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SOME PHARMACOLOGICAL ACTIVITIES OF ESSENTIAL OILS OF CERTAIN UMBELLIFEROUS FRUITS

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SUMMARY

Essential oils were prepared by hydrodistillation from the fruits of nine plants belonging to family Umbelliferae. These plants are: *Anethum graveolens* (dill), *Apium graveolens* (celery), *Carum carvi* (caraway), *Carum copticum* (ajowan), *Coriandrum sativum* (coriander),*Cuminum cyminum* (cumin), *Foeniculum vulgare* (fennel), *Petroselinum sativum* (parsley) and *Pimpinella anisum* (anise). The percentage yield, specific gravity and refractive index of each oil were determined. Pharmacological study and LD_{50} values of these oils were also carried out.

The essential oil of coriander evoked a marked analgesic activity in mice, while dill and anise oils have significant antipyretic activities post-administration in rats. Oils of coriander, celery, parsley and cumin induced significant anti-inflammatory activities 2, 3 and 5 hours post-administration in rats. Parsley oil exhibited a powerful antibacterial activity against all the tested bacteria except *Salmonella typhimurium*. While cumin oil produced a marked antifungal activity against all selected strains of fungi.

INTRODUCTION

Most umbelliferous plants are popularly used as spices and condiments e.g. coriander, cumin, dill, celery, parsley and ajowan. They are also recommended as flavors in food and beverages e.g. fennel, anise and caraway. They are reported to be used as aromatic, stimulant, antispasmodic, sedative, galactagogue, calmative and digestive drugs (Chopra et al., 1956 and Boulos, 1983). Coriander is used as aphrodisiac and in confectionery. Caraway and coriander are utilized as rubefacient, anti-inflammatory and antirheumatic. Caraway is also used as a lactagogue (Chopra et al., 1956). Ajowan is used in diarrhea, colic, flatulence and for treatment of cholera. Celery is recommended as diuretic, diaphoretic, nerve calmative and for treatment of bronchitis, asthma as well as for liver and spleen diseases (Chopra et al., 1956). Cumin is prescribed for treatment of dyspepsia, diarrhea and in snake bites. While anise is used for treatment of flatulence, colic and as diuretic. Dill is also used as diuretic and its infusion is calmative for stomach pains and its decoction as antipoison (Boulos, 1983). Fennel is used as stomachic, expectorant, aphrodisiac and appetizer. Parsley is utilized as diuretic and its decoction is used in the morning as anthelmintic (Boulos, 1983).

The petroleum ether and chloroformic extracts of ajowan showed a moderate spasmolytic action on the isolated rabbit's intestine (Haggag, 1971). The diuretic activity of the ethanolic extract and volatile oil of dill was carried out on dogs (Thabet, 1990). It showed that the urine flow was increased in doses which produced no effect or slight drop of blood pressure. Aqueous extracts of celery showed a significant anti-inflammatory activity

(Lewis et al., 1985).

The aim of this work is to determine the safety of the essential oils of the previously mentioned umbelliferous fruits and also to study their other possible pharmacological effects.

MATERIAL AND METHODS

Plant Material:

The dried ripe fruits of *Anethum graveolens* L., *Apium graveolens* L., *Carum carvi* L., *Coriandrum sativum* L., *Foeniculum vulgare* Mill., *Petroselinum sativum* Hoffm. and *Pimpinella anisum* L. were obtained - in June 1992- from plants cultivated in the Experimental Station of Medicinal Plants (ESMP), Department of Pharmacognosy, Faculty of Pharmacy, Cairo University at Giza. While the fruits of *Carum copticum* L. and *Cuminum cyminum* L. were obtained from the local market. in June 1992. Their identity was kindly confirmed by Prof. F.M. Soliman, Department of Pharmacognosy, Faculty of Pharmacy, Cairo University.

Preparation of the essential oils:

The oils were prepared by hydrodistillation (Egyptian Pharmacopoeia, 1984) of the dry fruits. The volatile distillate in each case was dried and submitted for investigation. Their percentage yields, refractive indices and specific gravities were determined.

Biological screening:

In all pharmacodynamic assays a 9:1 emulsion of each essential oil with Tween 80 (10 %) was administered. The tested dose was set based on 1/20 of the calculated LD_{50} for each essential oil.

A- Acute Toxicity:

1. Determination of Median Lethal Dose (LD_{50}):

The LD_{50} of the essential oils were determined in mice using the procedure described by Kerber (1941).

B- Pharmacological effects:

1- Analgesic effect:

This experiment was carried out as described by Okun et al., (1963). Fifty five mice of both sexes weighing from 20-25 g, were divided into 11 groups of 5 mice each. The first group served as a control. Group 2 was orally administered acetylsalicylic acid (ASA) (Aspirin® Bayer Co., Germany) in a dose of 50 mg/kg b.wt., active ASA and served as a standard. The other nine groups were orally administered essential oil emulsion of each of coriander, caraway, fennel, dill, celery, anise, parsley, cumin and ajowan oils in a dose of 37.5, 41.25, 26.25, 18.75, 33.75, 28.75, 21.25, 21.75 and 28.75 mg/kg b. wt., respectively. After 30 min, each mouse was intraperitoneally injected with 0.25 ml of a suspension of 0.2 mg/ml of p-benzoquinone in water. Meanwhile, mice were observed for writhing at 1, 2, 3 and 5 hours post-administration. Animals devoid of writhing in each group were recorded and the analgesic potency of the tested essential oils were determined as % protection against writhing.

2- Antipyretic effect:

Fifty five mature albino rats of either sexes weighing 180-200 g were divided into eleven groups and are made hyperthermic by subcutaneous injection of 12 % yeast suspension (1 ml/kg b.wt.) as described by Teotine *et al.* (1963). After 15 hours, the temperature of each rat was recorded. The first group was left as a control while the second group was orally administered ASA in a dose of 50 mg/kg b.wt. and left as a standard. The other nine groups were orally administered essential oil emulsion of each of coriander, caraway, fennel, dill, celery, anise, parsley, cumin and ajowan in a dose of 37.5, 41.25, 26.25, 18.75, 33.75, 28.75, 21.25, 21.75 and 28.75 mg/kg b.wt., respectively. The rectal temperature of each rat was then recorded at 1, 1.5, 2.5 and 3.5 hours post-injection.

3. Anti-inflammatory effect:

The method of Domenjoz et al. (1955) which depends on induction of pedal inflammation in the rat paw, was adopted. Fifty five mature rats of either sexes (225-250 g b.wt.) were divided into eleven groups, 5 animals each. In all rats, pedal inflammation was induced by subcutaneous injection of formalin (0.05 ml, 4 %) in the right paw. At the beginning of the experiment the thickness of the left paw was measured in mm. Thereafter, the first group was kept as a non-treated control. While the second group was orally administered phenylbutazone (oxyzone®, El-Nile Co., Egypt) in a dose of 15 mg/kg b.wt. The other nine groups were orally administered the essential oil emulsions at the same doses as described in the antipyretic effect. At 1, 2, 3 and 5 hours post-administration of the tested oils, the thickness of paws in all groups was measured using skin caliber. The mean response (increase in the paw thickness after pedal inflammation) for each group was calculated.

4. Antimicrobial effect:

The antimicrobial activity of the tested essential oils was studied *in vitro*, against two Gram positive bacteria (*Staphylococcus aureus* and *Streptococcus pyogen*), 4 Gram negative bacteria (*Escherichia coli*, *Salmonella typhimurium*, *Pseudomonas aeruginosa* and *Proteus mirabilis*) and 4 fungi (*Penicillium notatum, Aspergillus niger, Aspergillus fumigatus* and *Microsporum canis*). These microbial strains were obtained from the Microbiology Department, Faculty of Veterinary Medicine, Cairo University. Different concentrations of each oil (0.1, 0.5, 1.0, 10, 20, 40, 80, 100 and 200 mg/ml) were prepared in 10 % aqueous solution of Tween 80 as a vehicle. The bore method described by Cooper and Woodman (1946) was used for determining the antimicrobial activity, while the agar plate dilution technique as described by Robell and Lamb (1953) was adopted for antifungal activity. The plates containing different concentrations of the tested oil with either bacterial or fungal strains were incubated at 37°C for 24 hours with bacterial strains or at 27°C for 7 days with moulds. The effect was determined by measuring the inhibition zones in mm for each concentration after the respective incubation periods.

Statistical analysis:

Data were statistically analyzed by Student's "t" test and Analysis of Variance (L.S.D) using computerized program of SAS (Cary, 1982) for means. The data of Protection % against writhing for analgesic activity are transformed according to Arcosine or Angular transformation (Steel and Torrie, 1980).

RESULTS AND DISCUSSION

The percentage yields of the essential oils of ajowan, anise, caraway, celery, coriander, cumin, dill, fennel and parsley were 0.98, 1.12, 1.62, 0.48, 0.29, 5.09, 1.59, 0.98 and 0.83 % respectively (Table 1). The specific gravity and refractive index of each oil were also determined (Table 1). These data are significant criteria for the identity and purity of these oils.

The results showed that the LD_{50} of essential oils of coriander, caraway, fennel, dill, celery, anise, parsley, cumin and ajowan in mice when given orally were 750, 825, 525, 375, 675, 575, 425, 435 and 575 mg/kg b.wt. respectively. The main symptoms of toxicity were characterized by colic pain, marked depression, shallow and slow respiration which ends with death. Thus, these essential oils are safe and non- toxic. (Buck elal. 1976).

From Table 2, oral administration of coriander oil to mice induced a higher protection percentage against writhing. While other oils produced a lower protection after their administration. ASA in a dose of 50 mg/kg produced a marked analgesic activity as recorded in Table 2. Thus, the fruits of coriander and their essential oil are recommended as analgesic drug to relief pain. This result explains its use as sedative in folk medicine.

From Table 3, it was found that the essential oils of dill and anise have a significant antipyretic effect when given orally to rats in doses of 18.75 and 28.75 mg/kg b.wt, after (1, 1.5 and 2.5 hrs) and (1 and 1.5 hrs) of their administration, respectively. ASA induced a marked antipyretic effect in a dose of 50 mg/kg after 1, 1.5, 2.5 and 3.5 hours post-treatment. The small doses of essential oils

Table 1: Percentages yields, specific gravities and refractive indices of the umbelliferous essential oils

Essential oil	Percentage*	Specific gravity**	Refractive index**
Coriander	0.29	0.8899	1.46134
Caraway	1.62	0.8881	1.48347
Fennel	0.98	0.9791	1.53527
Dill	1.59	0.9699	1.49537
Celery	0.48	1.0005	1.49535
Anise	1.12	1.0043	1.55323
Parsley	0.83	0.9384	1.50130
Cumin	5.09	0.9263	1.50232
Ajowan	0.98	0.9227	1.48636

* Average of three determinations.
** Average of four determinations.

Table 2 : Analgesic activity of essential oils and Acetylsalicylic acid (ASA) in mature mice.

Groups	Dose (mg/kg b.wt)	Protection % against writhing after 1 hr	2 hrs	3 hrs	5 hrs	Mean
Control	---	0	0	0	0	0
ASA	50.00	100 [90.00]	100 [90.00]	100 [90.00]	80 [63.44]	(a) 87.11
Coriander	37.50	80 [63.44]	90 [90.00]	100 [90.00]	80 [63.44]	(ab) 79.22
Caraway	11.25	0 [5.00]	20 [26.56]	80 [63.44]	40 [39.23]	(b) 33.56
Fennel	26.25	60 [50.77]	60 [50.77]	60 [50.77]	20 [26.56]	(cd) 44.72
Dill	16.75	40 [39.23]	60 [50.77]	60 [50.77]	40 [39.23]	(cd) 45.00
Celery	33.75	80 [63.44]	60 [50.77]	60 [50.77]	40 [39.23]	(cd) 51.85
Anise	29.75	80 [63.44]	60 [50.77]	60 [50.77]	40 [39.23]	(cd) 51.85
Parsley	21.25	60 [50.77]	60 [50.77]	80 [63.44]	60 [50.77]	(cd) 53.94
Cumin	21.75	20 [26.56]	60 [50.77]	80 [63.44]	60 [50.77]	(cd) 47.89
Ajowan	29.75	100 [90.00]	60 [50.77]	60 [50.77]	40 [39.23]	(bc) 58.94

(a, b, c, d) means with the same letter are not significantly different at ($P < 0.01$).
LSD = 20.524
Mean-Square for protection % = 577.47
Mean-Square for types of oil = 1058.23**
[ ] Data are transformed according to arcsine or angular tranformation.

Table 3 : Antipyretic effect of essential oils in hyperthermic rats using acetylsalicylic acid as a standard (n=5).

Groups	Dose (mg/kg b wt)	Mean rectal temperature (C°)					Mean
		before	after				
			1 hr	1.5 hrs	2.5 hrs	3.5 hrs	
Control	---	38.00 ± 0.07	38.00 ± 0.11	37.90 ± 0.11	37.80 ± 0.11	37.62 ± 0.11	(a) 37.864
Acetylsalicylic acid	50.00	38.00 ± 0.10	37.16 ± 0.05 ***	37.08 ± 0.04 ***	37.10 ± 0.03 ***	37.14 ± 0.05 ***	(ab) 37.296
Coriander	37.50	37.94 ± 0.15	37.84 ± 0.15	37.72 ± 0.13	37.58 ± 0.12	37.46 ± 0.07	(a) 37.708
Caraway	41.25	37.96 ± 0.16	37.98 ± 0.16	37.90 ± 0.15	37.96 ± 0.18	37.78 ± 0.14	(a) 37.929
Fennel	26.25	38.08 ± 0.23	37.68 ± 0.23	37.78 ± 0.23	37.92 ± 0.25	37.94 ± 0.23	(a) 37.860
Dill	18.75	37.98 ± 0.14	36.72 ± 0.13 ***	36.98 ± 0.18 ***	37.16 ± 0.17 **	37.30 ± 0.21	(ab) 37.228
Celery	33.75	38.10 ± 0.18	37.96 ± 0.16	37.82 ± 0.12	37.90 ± 0.10	37.54 ± 0.10	(a) 37.864
Anise	28.75	37.88 ± 0.21	37.10 ± 0.16 ***	37.26 ± 0.16 **	37.40 ± 0.15	37.50 ± 0.18	(ab) 37.428
Parsley	21.25	38.14 ± 0.11	36.06 ± 0.09	37.94 ± 0.11	37.80 ± 0.13	37.68 ± 0.13	(b) 35.924
Cumin	21.75	38.02 ± 0.15	37.58 ± 0.13	37.84 ± 0.13	37.74 ± 0.14	37.66 ± 0.12	(a) 37.848
Ajowan	28.75	37.98 ± 0.17	37.56 ± 0.15	37.86 ± 0.15	37.82 ± 0.14	37.70 ± 0.14	(a) 37.864

*** Significant at (P < 0.005)
** Significant at (P < 0.01)
(a,b) means with the same letter are not siginficantly different at (P < 0.01)
LSD = 1.7219
Mean-Square for rectal temperature = 2.448 at F value = 1.35
Mean-Square for types of oil = 1.742 at F value = 0.96

Table 4 : Anti-inflammatory activity of essential oils and phenylbutazone in mature rats (n=5).

Groups	Dose (mg/kg b wt)	Mean increasen thickness of paw in mm after				Mean
		1 hr	2 hrs	3 hrs	5 hrs	
Control	---	4.06 ± 0.11	4.56 ± 0.06	5.01 ± 0.03	5.32 ± 0.04	(a) 4.995
Phenylbutazone	15	3.63 ± 0.13 *	3.42 ± 0.05 ***	3.90 ± 0.15 ***	3.64 ± 0.09 ***	(f) 3.648
Coriander	37.5	4.06 ± 0.21	3.98 ± 0.30 **	4.23 ± 0.21 ***	4.08 ± 0.24 ***	(de) 4.090
Caraway	41.25	3.96 ± 0.21	5.08 ± 0.33	4.36 ± 0.11 ***	4.30 ± 0.11 ***	(cd) 4.430
Fennel	26.25	4.14 ± 0.14	4.50 ± 0.38	4.42 ± 0.37 **	4.28 ± 3.6	(cde) 4.335
Dill	18.75	4.36 ± 0.08	4.66 ± 0.27	5.20 ± 0.19	5.14 ± 0.09	(ab) 4.860
Celery	33.75	4.22 ± 0.09	4.10 ± 0.13 ***	4.78 ± 0.20 ***	4.58 ± 0.15 ***	(bcd) 4.490
Anise	28.75	4.10 ± 0.18	4.84 ± 0.21	4.68 ± 0.04 ***	4.68 ± 0.04 ***	(bc) 4.520
Parsley	21.25	4.06 ± 0.06	4.32 ± 0.06 ***	5.12 ± 0.05 ***	4.84 ± 0.03 ***	(abc) 4.590
Cumin	21.75	3.98 ± 0.29	3.88 ± 0.17 ***	4.06 ± 0.25 ***	3.84 ± 0.21 ***	(ef) 3.940
Ajowan	28.75	4.28 ± 0.09	5.02 ± 0.68	4.46 ± 0.14 ***	4.22 ± 0.15 ***	(bcd) 4.495

*** Significant at (P < 0.005)
** Significant at (P < 0.01)
* Significant at (P < 0.05)
(a, b, c, d e, f) means with the same letter are not significantly different at (P < 0.01)
LSD = 0.4206
Mean-Square for mean swelling = 0.5753 at F value (0.78)
Mean-Square for types of oil = 0.6163 at F value (7.26)

Table 5: Antibacterial activity of different concentrations of essential oils .

Strains of bacteria	Concentrations of oil (mg/ml)	Diameter of inhibition zones in mm (mean ± S.E.)								
		Coriander	Caraway	Fennel	Dill	Celery	Anise	Parsley	Cumin	Ajowan
Escherichia coli	10	0	0	0	0	0	0	13.20±0.37	0	0
	20	15.20±0.58	0	0	0	13.20±0.58	0	13.40±0.40	0	0
	40	18.00±0.55	12.00±0.45	0	0	15.20±0.58	0	14.20±0.37	0	0
	80	20.60±0.40	15.00±0.45	0	14.60±0.25	16.20±0.20	0	16.20±0.20	0	0
	100	23.40±0.75	17.20±0.37	0	19.00±0.89	17.40±0.25	0	16.60±0.25	0	11.60±0.60
	200	23.80±0.74	18.80±0.37	0	20.40±0.25	19.30±0.94	0	19.00±0.32	0	17.00±0.32
Salmonella typhimurium	1	0	0	14.20±0.58	0	0	0	0	0	0
	10	0	0	18.20±0.37	0	0	0	0	0	0
	20	12.60±0.25	12.20±0.37	19.40±0.25	0	13.00±0.32	0	0	0	0
	40	14.40±1.96	14.20±0.37	21.20±0.37	0	15.00±0.55	0	0	0	0
	80	17.80±0.58	15.60±0.20	22.80±0.20	13.80±0.37	15.80±0.37	0	0	0	0
	100	19.60±0.51	17.00±0.32	24.20±0.37	17.40±0.60	16.80±0.37	0	10.20 ± 0.20	0	0
	200	23.00±0.89	19.00±0.32	25.60±0.51	26.80±1.39	19.60±1.29	0	14.40 ± 0.40	0	0
Pseudomonas aeruginosa	10	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	13.20±0.37	0	0
	40	0	11.20±0.20	10.40±0.25	11.40±0.25	0	0	14.20±0.20	0	0
	80	12.80±0.37	11.80±0.20	10.80±0.20	13.00±0.32	0	0	16.80±0.37	0	0
	100	15.80±0.37	13.00±0.32	12.00±0.32	13.90±0.33	0	0	19.70±0.49	0	13.20±0.49
	200	19.20±0.58	15.00±0.32	13.90±0.33	16.00±0.32	0	11.80±0.37	21.50±0.22	12.20±0.20	14.90±0.33
Proteus mirabilis	10	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	0	0
	40	0	0	0	0	0	0	10.20±0.20	0	0
	80	0	0	0	0	0	0	11.20±0.20	0	0
	100	13.00±0.71	0	0	10.60±0.25	0	0	12.30±0.20	0	0
	200	15.20±0.37	0	0	13.00±0.32	0	0	14.00±0.32	10.20±0.20	0
Staphylococcus aureus	10	0	0	0	0	0	0	14.80±0.66	0	0
	20	13.20±0.37	0	0	0	14.00±0.32	0	16.40±0.25	14.00±0.32	0
	40	14.40±0.40	0	0	0	18.40±0.40	0	18.20±0.37	17.60±1.29	0
	80	16.80±0.58	0	0	14.60±0.40	19.40±0.25	0	16.80±0.25	18.20±0.37	0
	100	22.20±0.74	0	0	17.40±0.25	20.60±0.40	0	19.20±0.58	19.00±0.32	0
	200	23.20±0.58	0	0	20.20±0.37	22.00±0.95	0	20.20±0.58	21.60±0.40	0
Streptococcus pyogens	0.5	0	0	13.80±0.97	0	0	0	0	0	0
	1	0	0	15.40±0.81	0	0	0	0	0	0
	10	0	0	17.80±1.72	0	0	0	15.40±0.40	0	0
	20	0	0	18.60±0.51	0	13.00±0.45	0	15.60±0.40	0	0
	40	0	0	22.80±0.86	0	15.20±0.49	0	16.40±1.21	0	0
	80	0	13.20±0.58	24.40±0.81	12.60±0.25	16.60±0.40	0	17.00±0.45	12.40±0.25	0
	100	0	16.60±0.80	26.20±0.49	15.40±1.21	18.40±0.68	0	17.80±0.58	14.40±0.40	0
	200	0	16.80±0.58	28.60±0.51	19.40±0.25	18.80±0.37	0	19.00±0.32	18.00±0.32	0

0 = Not Detectable.

Table 6: Antifungal activity of different concentrations of essential oils.

Strains of fungus	Concentrations of oil (mg/ml)	Diameter of inhibition zones in mm (mean ± S.E.)								
		Coriander	Caraway	Fennel	Dill	Celery	Anise	Parsley	Cumin	Ajowan
Penicillium notatum	10	0	0	0	0	0	0	0	13.00±0.71	0
	20	0	0	0	0	10.80±0.20	0	0	18.20±1.07	0
	40	0	0	0	0	12.60±0.51	0	9.80±0.20	24.60±0.93	0
	80	0	0	0	0	17.00±0.32	11.40±0.25	11.20±0.20	29.20±0.37	0
	100	0	0	0	0	18.00±0.32	12.40±0.25	12.40±0.25	35.00±0.71	0
	200	0	15.80±0.80	0	11.40±0.51	27.20±0.37	15.20±0.37	13.40±0.40	43.20±1.07	0
Aspergillus niger	10	0	0	0	0	0	0	0	11.40±0.51	0
	20	0	0	0	0	0	0	13.60±0.51	13.60±0.40	0
	40	0	0	0	0	10.80±0.20	0	16.60±0.37	18.40±0.51	0
	80	0	0	0	0	11.20±0.20	0	20.40±0.40	24.20±0.58	0
	100	0	0	0	0	12.10±0.10	0	23.60±0.32	29.40±0.51	0
	200	0	0	20.80±0.37	18.80±0.37	13.40±0.25	11.60±0.25	27.60±0.68	39.60±0.51	0
Aspergillus fumigatus	10	0	0	0	0	0	0	0	0	0
	20	0	0	0	0	0	0	0	12.00±0.32	0
	40	0	0	0	0	11.60±0.25	0	14.40±0.51	16.40±0.51	0
	80	0	0	0	0	13.60±0.25	0	18.80±0.20	20.60±0.51	0
	100	0	0	17.40±0.51	0	13.60±0.25	11.40±0.25	20.00±0.32	28.60±0.30	0
	200	0	0	29.60±0.51	18.80±0.37	11.80±0.20	13.20±0.20	23.40±0.51	37.20±0.58	0
Microsporum canis	10	0	0	0	0	0	0	0	13.20±0.58	0
	20	0	0	0	0	14.60±0.51	0	0	17.40±0.51	0
	40	0	0	0	0	16.60±0.40	0	12.80±0.58	23.80±0.73	0
	80	0	0	0	0	19.80±0.25	0	13.20±0.37	30.20±0.66	0
	100	0	0	0	0	20.00±0.32	11.00±0.32	13.80±0.37	34.60±0.40	0
	200	0	0	15.00±0.45	16.80±0.37	21.00±0.32	12.80±0.49	16.80±0.58	41.20±0.49	0

0 = Not Detectable

of dill and anise which produce a significant antipyretic effect relative to that of ASA favour their use for this purpose.

Oral administration of essential oils of coriander, celery, parsley and cumin to rats induced a significant anti-inflammatory effect at 2, 3 and 5 hours post-administration. Also the essential oils of caraway, anise and ajowan induced a significant anti-inflammatory effect at 3 and 5 hours post-administration. While essential oil of fennel produced a significant effect at only 3 hours post-administration (Table 4). Phenylbutazone in a dose 15 mg/kg b.wt. induced a significant anti-inflammatory effect as it reduced the thickness of inflamed paw at 1, 2, 3 and 5 hours post-administration. The effect was comparable to that induced by standard phenylbutazone (15 mg/kg). This anti-inflammatory effect may be due to the presence of terpenoid constituents in the essential oils. Similar findings were reported for the use of celery extracts, in folk medicine, for treatment of rheumatic pains (Tutin 1968; Usher 1974 and Leung 1980). Moreover, Lorenete *et al.* (1989) reported that the essential oil of *Bupleurum fruticosum* (Umbelliferae) showed a potent anti-inflammatory activity which can be in part attributed to the two major components, α- and β-pinenes. Although the presence of thymol and carvacrol, as minor components potentiated the action of these hydrocarbons. In conclusion, all the tested essential oils except those of dill and fennel showed a good antiinflammatory activity. Thus, they can be utilized for treatment of rheumatic inflammations.

From Table 5, it was found that the essential oils of parsley, coriander, celery and caraway inhibited the growth of *E. coli*, while fennel, coriander, caraway and celery essential oils are active against *S. typhimurium*. The essential oil of parsley showed appreciable activity against *P. aeruginosa* and *P. mirabilis*, while parsley, celery, coriander and cumin oils showed an inhibitory activity against *S. aureus*. Moreover, fennel, parsley and celery essential oils showed some reduction of the growth rate of *S. pyogen*. Whereas, the essential oils of anise and ajowan had no observable effect on the activity of all investigated bacteria. The oil of parsley is thus, the drug of choice for treatment of infections caused by *E. coli* and *S. aureus*. While the oil of fennel is recommended for infections caused by *S. typhimurium* and *S. pyogen*.

From Table 6, it is concluded that the essential oil of cumin exhibited a powerful antifungal activity against all selected strains of fungi. This explains its use in folk medicine as antidiarrheal drug. The essential oils of celery and parsley produced a moderate antifungal activity. While the other oils showed no antifungal activity against all selected strains of fungi. Oil of cumin can be utilized for treatment of dermatophytosis as well as other infections caused by the tested fungi.

In conclusion, our results demonstrate that essential oils of (coriander); (dill and anise) and (coriander, celery, parsley and cumin) can be recommended for successful treatment of pains, fever and inflammation, respectively. In addition, parsley and cumin oils could therapeutically be used for the treatment of various infections caused by selected bacteria and fungi, respectively.

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