

## Chemical and Pharmacological Study of *Cymbopogon proximus* Volatile Oil

<sup>1</sup>Kamal E.H. El Tahir and <sup>2</sup>Maged S. Abdel-Kader

<sup>1</sup>Department of Pharmacology

<sup>2</sup>Department of Pharmacognosy, College of Pharmacy, King Saud University,  
P.O. Box 2457 Riyadh 11451, Kingdom of Saudi Arabia

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**Abstract:** The volatile oil of *Cymbopogon proximus* was prepared by hydrodistillation method and analyzed chemically by GC/MS. The chromatogram showed 8 peaks corresponding to eight components with piperitone representing 72.44% of the oil's composition. Oral and intraperitoneal (i.p.) administration of the volatile oil to male, female rats and mice resulted in LD<sub>50</sub> values in the range of 1.9- 2.6 mL kg<sup>-1</sup> with an oral absorption of 80-90%. I.p. administration of the oil to anaesthetized rats (0.2-1.6 mL kg<sup>-1</sup>) decreased the arterial blood pressure in a dose-dependent manner without significant changes in the heart rate except in the largest dose tested where a 16% decrease was observed. The induced decreases were not antagonized by atropine or mepyramine but were significantly reduced by indomethacin. The oil did not induce significant changes in the ECG. I.p. administration of the oil (1.2 mL kg<sup>-1</sup>) to mice before induction of convulsions with electric shock, pentylenetetrazole, picrotoxin and strychnine resulted in complete protection only against the electrically induced convulsions. I.p. administration of the oil to pigeons in doses of 0.4 and 0.8 mL kg<sup>-1</sup> significantly protected against ouabain-induced vomiting. The results of these studies pointed to the involvement of prostaglandins in the oil-induced cardiovascular depressant effects and a probable antidopaminergic and antigliutamic-aspartic acids in the antiemetic and anticonvulsant effects, respectively.

**Key words:** *Cymbopogon proximus*, oil, GC/MS, cardiovascular system, convulsions, vomiting

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### INTRODUCTION

Halfabar, the common name of *Cymbopogon proximus*, is a common weed with strong aromatic odour grows in Southern Egypt and Northern parts of Sudan (Boulos, 1999). In Egypt, the plant is widely used in the folk medicine as an effective renal antispasmodic and diuretic (Boulos, 1983; Batanouny *et al.*, 1999). GC/MS analyses were performed on the oil prepared from samples obtained from Burkina Faso and Sudan and showed significant composition differences. Piperitone was identified as the major component in samples obtained from Burkina Faso while those of Sudan were free from that compound (Menuet *et al.*, 2000; Siddiqui *et al.*, 1980). The volatile oil showed ovicidal, larvicidal and antioxidant activities (Menuet *et al.*, 2000; Bassole *et al.*, 2003). The literature lacks data about the pharmacological effects of the oil on different organs. In this study the effects of the oil on the cardiovascular system, convulsions and vomiting induced to experimental animals were studied.

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**Corresponding Author:** Maged S. Abdel-Kader, Department of Pharmacognosy, College of Pharmacy,  
King Saud University, P.O. Box 2457 Riyadh 11451, Kingdom of Saudi Arabia  
Tel: +96614677246 Fax: +96614677245

## MATERIALS AND METHODS

### Plant Material

The plants of *Cymbopogon proximus* (Hochst. ex A. Rich.) Stapf Fam. Poaceae (Gramineae) were purchased from the local market in Alexandria-Egypt (August, 2005). The plant material was identified by Saniya Kamal, Prof. of Taxonomy, College of Science, Alexandria University. A voucher specimen (#CP15) was deposited at the herbarium of the College of Science.

### Preparation and Analysis of the Oil

The dry powdered plants of *Cymbopogon proximus* (250 g) were subjected to hydrodistillation for 5 h (Egyptian Pharmacopoeia, 1984). The oil was separated and the aqueous layer was extracted with ether, the oil and ether were dried over anhydrous sodium sulphate. The ether was evaporated under reduced pressure and the residue left was combined with the oil. The yield of volatile constituents was 5.44% w/w. The GC/MS analysis was carried out on Gas chromatography Mass spectrometer GC-17A Shimadzu, Auto injector-AOC-201, Shimadzu, Japan, using capillary column of fused silica (30 m×0.25 mm i.d.) coated with 5% phenyl methyl polysiloxane (DB-5). Helium ultra pure was used as carrier gas at flow rate 25 mL min<sup>-1</sup>. Oven temperature was programmed at 60-200°C at 10°C/min, the injection mode split ratio was 1:50, column inlet program was 25.5 cm sec<sup>-1</sup> and the MS detection routine was from 9-60 min. The scan of m/z was from 80-550 and the Start-Stop masses were from 40-600. Identification of the constituents was performed by aid of the computer library search (CAS No. 5989-27-5, Entry 8747, LIB# 1).

### Source of the Animals

Experimental Animals Care Center, King Saud University, Riyadh, Kingdom of Saudi Arabia. The animals were housed in suitable metabolic polypropylene cages under controlled hygienic conditions at room temperature 23±2°C, 55% relative humidity and normal light cycle of 12 h light and 12 h dark. The animals were allowed free access to rodents' chow pellets and water. The experiments and the procedures used in this study were approved by the Ethical Committee of the College of Pharmacy, King Saud University.

### Determination of the Lethal Dose 50 Values (LD<sub>50</sub>) of the Volatile Oil of *Cymbopogon Proximus* in Rats and Mice

#### Weight of the Rats and Mice

All of the rats used were 150±2 g and all the mice used were 25±0.6 g.

#### Doses for Determination of LD<sub>50</sub>

For both rats and mice: 0.75, 1.5, 2 and 3 mL kg<sup>-1</sup> (i.p) and orally.

#### Number of Animals per Group

This was indicated under each Table on line with the significance value.

### Determination of the Absorption Percentage

$$\frac{(\text{i.p})\text{LD}_{50} \text{ dose}}{\text{OralLD}_{50} \text{ dose}}$$

Initially, the oil was mixed with 0.25% aqueous solution of sodium carboxymethyl cellulose (NaCMC) in the ratio of 1:3 (oil: NaCMC). Pilot experiments were performed to find the minimal lethal dose in male rats and mice via intraperitoneal route injection. The obtained doses were taken as a guide for the design of the experiments using 4 doses, the 4th dose being the dose that induces death in all animals.

To start the experiment, male and female Wistar rats, male and female Swiss albino mice were divided into 16 groups eight for rats (males and females) and 8 for mice (males and females) with 10 animals in each group. Each subgroup was administered a dose of the volatile oil in the range of 0.75-3 mL kg<sup>-1</sup> (i.p.). In another 16 groups the volatile was administered in a similar dose range orally. The animals were observed closely and continuously for 2 h. Any live animals were kept and observed frequently for 72 h. At the end of this period, the % of death was calculated in each group. During the whole period of observation, the animals were checked for any changes in behaviour or any symptoms in any of the observable body systems. The percentage deaths were converted into probits and the LD<sub>50</sub> values were calculated using linear regression as described by (Ghosh, 1984).

#### **Preparation of the Animals for Measurement of the Arterial Blood Pressure and Heart Rate**

Male Wistar rats (150 g body weight) were anaesthetized and prepared for the measurement of the arterial blood pressure and heart rate as described before (El Tahir *et al.*, 1991, 1993). In brief, the rats were anaesthetized using 25% (w/v) aqueous urethane in doses of 1.25 g kg<sup>-1</sup> (i.p.). The carotid artery was cannulated and connected to an ITT blood pressure transducer for measurement of the arterial blood pressure. The heart rate was calculated from the blood pressure pulse by increasing the rate of recording from 0.05 cm sec<sup>-1</sup> to 1 cm sec<sup>-1</sup> in the Narco Biosystems (USA) physiograph used for recording. All injections of test drugs were injected intraperitoneally. Changes in the arterial blood pressure were quantified using the calibration system built-in the physiograph. Changes in blood pressure were reported in mmHg and changes in the heart rate were reported as % change from the pre-dosing rate.

#### **Effect of Receptor Blockers and Enzyme Synthesis Inhibitors**

To investigate the effect of the receptor blockers on the induced changes of blood pressure and heart rate atropine (2 mg kg<sup>-1</sup>) or mepyramine (5 mg kg<sup>-1</sup>) were injected (i.p.) 10 min before administration of a submaximal dose of the volatile oil. However, the non-selective COX enzyme inhibitor-indomethacin was administered (i.p.) at a dose of (25 mg kg<sup>-1</sup>) 30 min before the submaximal dose of the volatile oil. The % antagonism was then calculated.

#### **Preparation of Mice for Recording the ECG**

Swiss albino mice (30 g body weight) were prepared for recording of the ECG as previously described for rats (El Tahir *et al.*, 1995; Bakheet *et al.*, 1999). In brief, the animals were anaesthetized with aqueous urethane 25% (w/v) in doses of (2 g kg<sup>-1</sup> i.p.). The mice were placed on their backs, the limbs at the fingers sites were fixed with an adhesive tape and the ECG needles were inserted subcutaneously to pick up lead II using ECG instrument. The speed of recording was set at 25 mm sec<sup>-1</sup> and sensitivity of 10 mm/mV. The heart rate was counted from the QRS complexes per unit time. Changes in the heart rate were calculated as % change compared with the predosing rate.

#### **Induction of Convulsions in Mice**

Experimental convulsions were induced in groups of Swiss albino mice (25 g body weight) via electrical shocks and chemicals. To induce electrical convulsions in mice, a Ugo Basile ECT unit 7801 instrument was used. The two electrodes of the instrument were attached to the left and right ears of each mouse. The mouse was then placed under a large glass funnel (diameter 30 cm) and an electric shock was applied using a frequency of 75 Hz, an electric current of 75 mA, a pulse width of 2 m sec and a shock duration of 2 sec. To investigate the effect of the oil on the induced convulsions, naïve mice were initially treated with the oil in the indicated doses (i.p.). Ten minutes later, an electric shock using the above parameters was applied and its result evaluated regarding the extension of the lower limbs (clonic convulsions) and death of the shocked animals.

For induction of chemical convulsions, the following chemicals were used with some modifications regarding the published methods: Pentylene tetrazole was administered (i.p.) into mice

using doses of (100 mg kg<sup>-1</sup>) (Banziger and Hane, 1967). Picrotoxin was administered (i.p.) in doses of (12 mg kg<sup>-1</sup>) (Bowser-Riley *et al.*, 1988). Strychnine was administered in dose of (15 mg kg<sup>-1</sup> i.p) (Bowser-Riley *et al.*, 1988). Following the injection of each convulsing drug, each mouse was placed under a large glass funnel (diameter 30 cm) and observed continuously for the onset of clonic convulsions in case of pentylene tetrazole and picrotoxin, time of death and the frequency of convulsions per 10 min starting from the time of onset of action. For strychnine the times of onset for the tonic convulsions and death were recorded.

### Induction of Vomiting

To examine the effect of the volatile oil on the vomiting process, pigeons (*Columba livia livia*) (body weight 250 g) were used. Vomiting was induced using a cardiac glycoside as described by (Hazlik, 1929) using ouabain, the water soluble cardiac glycoside, instead of digoxin. Aqueous ouabain was administered intravenously via a wing vein using a 22 gauge needle in doses of (100 µg kg<sup>-1</sup>). Each animal was then placed under a large glass funnel (diameter 30 cm) and observed continuously and via a video camera recording for the onset of down-head movement, flopping of wings and the expulsion of gravel. To investigate the influence of the volatile oil on ouabain-induced vomiting, the oil was administered (i.p.) into naïve animals and 10 min later ouabain was injected i.v. and the animals observed for the previously indicated parameters.

### Statistical Analysis

All values reported in this study are mean±SE mean with N = number of experiments performed. Significant differences between the control and different treatments were calculated using paired or unpaired t-test or analysis of variance (ANOVA) as appropriate. p-values of <0.05 were considered significant.

## RESULTS

### Volatile Oil Components

GC/MS study revealed the presence of eight components in the volatile oil of *Cymbopogon proximus*. Summary of the GC/MS analysis is shown in Table 1. The compounds were identified by comparison of their retention time and mass spectra by aid of the computer library search (CAS No. 5989-27-5, Entry 8747, LIB# 1). The obtained results were comparable with the data reported for the oil samples obtained from Burkina Faso with some quantitative differences (Menut *et al.*, 2000).

### The LD<sub>50</sub> (The Lethal Dose 50) in Mice and Rats

The oral and intraperitoneal doses of the volatile oil of *Cymbopogon proximus* in both male and female mice and rats are shown in Table 2. The clear symptoms that were observed before death in both types of animals were staggering, loss of righting reflex, loss of corneal reflex and respiratory depression. Following the death of the animals, the thoraxes were opened to check the status of the hearts, if the heart is still beating it can be concluded that the cause of death was respiratory

Table 1: Identified volatile constituents of *Cymbopogon proximus* determined by GC/MS

Peak No.	Compound name	RT	M+	Base peak	Relative (%)
1	α-Terpinene	13.07	136	93	4.64
2	Carene	16.19	136	43	1.77
3	Limonene	16.43	136	59	2.40
4	Piperitone	17.39	152	82	72.44
5	p-Menth-2-en-1-ol	17.83	154	124	0.49
6	Elenol	21.99	222	59	9.43
7	Bulnesol	23.20	222	189	2.11
8	Eudesmol	23.48	222	59	6.60

Table 2: The LD<sub>50</sub> values of the volatile oil of *Cymbopogon proximus* in male rats and mice

Type of Animal and Sex	LD <sub>50</sub> value (mL kg <sup>-1</sup> )		Absorption (%)
	Orally	Intraperitoneally	
Rat:			
Male	2.6	2.36	90.76
Female	2.4	2.15	89.58
Mice:			
Male	2.10	1.9	90.47
Female	2.25	1.89	84

Table 3: Effect of the volatile oil of *Cymbopogon proximus* on the arterial blood pressure and heart rate of rats

Volatile oil dose (μL kg <sup>-1</sup> ) (i.p.)	Decrease in blood pressure (mmHg)	% decrease in the (heart rate)
25	-	-
50	3.0±0.9	-
100	5.0±0.8	-
200	14.0±1.6*	3.0±2
400	20.8±1.2*	7.0±4
800	29.3±1.7*	10.0±6
1600	33.7±4.9*	15.9±1.3*

\*: p<0.05, N = 8

failure. The hearts were found beating suggesting that the cause of death was not due to cardiac arrest but most probably due to respiratory failure.

From Table 2, the oral and the intraperitoneal LD<sub>50</sub> values for both rats and mice seems to be comparable. Such similarity indicates almost complete absorption of the volatile oil when administered orally. The percentage absorption in male and female rats was 90.76 and 89.58, respectively and the corresponding values in mice were 90.47 and 84%, respectively (Table 2).

#### Effect on Arterial Blood Pressure

Intraperitoneal administration of the volatile oil into anaesthetized male Wistar rats produced dose-dependent decreases in the arterial blood pressure. Significant decreases were observed only following doses more than 200 μL kg<sup>-1</sup>. The cumulative results following treatment of rats with the volatile oil are shown in Table 3. Treatment of the anaesthetized animals with the volatile oil in doses of 25-1600 μL kg<sup>-1</sup> intraperitoneally induced small decreases in the heart rate. The induced bradycardia was significant only at the highest dose administered. The decreases in the blood pressure were not blocked by atropine (2 mg kg<sup>-1</sup> i.p) and mepyramine (5 mg kg<sup>-1</sup> i.p) but were significantly antagonized by indomethacin (25 mg kg<sup>-1</sup> i.p) (p<0.05, N = 8). The % antagonism was 85±3.4% for the decrease in the arterial blood pressure and 61.3±3.1 for the heart rate.

#### Effect of the Volatile Oil on the Electrocardiogram of Mice

Intraperitoneal administration of the volatile oil of *Cymbopogon proximus* in doses of 0.2 and 1.2 mL kg<sup>-1</sup> did not induce any observable changes in the ECG waves or segments. However all the doses tested induced variable changes in the heart rate.

#### Effect of the Volatile Oil on Electrically and Chemically-induced Convulsions in Mice

Application of an electric shock to mice ears with the following parameters: current 75 mA, frequency: 75 Hz, pulse width: 2 sec and duration 2 sec induced full extension of the lower limbs and death of the animals within 2 sec (Table 4) pre-treatment of the animals with the volatile oil in a fixed dose of 1.2 mL kg<sup>-1</sup> (i.p) for 10 min completely prevented the electrical shock-induced extension of the lower limbs and death (N = 12).

Intraperitoneal administration of pentylene tetrazole in a dose of 100 mg kg<sup>-1</sup> induced clonic convulsions after 1.1±0.05 min and death 17.4±1.6 min following administration of the drug. The frequency of convulsions was 11.3±1.7 per 10 min (N = 12) (Table 4). Pre-treatment of mice with the

Table 4: Effect of the volatile oil of *Cymbopogon proximus* (1.2mL kg<sup>-1</sup>) on the electrically-and chemically-induced convulsions in mice

Convulsing agent	Treatment	Time of onset of convulsions	Frequency of convulsions per 10 min	Time of death following administration
Electrical shock	None (control)	<1 sec	1	2 sec.
	Oil	None*	None*	None*
Pentylene tetrazole (100mg kg <sup>-1</sup> i.p)	None (control)	1.10±0.05 min	11.3±1.7	17.4±1.6 min
	Oil	20.4±1.3*	3.10±1.7*	2.60±0.5* h
Picrotoxin (12mg kg <sup>-1</sup> ) i.p.	None (control)	4.70±2.3 min	4.50±1.2	15.3±3.1 min
	Oil	30.7±1.9* (min)	1*	3.40±1.1* h
Strychnine(i.p) 1.5mg kg <sup>-1</sup>	None (control)	2.10±0.9 min	1	2.70±0.4 min
	Oil	7.30±1.6* (min)	1	31.0±1.9* min

\*: p<0.001, N = 12 compared with the corresponding Non-treated controls

oil in doses of 1.2 mL kg<sup>-1</sup> (i.p) for 10 min before administration of pentylene tetrazole significantly prolonged the above parameters (Table 4) except the frequency of convulsions which was decreased.

Administration of picrotoxin in a dose of 12 mg kg<sup>-1</sup> intraperitoneally induced clonic convulsions 4.7±2.3 minutes following administration of the drug and death 15.3±3.1 min following administration of the drug. The frequency of convulsions was 4.5±1.2 per 10 min (N = 12) (Table 4). Pretreatment of the mice with the volatile oil at doses of 1.2 mL kg<sup>-1</sup> intraperitoneally for 10 min before picrotoxin significantly prolonged the above parameters except the frequency and did not prevent death. The cumulative results are shown in Table 4.

Administration of strychnine 1.5 mg kg<sup>-1</sup> intraperitoneally into mice induced tonic convulsions following a delay of 2.1±0.9 minutes. The animals died 2.7±0.4 minutes after injection. The frequency of convulsions was 1 (N = 12) (Table 4). Pretreatment of the animals with the volatile oil at doses of 1.2 mL kg<sup>-1</sup> (i.p) significantly prolonged the above parameters except the frequency. The cumulative findings are shown in Table 4.

#### Effect of Vomiting in Pigeons

Intravenous administration of ouabain at a dose of 100 µg kg<sup>-1</sup> into the wing vein of pigeons *Columbia livia* resulted in a sequele of vomiting starting with wing flopping 6.5±1.1 min and expulsion of gravel (real vomiting) 7.3±0.8 min following administration. The frequency of vomiting was 3.5±1.3 episodes per 20 min. Intraperitoneal administration of the volatile oil in doses of 400 µL kg<sup>-1</sup> and 800 µL kg<sup>-1</sup> 10 min before ouabain significantly delayed the onset and completely protected, respectively the pigeons against ouabain-induced vomiting.

## DISCUSSION

The volatile oil yield from the whole plants of *Cymbopogon proximus* prepared by hydrodistillation method was 5.44% w/w. GC/MS analysis revealed that the oil contains only 8 components with piperitone forming 72.44% of the oil. Other minor components of the oil such as elemol and β-eudesmol are known constituents of the plant (Elgamal and Wolff, 1987). Analysis of the volatile oil sample from Burkina Faso showed that piperitone is the major component (55.6 %) while Sudanese sample was free from that component (Menut *et al.*, 2000; Siddiqui *et al.*, 1980). It is most likely that this difference is the result of miss identification of the Sudanese sample.

The results of the pharmacological study revealed that the intraperitoneal and oral LD<sub>50</sub> values of the volatile oil of *Cymbopogon proximus* were comparable in both male and female rats and mice. This suggests that the oil was very well absorbed. The extent of absorption following the administration via gavage ranged from 84-90%. The cause of death in the animals seemed to be a generalized central depression together with respiratory failure.

Administration of the volatile oil to anaesthetized rats induced decreases in the arterial blood pressure and the heart rate. The effects were not antagonized by the non-specific muscarinic receptor blocker atropine (Barnes, 1990) or by the antihistamine H<sub>1</sub> receptor blocker mepyramine (Niemegeers *et al.*, 1982). Thus, neither cholinergic muscarinic nor histaminergic mechanisms were involved in the observed cardiovascular depressant actions. However, pretreatment of the animals with indomethacin the non-selective COX enzyme inhibitor (Moncada and Vane, 1978), significantly blocked the observed effects. Thus, vasodilatory prostaglandins seemed to be involved in the induced hypotension and bradycardia. The most likely candidates are prostacyclin and PGE<sub>2</sub> (El Tahir and Ageel, 2002). The study did not deal in detail with regard to the component of the volatile oil that might have been involved in the induced hypotension and bradycardia.

The experiments performed using mice ECG recordings revealed the cardiac safety of the volatile oil and its components regarding direct effects on the cardiac muscles and conduction processes. However, they pointed to the slight bradycardiogenic effects of the volatile oil. The initial acute toxicity studies revealed the central nervous system depressant actions of the volatile oil. This directed the attention to investigate its effect against electrically and chemically induced seizures. The results clearly pointed to the inherent anticonvulsant effect of the volatile oil. The great effectiveness of the volatile oil against clonically-induced (via electric shocks, picrotoxin and pentylene tetrazole compared with the tonic convulsion induced by strychnine (Bowser-Riley *et al.*, 1988) suggest a potential role of the oil for treatment of petit-mal seizures. The antagonistic effect of the volatile oil may be due to suppression of release for action of some central stimulants such as glutamic and aspartic acids probably mediated via a prostaglandin releasing step.

The studies also revealed another central action for the volatile oil as revealed by its antagonism to ouabain-induced vomiting. Ouabain-induced vomiting is believed to involve dopamine release (Boireau *et al.*, 1998) thus, the anti-emetic effect of the volatile oil may have involved an inhibitory effect upon dopamine release at the site of the vomiting centre in the medulla.

In conclusion the results of this study clearly points to the potential of the volatile oil as a hypotensive, anticonvulsant and antiemetic agent.

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#### REFERENCES

- Bakheet, D.M., K.E.H. El Tahir, M.I. Al-Sayed, H.A. El-Obeid and K.A. Al-Rashood, 1999. Studies on the cardiovascular depressant effects of N-ethyl-and N-benzyl-1,2-di phenyl ethanolamines in the rat: Elucidation of the mechanisms of action. *Gen. Pharmacol.*, 33 (1): 17-22.
- Banziger, R. and D. Hane, 1967. Evaluation of a new convulsant for anticonvulsant screening. *Arch. Int. Pharmacodyn.*, 167 (2): 245-249.
- Barnes, P.J., 1990. Muscarinic receptors in airway, Recent development. *J. Applied Physiol.*, 68 (5): 1777-1785.
- Bassole, I.H.N., W.M. Guelbeogo, R. Nebie, C. Costantini, N. Sagnon, Z.I. Kabore and S.A. Traore, 2003. Ovicidal and larvicidal activity against *Aedes aegypti* and *Anopheles gambiae* complex mosquitoes of essential oils extracted from three spontaneous plants of Burkina Faso. *Parassitologia*, 45 (1): 23-26.
- Batanouny, K.H., S. Abou Tabl, M. Shabana and F. Soliman, 1999. Wild medicinal plants in Egypt. An inventory to support conservation and sustainable use. Academy of Scientific Research and Technology, Egypt International Union for Conservation (IUCN).

- Boireau, A., M. Meunier and A. Imperato, 1998. Ouabain-induced increase in dopamine release from mouse striatal slices is antagonized by riluzole. *J. Pharm-Pharmacol.*, 50 (11): 1293-1297.
- Boulos, L., 1983. Medicinal plants of North Africa. Reference Publication Inc., Michigan, pp: 92.
- Boulos, L., 1999. Flora of Egypt. Al Hadara Publishing, Cairo, Egypt, 1: 291-301.
- Bowser-Riley, F., S. Daniels and E.B. Smith, 1988. Investigation into the origin of the high pressure, neurological syndrome: The interaction between pressure, strychnine and 1, 2-propandiols in the mouse. *Br. J. Pharmacol.*, 94 (4): 1069-1076.
- Egyptian Pharmacopoeia (Eng. Text), 1984. Cairo University, Cairo, 3rd Edn., 429: 472-733.
- Elgamal, M.H. and P.A. Wolff, 1987. Further contribution to the sesquiterpenoid constituents of *Cymbopogon proximus*. *Planta Med.*, 53 (3): 293-294.
- El Tahir, K.E.H., M.A.S. El-Naser, A.M. Ageel, H.A. El-Obeid and K.A. Al-Rashood, 1991. The cardiovascular depressant effects of N-methyl and N-isobutyl-1, 2-diphenyl etanolamines: Elucidation of the mechanisms of action. *Arch. Int. Pharmacodyn. Ther.*, 309: 88-102.
- El Tahir, K.E.H., M.M.S. Ashour and M.M. Al-Harbi, 1993. The Cardiovascular actions of the volatile oil of the black seed (*Nigella sativa*) in rats: Elucidation of the mechanisms of action. *Gen. Pharmar.*, 24 (5): 1123-1131.
- El Tahir, K.E.H., H.A. Al-Khamees and S.M. Bayomi, 1995. Cardiovascular effects of some 2-substituted triazolo [1, 5- $\alpha$ ] pyrimidin-4 (4/4) one-6-carboxylic acid ethyl esters. *Boll. Chim. Farmaceutico.*, 134 (11): 604-608.
- El Tahir, K.E.H. and A.M. Ageel, 2002. Pharmacotherapeutic management of pain. *Saudi Pharm. J.*, 10 (3): 73-85.
- Ghosh, M.N., 1984. Fundamentals of Experimental Pharmacology. Scientific Book Agency, Calcutta, India, pp: 154.
- Hazlik, P.J., 1929. A new method for estimating the potency of digitalis: Pigeon emesis. *J. Pharmacol. Exp. Ther.*, 35: 363-391.
- Menut, C., J.M. Bessiere, D. Samate, A.K. Djibo, G. Buchbauer and B. Schopper, 2000. Aromatic plants of Tropical West Africa. XI. Chemical composition, antioxidant and antiradical properties of the essential oils of three *Cymbopogon* species from Burkina Faso, *J. Essential Oil Res.*, 12 (2): 207-212.
- Moncada, S. and J.R. Vane, 1978. Pharmacology and endogenous roles of prostaglandins endoperoxides, thromboxane A<sub>2</sub> and prostacyclin. *Pharmacol. Rev.*, 30 (3): 293-331.
- Niemegeers, C.J.E., F.H.L. Awouters and A.A.J. Janssen, 1982. The *in vivo* pharmacological profile of histamine H<sub>1</sub> antagonists in the rat. *Drug Dev. Res.*, 2: 559-566.
- Siddiqui, M.S., L.N. Misra, M.C. Nigam, I.M. Abu-AI-Futuh, 1980. Chemotaxonomy of *Cymbopogon*: Gas chromatographic examination of essential oil of *Cymbopogon proximus*. *Parfuemerie und Kosmetik*, 61 (11): 419-420.