±0.2
AMF	10	35.6±0.2	33.4±0.1	31.8±0.2*	31.4±0.3*	30.6±0.4*
	25	35.8±0.1	34.3±0.2	32.8±0.3*	32.2±0.3*	31.6±0.3*
	50	35.7±0.5	33.3±0.5	31.5±0.7*	31.3±0.7*	30.7±0.8*

n = 6; *P<0.05 compared to vehicle control (Student's *t* - test), Clonidine was administered 30 min after the drug treatment.

2.8 Behavioural studies

2.8.1 Noradrenaline mediated behaviour

The effect of fractions was studied on clonidine-induced hypothermia, an animal model recommended by Drew *et al.,* [10] to study the effect of drugs on the noradrenaline (NA) mediated behavior. Albino rats, divided into groups of six each, received vehicle, piracetam (100mg/kg), or PEF, AEF, and AMF (10,25 or 50mg/kg) intraperitoneally 30 min before clonidine (0.1mg/kg) and rectal temperature was recorded at 0, 60, 120, 150, and 180 min. Due care was taken to avoid stress of inserting the probe.

2.8.2 Serotonin mediated behaviour [11]

Rats (n = 6) were treated with PEF, AEF, AMF (10,25 or 50 mg/kg), piracetam (100mg/kg) or vehicle 30 min before lithium sulphate (250mg/kg i.p.) and the number of head twitches were counted for 60 min after lithium sulphate.

2.8.3 Dopamine mediated behaviour

Mice were divided into groups of six each. Animals received haloperidol (1mg/kg i.p.) 30 min after vehicle, piracetam (100mg/kg), PEF, AEF, or AMF in doses of 10, 25 or 50 mg/kg i.p. and the duration of catalepsy was noted at 5,15, 30, 60, 90 and 120 min intervals using 'Bar test' described by Ferre *et al.,* [12].

In brief, the forepaws of mouse were placed on wooden bar (0.9cm diameter) resting 2.5cm high from the table and duration of imposed posture was noted twice and greater time was chosen for calculation.

2.9 Acetylcholine mediated behaviour

Chemical hypoxia was induced by subcutaneous injection of sodium nitrite (250mg/kg) 60 min after the administration of vehicle, PEF, AEF, AMF (doses that exhibited nootropic activity) or pilocarpine (30 mg/kg). The percentage mortality due to respiratory arrest was noted [13]. Each group consisted of 8 animals.

2.10 Chemical identification

The fractions were subjected to chemical tests for identification of the categories of compounds as described by Harborne [14]. Chemical shifts were studied as described by Markham [15].

2.11 Statistical analysis

The data obtained were analysed using one way analysis of variance (ANOVA) followed by Dunnett's test or Student's *t* - test. Kruscal-Wallis test was used for non-parametric data. Differences were considered significant at the 5 % level.

Table 4
Effect of piracetam, PEF, AEF and AMF on lithium-induced head twitches in rats

Treatment	Dose mg/kg	No. of head twitches (mean ± SEM)
Vehicle	-	36.0 ± 6.71
Piracetam	100	14.0 ± 2.46**
PEF	10	0.0
	25	0.0
	50	0.0
AEF	10	37.83 ± 5.14
	25	49.0 ± 3.69
	50	51.83 ± 2.54*
AMF	10	34.16 ± 3.4
	25	11.0 ± 1.87**
	50	22.0 ± 2.43*

n = 6; *P <0.05 and **P<0.01 compared to vehicle treated group (Student's *t* - test) Lithium sulphate (250mg/kg) was administered 30 min after the drugs and the number of head twitches was counted for 60min after lithium sulphate. PEF= Ethyl acetate fraction of acetone soluble part of pet ether extract,
AEF = Ethyl acetate fraction of acetone soluble part of ethanolic extract and AMF = methanolic fraction of acetone soluble part of ethanolic extract.

3. Results

3.1 Acute toxicity

The approximate oral LD_{50} of fractions having nootropic activity i.e. PEF and AMF was 300 mg/kg, 3.0 g/kg respectively. The LD_{50} of AEF was greater than 5 g/kg.

3.2 Nootropic activity

The transfer latency (TL) on the elevated plus maze was expressed as inflexion ratio (IR). The IR, after 24h, was significantly (P<0.05) increased by the acetone soluble parts of pet ether extract and ethanolic extract. Piracetam, *per se*, increased the IR and antagonized the amnesic effect of scopolamine. PEF, in all doses, AEF 10mg/kg, and AMF 50mg/kg exhibited increased IR (P<0.05). Although AEF, 25mg/kg, increased the IR, it could not reach the desired significance because of biological variation and in a dose of 50mg/kg caused decrease in IR. Lower doses of AMF were without any effect. The observations are given in Table 1.

Scopolamine decreased the IR indicating induction of amnesia. Except AEF (50mg/kg) all other drugs like piracetam (P<0.05), PEF, 10mg/kg (P<0.01), 25mg/kg (P<0.005), 50mg/kg (P<0.01); AEF, 10mg/kg (P<0.01), 25mg/kg (P<0.01), and AMF, 10mg/kg (P<0.01), 25mg/kg (P<0.05), 50mg/kg (P<0.01) significantly antagonized amnesic effect of scopolamine. The observations are given in Table 2.

3.3 Active avoidance learning

The vehicle treated rats required 38.5 ± 3.5 unshocked trials for 100% learning. The PEF, AEF and AMF required 35.0 ± 2.5, 40.5 ± 4.2 and 30.8 ± 4.3 unshocked trials. The active avoidance learning was not modified by any fraction.

3.4 Behavioural effects

3.4.1 Noradrenaline-mediated behaviour

The rectal temperature decreased from 36.0 ± 0.2°C to 33.43 ± 0.3°C 180 min after clonidine. Piracetam, PEF, and AEF were without any significant effect. However, AMF, in all the doses used, potentiated clonidine-induced hypothermia (Table 3).

3.4.2 Serotonin mediated behaviour

Lithium induced 36.0±6.71 head twitches in vehicle treated group. PEF, in all doses, completely inhibited head twitches. Piracetam, (P<0.01); AMF, 25mg/kg (P<0.01) and 50mg/kg (P<0.05) reduced the head twitches; whereas AEF in all doses showed an increase in the number of head twitches, however only AEF, 50mg/kg, could increase head twitches significantly (P<0.05). The observations are given in Table 4.

3.4.3 Dopamine mediated behaviour

In vehicle treated group, haloperidol produced peak catalepsy 30 min after its administration. Piracetam inhibited catalepsy, but only till 30 min. PEF, in lower doses had no effect on haloperidol-induced catalepsy and in a dose of 50mg/kg, inhibited catalepsy till 60 min only. AEF induced dose dependent inhibition till 60 min but the peak effect of haloperidol was not modified by any fraction.

Table 5
Effect of piracetam and AMF on haloperidol-induced catalepsy in mice.

Treatment (mg/kg)	Duration of catalepsy in sec (mean ± SEM) at 5	15	30	60	90 min.
Vehicle	257.5±15.7	278.3±15.0	298.0±1.3	300±0	300±0
Piracetam (100)	14.5±3.4*	31.5±5.0*	122.8±9.8*	259.1±22.1*	300±0
AMF (10)	67.6±5.3*	169.1±11.1*	300±0	300±0	300±0
(25)	44.0±3.8*	172.6±5.6*	259.1±14.5	294.6±5.3	300±0
(50)	58.6±6.2*	150.0±15.6*	268.0±12.0	296.6±3.3	300±0

n = 6; *P<0.05 compared to vehicle treated group. Haloperidol (1mg/kg i.p.) was administered 30min after piracetam or AMF.

AMF was least effective in inhibiting haloperidol-induced catalepsy (Table 5).

3.5 Acetylcholine mediated behaviour

The animals receiving the vehicle showed 100% mortality after sodium nitrite injection while animals treated with doses that exhibited nootropic activity i.e AEF (10 mg/kg), PEF and AMF (50 mg/kg) showed only 25%, 12.5% and 37.5% mortality respectively (P<0.05 Fisher exact test). The pilocarpine treated group showed no mortality.

3.6 Chemical identification

The PEF was found to contain sterols (Salkowski test and Liebermann-Burchard test) and glycosides. AEF contained sterols, glycosides, saponins (Foam test and haemolysis test) and flavonoids (Shinoda test), whereas AMF contained glycosides and saponins. AEF was found to contain butein and coreopsin.

4. Discussion

Nootropic drugs belong to the new class of psychotropic agents with selective facilitatory effect on intellectual performance, learning and memory. The present study shows that the ethyl acetate fraction of acetone soluble parts of both the pet ether and ethanolic extract and the methanolic fraction of the acetone soluble part of ethanolic extract exhibited nootropic activity. Shortening of the transfer latency by these fractions, as shown by increased inflexion ratio, is in accordance with the hypothesis of Itoh *et al.,* [16]. The fractions met a major criterion for nootropic activity, namely, improvement of memory in absence of cognitive deficit [17].

PEF, in all doses, AEF 10mg/kg, and AMF 50mg/kg exhibited improved cognition. Although AEF, 25mg/kg, increased the inflexion ratio (IR), the difference could not reach the desired significance (P>0.05) and in a dose of 50mg/kg deteriorated memory. Such biphasic dose response effect on the cognitive behaviour of mice in the plus maze (nootropic action at low dosage and hypomnesic action with the high dosage) has been demonstrated earlier by Bartolini *et al.,* [18]. Lower doses of AMF were without any effect on memory.

Numerous studies on learning and memory reveal that cholinergic system plays an important role. Several findings indicate that cholinergic system in the amygdala is involved in the memory process and cholinergic neuronal activities in the amygdala change after learning a task [19]. Scopolamine and other antimuscarinic drugs induce cognitive disturbance by blocking postsynaptic muscarinic receptors.

However, psychotropic agents may influence central cholinergic system *via* modulation of dopaminergic or serotonergic systems [20]. The agents such as carbachol, which improve cholinergic transmission are known to improve cognitive function [19]. Piracetam and PEF in all doses and AEF in lower doses significantly antagonized amnesic effect of scopolamine but AEF and AMF in higher dosage failed to reverse hypomnesic effect of scopolamine.

According to Poschel [17] a nootropic agent is the one which improves memory in absence of cognitive deficit. It is reported that the drugs improving acquisition may have adverse effect on retention of

the learned task and any drug which tend to induce arousal, like amphetamine, can facilitate learning acquisition and yet attenuate retention of learning [21].

It is therefore proposed that a memory facilitating drug should be capable of retention of learned task when administered after learning acquisition [22]. Several researchers have shown that the nootropic agents have failed to improve active avoidance learning [9, 23]. This indicates that the agents which improve retention, may be good candidates for further studies.

Despite extensive research, the neurological basis of learning and memory remains controversial.The fractions having nootropic activity have improved cholinergic trasmision as observed from decreased mortality in animals treated with the fractions and sodium nitrite.

The sodium nitrite converts hemoglobin into methemoglobin and the oxygen carrying capacity is reduced to such extent that the animal can not breath and dies due to respiratory arrest and agents improving cholinergic transmission decrease the mortality rate [13]. Protection by pilocarpine in this experiment has substantiated the involvement of cholinergic system in this model.

Although involvement of central cholinergic system is well established, the role of other neurotransmitter systems can not be ignored. Biogenic amines are involved in learning and memory processes. Desipramine, a NA uptake inhibitor, showed a tendency to enhance latent learning in mice [24]. Clonidine reduces noradrenaline release and thereby induces hypothermia [10]. Piracetam, PEF, and AEF failed to reverse clonidine induced hypothermia indicating that noradrenergic mechanism is not involved in the nootropic effect of these compounds. On the other hand, AMF potentiated clonidine-induced hypothermia.

Several studies have indicated that increase in serotonergic transmission can interfere with learning acquisition and memory consolidation [25-29]. Lithium induced head twitches are due to increased formation of 5-HT in the central nervous system [11]. PEF, in all doses, completely inhibited head twitches. Piracetam, AMF, 25mg/kg and 50mg/kg reduced the head twitches whereas AEF in all doses showed an increase in the number of head twitches. The fractions that increased head twitches exhibited diminished inflexion ratio suggesting that the fractions with nootropic activity acted by decreasing serotonergic transmission.

Controversial reports are available on the involvement of DA activity in learning and memory. It has been demonstrated that learning and memory storage can proceed normally despite depletion of brain DA [30]. Piracetam, in one study, exhibited increase in dopaminergic activity [31] and in another study failed to affect DA levels significantly [32].

In our study piracetam facilitated DA activity and inhibited catalepsy, but only upto 30 min. PEF, in lower doses had no effect on haloperidol-induced catalepsy and in a dose of 50mg/kg, inhibited catalepsy upto 60 min only. AEF induced dose related inhibition upto 60 min but the peak effect of haloperidol was not modified by any fraction. AMF was least effective in inhibiting haloperidol-induced catalepsy. Thus dopaminergic mechanism does not seem to play an important role in the nootropic activity of *B. monosperma.*

Sodium nitrite is known to convert hemoglobin into methemoglobin thereby reducing oxygen carrying capacity and reducing cholinergic transmission also, ultimately leading to death [13]. The diminished effect of sodium nitrite in presence of pilocarpine, PEF, AEF and AMF indicate that they increase cholinergic transmission and this could be the reason for their nootropic activity. These fractions have antagonized the amnesic effect of scopolamine in the elevated plus maze paradigm.

The approximate LD_{50} of PEF and AMF was 300mg/kg, 3.0g/kg respectively. Whereas the LD_{50} of AEF was greater than 5g/kg indicating considerable margin of safety of the AEF and AMF. Both AEF and AMF contained saponins which like saponins of *Panax ginseng* or *Bacopa monnieri* may improve memory.

The study indicates that all fractions improve cholinergic transmission and other neurotransmissions are also involved in their nootropic activity. The nootropic effect of AMF may be beacuse of diminished noradrenergic transmission. The dopaminergic system has insignificant role to play in the observed effects, as the dopaminergic transmission was modified upto 30 min only. PEF in all doses completely inhibited serotonergic transmission. AMF reduced serotonergic transmission whereas AEF in all doses showed an increase in the number of head twitches. These observations incidate that dopaminergic, noradrenergic and serotonergic transmission may not be directly involved in the improving memory. Thus the study concludes that flowers of *Butea monosperma* may serve as a potential source of nootropic agents. Further studies are required to isolate the active principles and to study the mechanism of action.

5. Acknowledgement

The authors are grateful to the All India Council for Technical Education, New Delhi for financial support.

References

1. Nadkarni KM. (1998) *Indian Materia Medica*, Popular Prakashan: Mumbai; 222-224.

2. Raj RK, Kurup PA. (1968) *Indian J. Med. Res.* 56: 13-18.

3. Kirtikar KR, Basu BD. (1989) In : Blatter E, Caius JF, Mhaskar KS. (Eds) *Indian Medicinal Plants*, Shiva Offset Press: Dehra Dun; 785-788

4. Bhatwadekar AD, Logade NA, Chintawar SD, Somani RS, Kasture VS, Kasture SB. (1999) *Indian J. Pharmacol.* 31: 153-155.

5. Kasture VS, Chopade CT, Deshmukh VK. (2000) *J. Ethnopharmacol.* 71: 65-75.

6 Singh HK, Dhavan BN. (1997) *Indian J. Pharmacol.* 2: 359-65.

7. Ying Y, Zhang JT, Shi CZ, Liu Y. (1994) *Acta Pharmaceutica Sinica* 29: 241-245.

8. Reddy DS. (1997) *Indian J. Pharmacol.* 29: 208-221.

9. Jaiswal AK, Bhattacharya SK. (1992) *Indian J. Pharmacol.* 24: 12-17.

10. Drew GM, Gower AJ, Marriot AS. (1977) Proceedings of British Pharmacology Society, *Br. J. Pharmacol.* 63: 468.

11. Wielosz M, Kleinrok Z. (1979) *J. Pharm. Pharmacol.* 31: 410-414.

12. Ferre S, Guix T, Prat G, Jane F, Kasas M. (1990) *Pharmacol. Biochem. Behav.* 35: 753-757.

13. Vogel HG, Vogel WH. (1997) *Drug discovery and evaluation,* Springer: New York; 349.

14. Harborne JB. (1965) *Phytochemical Methods: A guide to modern techniques of plant analysis.* Second edition, Chapman and Hall: London.

15. Markham KR. (1982) *Techniques of flavonoid identification,* Chemistry Division, Department of Scientific and Industrial Research: Petone, Newzeland; 39.

16. Itoh J, Nabeshima T, Kameyama T. (1990) *Psychopharmacol.,* 101: 27-33.

17. Poschel BPH.(1988) In: Iversen LL, Iversen SD, Snyder SH. (Eds) *Handbook of Psycho-pharmacology,* Vol. 20, Plenum press; New York: 437-445.

18. Bartolini L, Casamenti F, Pepeu G. (1996) *Pharmacol. Biochem. Behav.* 53: 277-283.

19. Numura Y, Nishiyama N, Saito H, Matsuki N. (1994) *Biol. Pharm. Bull.* 17: 490-494.

20. DeSouza SM, Giumaraes FS, Graeff FG, Tomaz C. (1993) *Behav. Brain Res.* 59: 141-145.

21. Giurgea C. (1973) *Cond. reflex.* 8: 108-115.

22. McGaugh JL, Patrinovich L. (1959) *Am. Psychol.* 72: 99-103

23. Bhattacharya SK, Upadhyay SN, Jaiswal AK, Sen AP. (1993) *Indian J. Exp. Biol.* 31: 898

24. Mason OP. (1984) *Catecholamines and behaviour,* Cambridge University Press: Cambridge; 177-245.

25. Ichihara K, Nabernima T, Kameyama T. (1993) *J. Pharmacol. Exp. Ther.* 26: 122-128.

26. Arnsten AF, Lin CH, Van Dyck CH, Stanhope KJ. (1997) *Neurobiol. Aging* 18: 21-28.

27. Barnes JM, Costall B, Coughlan J, Domeney AM, Gerard PA, Lelly ME, Naylor RJ, Onaivi ES, Tomkins DM, Tyers MB. (1990) *Pharmacol. Biochem. Behav.* 35: 955-962.

28. Chugh Y, Sankarnarayanan A, Sharma PL. (1991) *Meth. Find. Clin. Pharmacol.* 11: 161-164.

29. Staubli U, Xu FB.(1995) *J. Neurosci.* 15: 2445-2452.

30. Davis HP.(1989) *J. Comp. Physiol. Psychol.* 95, 556-564.

31. Nyback F, Wiesel A, Skett P.(1979) *Psycho-pharmacol.* 61: 235-238.

32. Bhattacharya SK, Upadhyay SN, Jaiswal AK, Bhattacharya S. (1989) *Indian J. Exp. Biol.* 27, 261-264.