ANTI-ULCERATIVE COLITIS ACTIVITY OF EXTRACTS AND VOLATILE OILS FROM THREE *OCIMUM* SPECIES

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The current study was designed to explore the potential of three *Ocimum* species; *Ocimum americanum*, *Ocimum basilicum* and *Ocimum basilicum* var. *thyrsiflora*, Family Lamiaceae as anti-ulcerative colitis agents. Both Alcohol and total phenolic extracts (200 and 400 mg/kg) in addition to volatile oil (50 mg/kg) of each evaluated plant were administrated orally to colitis rats (4% acetic acid) for 5 consecutive days. Different anti-ulcerative colitis potentials were observed for the explored extracts in a dose dependent manner. All investigated alcohol and total phenolic extracts at dose 400 mg/kg produced similar activity as dexamethasone (0.1 mg/kg), the standard drug. For *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* the percent protection from control colitis were 65.92, 67.2 and 66.51%, respectively for alcohol extracts and 58.20, 60.11 and 59.15%, respectively for total phenolic extracts, while it was 71.54% for dexamethasone. Volatile oils unlikely exhibit little capacities (5.95, 6.90 and 6.27%). The current results proposed that the investigated extracts well inhibited lipid peroxidation induced by acetic acid and provide defensive effects against UC, through significant decline in the raised colonic malondialdehyde (MDA) content ranged from 42.49 to 47.05% change of control colitis. In addition to a significant reduction in the elevated level of plasma TNF-alpha that could explain the anti-ulcerative colitis potentials of these extracts. The total alcohol

extracts of the three species were found harmless up to 4000 mg/kg and showed no side effects on both functions of liver and kidney after oral administrated (400 mg/kg) for 14 successive days.

Keywords: *Ocimum americanum*, *Ocimum basilicum*, *Ocimum basilicum* var. *thyrsiflora*, TNF-α, phenolic, volatile oils

INTRODUCTION

Ulcerative colitis (UC) is considered as one of the known chronic types of inflammatory bowel disease that mainly alters the colonic mucosa and sub-mucosa and described by signs of bloody diarrhea, abdominal cramps and fatigue (Feagan et al., 2013). The exact cause of UC remains to be elucidated. There are several hypotheses regarding the pathogenesis of UC over the past decade. One of the hypotheses proposed that the syndrome obtained due to the decontrolled intestinal immune response motivated by many unknown environmental factors (including luminal or microbial antigens) interaction between the patient genotype and intraluminal micro-biota or possibly extra lethal pathogens (De Souza and Fiocchi, 2016). Healing of UC is subsequent and designed according to the patient deprived of the occurrence of a single generally potent medication.

The therapy achievement of UC relies on the development of each stage. In mild-to-moderate cases, oral treatment with 5-aminosalicylic acid medication is recommended, followed by a course of corticosteroids if there is no response. Patients who used corticosteroids must be changed to azathioprine/6-mercaptopurine with following regular reducing of corticosteroids. Furthermore, antitumor necrosis factor-alpha Antibodies; Infliximab, ADA or golimumab can be given to the cases who showed no healing after using the normal therapy with corticosteroids in addition to AZA/6-mercaptopurine (Blonski et al., 2014).

Family Lamiaceae is well known as the richest essential oil-contain plant families. It includes 259 genera and 7000 species. Essential oils redeemed from this family have been used as a remedy for different types of diseases such as intestinal syndrome and bronchitis (Pandey et al., 2014). The *Ocimum* genus, comprising 150 species grows widely and scattered in both tropical and subtropical areas of Africa, Asia and Central and South America (Soumen et al., 2013).

Ocimum basilicum (*O. basilicum*) or holy basil, *Ocimum americanum* (*O. americanum*) or lime, hairy, hoary basil and *Ocimum basilicum* var. *thyrsiflora* (*O. basilicum var. thyrsiflora*) or Thai sweet basil (Pandey et al., 2014). Volatile oils extracted from *Ocimum* were commonly known as natural flavoring agents of profitable significance. The explored *Ocimum* plants are recognized for their wide biological potentials (Gülçin et al., 2007 and Sishu et al., 2010).

New treatment options might offer viable approaches for patients with UC. Special interest has been focused on herbal-based products. So, the goal of the current study is an evaluation of three *Ocimum* species as anti-ulcerative colitis agents.

MATERIALS AND METHODS

1. Phytochemical Studies

1.1. Plant material

Fresh aerial parts of each investigated plant; *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* were collected (2017) in its flowering period, from Delta region, Egypt. The plant samples were identified by Taxonomist (Dr. Jacob Thomas, King Saud University, College of Science) and compared with previously reported data for the plant's descriptions (Boulos, 2000). The plant sample was divided into two parts each of 1.5 kg. The first part was dried in shade aerated place, grinded to powder and stored in dark bottles. The second part was freshly collected in the flowering stage then freezed at -20ºC to be used for essential oil extraction. Both parts were kept for further investigations.

1.2. Phytochemical screening

Dried aerial parts sampling obtained from the selected plants were exposed to phytochemical examination for investigating their different constituents (Khan et al., 2011 and Awaad et al., 2018).

1.3. Extraction and fractionations

Each investigated plant powder (500 g) was extracted separately using percolation method in ethanol 95% at room temperature (Awaad et al., 2018). The obtained ethanol extracts were then filtered off individually and re-extracted four times. Solvent was evaporated under reduced pressure at a temperature less than 25°C. The obtained residues were symbolized as alcohol extracts.

1.4. Preparation of essential oil

For essential oil preparation, fresh leaves of the investigated plants (1000 g each) were exposed separately to hydro-distillation for 9 hours. The obtained oils were dried from its excess water through passing over anhydrous sodium sulphate and quantitatively calculated (Moghaddam et al., 2011). Volatile oils were extracted, subsequently the water left was then exposed to extraction using butanol saturated with water (500 ml X 4 times) to extract the leftover constituent (phenolic compounds) and concentrated using low pressure and a temperature below 35°C to get total phenolic extract.

Alcohol extracts, total phenolic extracts and volatile oil of the investigated plants were stored in the freezer (-10ºC) for further pharmacological investigations.

1.5. Estimation of some total phytochemical contents

Quantitative analysis of phenols, flavonoids and tannins were carried out as published (Bhumi and Savithramma, 2014).

2. Pharmacological Studies

2.1. Animals

Male and female mice (Swiss albino 25-32 g) in addition to male rats (Wister 150-175 g) were kept at lab under standard environmental conditions in standard polypropylene cages and sustained for one week before experimentation.

2.2. Acute toxicity (LD_{50}) test

Investigated alcohol extracts (up to 4000 mg/kg) were separately evaluated for their toxicity by determination of LD_{50} (oral median lethal dose) (El-Meligy et al., 2017).

2.3. Sub-chronic toxicity

Wister rats were grouped in ten and put in four cages each. Group one (normal control) administered the vehicle (5 ml/kg) only. Animals from group two to group four were orally administrated the total alcohol extracts of *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* (400 mg/kg each) daily for 14 repeated days. Sera were collected to be used for further biochemical examination (Soliman et al., 2012).

2.4. Anti-ulcerative colitis activity

For this purpose, 12 experimental groups, each contains six Male rats. Animals of both group one (normal control) and group two (control colitis) administrated 5 ml/kg of vehicle, group three (reference group) administrated 0.1 mg/kg of standard dexamethasone. Animals of groups four to twelve were given alcohol extracts, total phenolic extracts (400 and 200 mg/kg) and volatile oils (50 mg/kg) of *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora*. All medicines were given orally, once daily for 5 continuous days, the first dose was given 2 h after induction of colitis by 2 ml (4% v/v) acetic acid (El-Meligy et al., 2015).

2.5. Estimation of possible mechanisms of action

2.5.1. Effect on colonic thiobarbituric acid reactive substance (malondialdehyde) content.

At the end of experiments, Colonic segments were eliminated, homogenized and centrifuged; the clear supernatant was used for assessment of and malondialdehyde contents using a kit from Sigma-Aldrich Chemicals, St. Louis, MO.

2.5.2. Effect on plasma TNF-alpha

Heparinized blood samples were collected at the end of the experiments and then deproteinized using metaphosphoric acid, the clear supernatant was used for assessment of TNF-alpha (Tumor Necrosis Factor-alpha) (ELISA kit purchased from Ray Biotech, Inc., Norcross, GA).

3. Statistical Analysis

Data were collected and statistically analyzed using SPSS, version 14 (SPSS, Chicago, IL). The following tests were used in this study: mean, standard deviation, one-way ANOV A test followed by the Tukey HSD (analysis of variance). Differences at p>05 were considered statistically significant.

RESULTS AND DISCUSSION

1. Phytochemical Studies

1.1. Phytochemical screening

The phytochemical investigation showed that the three plant species contain carbohydrates or glycosides, flavonoids, volatile oils, unsaturated sterols and/or triterpenoids, tannins and proteins and/or amino acids (Table 1).

Table (1). Preliminary phytochemical screening of plants under investigation.

Plant name / Test	*O. americanum*	*O. basilicum*	*O. basilicum* var. *thyrsiflora*
Alkaloids and/or nitrogenous bases	-	-	-
Anthraquinones	-	-	-
Carbohydrates or glycosides	+	+	+
Cardinolides	-	-	-
Flavonoids	+	+	+
oxidase enzyme	-	-	-
Proteins and/or amino acids	+	+	+
Saponins	-	-	-
Tannins	+	+	+
Unsaturated sterols and/or triterpenoids	+	+	+
Volatile oil	+	+	+

(-), absent; (+), present

1.2. Estimation of Total phenols, flavonoids and total tannins

Quantitative estimation of the aqueous extract constituents (Table 2) was found to be approximately near to each other in the three species under investigation. Total phenols were the higher concentrations in all of them, they were 18.50±0.11, 17.91±0.21 and 18.12±0.13 for *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* respectively.

2. Pharmacological Studies

2.1. Acute toxicity (LD_{50}) test

It was proposed that the investigated extracts are considered safe as the oral LD_{50} was higher than 4000 mg/kg. No symptoms of acute toxicity were observed and there was zero mortality for 24 hours.

2.2. Sub-chronic toxicity

Results showed no significant alteration on liver function including ALT, AST, total bilirubin, total proteins, albumin levels or kidney function including of urea and creatinine levels in the sera of treated rats with alcohol extracts to rats (400 mg/kg) orally for 14 days compared to normal animals (Table 3).

Table (2). Quantitative analysis of secondary metabolites of *Ocimum americanum, Ocimum basilicum and Ocimum basilicum* var. *thyrsiflora* leaves.

Parameter / Plant species	Concentration (mg/100 g dw)		
	Ocimum americanum	***Ocimum basilicum***	***Ocimum basilicum* var. *thyrsiflora***
Total flavonoids	9.80±0.20	9.13±0.22	9.56±0.14
Total carbohydrates	6.70±0.23	6.30±0.23	6.26±0.23
Total phenols	18.50±0.11	17.91±0.21	18.12±0.13
Total tannins	5.60±0.40	5.10±0.40	5.28±0.40
Volatile oils	4.22±0.11	3.81±0.12	3.94±0.21

Table (3). Effect of the total alcohol extracts of *Ocimum americanum, Ocimum basilicum and Ocimum basilicum* var. *thyrsiflora* on liver and kidney functions.

Parameter	Control	***Ocimum americanum***	***Ocimum basilicum***	***Ocimum basilicum* var. *thyrsiflora***
ALT (U/L)	61.33±2.48	65.30±2.51	63.10±2.01	65.30±2.51
AST (U/L)	46.90±2.25	50.40±2.54	48.12±2.24	50.40±2.54
Total bilirubin (mg/dL)	1.70±0.11	1.65±0.10	1.67±0.11	1.69±0.14
Total protein (g/dL)	8.20±0.09	8.30±0.34	8.10±0.14	8.21±0.30
Albumin (g/dL)	3.7±0.06	3.2±0.11	3.3±0.12	3.5±0.21
Urea (mg/dL)	35.06±2.35	37.33±2.09	36.13±2.19	34.35±2.39
Creatinine (mg/dL)	0.43±0.20	0.41±0.25	0.42±0.21	0.40±0.35

All extracts (400 mg/kg) was administrated to rats for 14 days, n=10, sera were collected and different enzymes were measured (Awaad et al., 2015).

2.3. Anti-ulcerative colitis activity

The acetic acid-induced colitis model resembles humans UC in terms of histopathological features including mucosal edema and sub-mucosal ulceration. Acetic acid causes over-production of oxidant radicals that play essential roles in the pathophysiology (Tahan et al., 2011).

In this study, the inflammatory evidence was significantly ameliorated by oral treatment with dexamethasone, alcohol extracts and total phenolic extracts of *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* for 5 days after colitis induction (Table 4 and Fig. 1).

Administration of total alcohol extracts (400 mg/kg) showed the highest potentials; they were as potential as dexamethasone (0.1 mg/kg) in their anti-ulcerative colitis activities. *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* produced 65.92, 67.2 and 66.52% percent protection from control colitis respectively, while it was 71.54% for dexamethasone. Moreover, total phenolic extracts showed closer activities (58.20, 60.11 and 59.15%) to that of total alcohol extracts. On the other hand, volatile oils of the investigated plants unlikely showed little activity (5.95 - 6.9%). These results suggested that the anti-ulcerative colitis potentials of the evaluated *Ocimum* species might be associated to their phenolic content, not to their volatile oil content.

Table (4). Effects of extracts from *Ocimum americanum*, *Ocimum basilicum* and *Ocimum basilicum* var. *thyrsiflora* on the macroscopic parameters of ulcerative colitis induced by acetic acid in rats.

Groups	**Dose (mg/kg)**	**Lesion score (0-5)**	**Ulcer area (mm^2)**	**Ulcer index**	**Wet W/L (g/cm)**
Normal control	5	0.00±0.00	0.00±0.00	0.00 ±0.00	0.38±0.05
Control colitis	5	4.00±0.89	58.20±1.21	62.20±1.86	0.96±0.09
Dexamethasone	0.1	1.50*±0.55	16.20*±1.17	17.70*±1.03	0.51*±0.09
Alcohol extract of *O. americanum*	400	1.80*±0.24	19.40*±0.27	21.20*±0.39	0.55*±0.04
	200	2.20*±0.18	25.20*±0.19	27.40*±0.48	0.62*±0.05
Total phenolic content extract of *O. americanum*	400	2.00*±0.15	24.00*±0.27	26.00*±0.34	0.48*± 0.05
	200	1.60*±0.25	25.50*±0.15	27.90*±0.30	0.50*±0.02
Volatile oil of *O. americanum*	50	3.50±0.23	55.00±0.30	58.50±0.43	0.86±0.05
Alcohol extract of *O. basilicum*	400	1.60*±0.16	17.2*±0.17	19.42*±0.29	0.53*±0.02
	200	1.95*±0.28	23.25*±0.15	25.50*±0.19	0.68*±0.01
Total phenolic content extract of *O. basilicum*	400	1.70*±0.11	22.00*±0.07	23.01*±0.12	0.46*± 0.11
	200	2.05*±0.15	28.55*±0.28	27.20*±0.20	0.55*±0.05
Volatile oil of *O. basilicum*	50	2.92±0.23	51.97±0.20	52.10±0.40	0.83±0.06
Alcohol extract of *O. basilicum var. thyrsiflora*	400	1.70*±0.14	18.45*±0.28	20.22*±0.15	0.54*±0.05
	200	1.95*±0.21	21.75*±0.55	24.00*±0.29	0.61*±0.01
Total phenolic content extract of *O. basilicum var. thyrsiflora*	400	1.90*±0.11	23.01*±0.17	24.80*±0.22	0.50*±0.01
	200	2.01*±0.25	27.50*±0.30	28.05*±0.45	0.57*±0.02
Volatile oil of *O. basilicum var. thyrsiflora*	50	3.01±0.21	53.02±0.40	55.60±0.11	0.84±0.12

* Significantly different from control colitis at $p< 0.05$. n = 6 (Awaad et al., 2015).

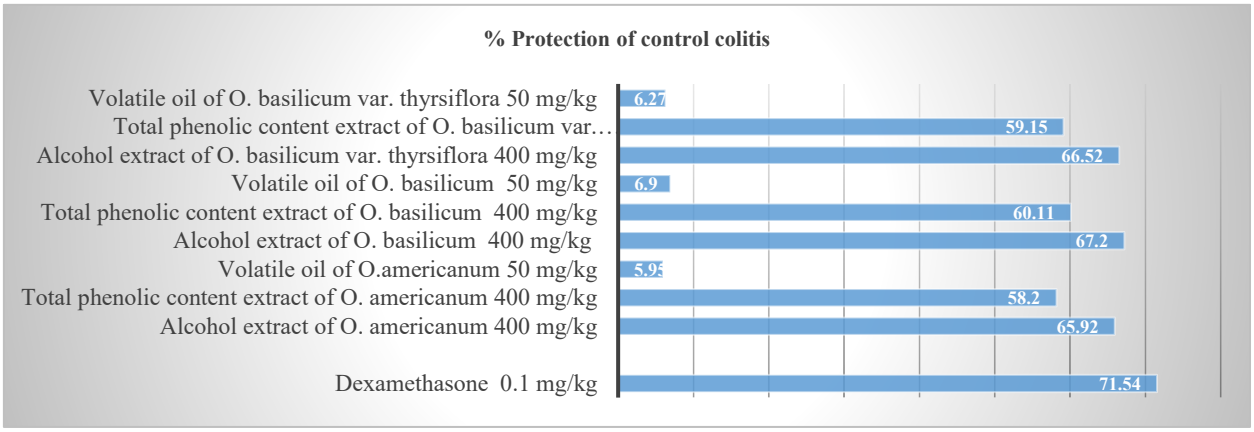

Fig. (1). Percent protection of control colitis for all investigated extracts of the three *Ocimum* species.

2.4. Estimation of possible mechanisms of action

2.4.1. Effect on colonic thiobarbituric acid reactive substance (malondialdehyde) content

Oxidative stress and its eventual lipid peroxidation may trigger free radicals chain reactions, disturb, the intestinal mucosal barrier integrity and could modulate some inflammatory mediators. Levels of malondialdehyde (MDA) were predominately applied as an indicator for lipid peroxidation induced by free radicals. Earlier research indicated that the antioxidant and anti-inflammatory agents significantly reduce the MDA levels in UC (Kuralay et al., 2003).

Oral administration of total alcohol extracts total and phenolic extracts (400 mg/kg) of *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* to rats with ulcerative colitis induced by acetic acid, produced a significant reduction in the elevated colonic MDA content with a percent change of control colitis ranging from 42.49 to 47.05% which are more effective than the standard dexamesathone which produced 39.25% (Table 5).

In this study, marked reduction in the elevated colonic MDA levels was observed after treatment with the investigated extracts. The current results proposed that the investigated extracts strongly inhibited lipid peroxidation provoked by acetic acid and provide protective response against ulcerative colitis.

These findings could be explained by the antioxidant potentials of these extracts (Atiphasaworn et al., 2017). Furthermore, *O. basilicum* alcohol extract was reported to possess anti-inflammatory activity (Selvakkumar et al., 2007) which might be included in the anti-ulcerative colitis activity.

Table (5). Effect of total alcohol extracts total and phenolic content extracts of *Ocimum americanum*, *Ocimum basilicum* and *Ocimum basilicum* var. *thyrsiflora* on colonic thiobarbituric acid reactive substance (MDA) content on acetic acid-induced ulcerative colitis in rats.

Group	MDA (nmol/mg tissue)	Change of control colitis (%)
Normal control	60.01±2.07	-
Control colitis	120.50±2.85	-
Dexamesathone (0.1 mg/kg)	73.20*±3.20	39.25
Alcohol extract of *O. americanum* (400 mg/kg)	66.50*±2.05	44.81
Total phenolic content extract of *O. americanum* (400 mg/kg)	63.80*±3.05	47.05
Alcohol extract of *O. basilicum* (400 mg/kg)	69.30*±2.80	42.49
Total phenolic content extract of *O. basilicum* (400 mg/kg)	65.40*±2.50	45.73
Alcohol extract of *O. basilicum var. thyrsiflora* (400 mg/kg)	67.20*±2.05	44.23
Total phenolic content extract of *O. basilicum var. thyrsiflora* (400 mg/kg)	65.30*±3.15	45.81

* Significantly different from the control colitis at $p< 0.05$. n=6

1.5.2. Effect on plasma TNF-alpha.

The pro-inflammatory cytokines TNF-α performed an essential role in UC pathogenesis. Elevated levels of TNF-α in UC patients have been observed in several research and thus agents targeting TNF-α have been studied. Furthermore, there is arise declaration promoting a genetic correlation between TNF-α and UC in section of patients (Sands and Kaplan, 2007).

Inflammation cascade activation process involves activation of antigen-presenting cells; macrophages and dendritic cells which sequentially cause activation and differentiation of CD4+ T lymphocytes. T lymphocyte cells differentiate into two types: T helper (Th)-1 and Th-2 cells. Th-1 cells were known to secrete interferon-gamma (IFNγ) and interleukin (IL)-2, IL-12, and IL-18; however, IL-4, IL-5, IL-6, IL-10, and IL-13 were secreted by Th-2 cells. IFNγ secreted from the Th-1 response progressively stimulates macrophages/monocytes to produce TNF-α (Neurath et al., 2002 and Lim and Hanauer, 2004). Additionally, Sangfelt et al. (2002) concluded that; TNF-α levels were decreased in distal UC patients treated with prednisolone.

In the present study, oral administration of total alcohol extracts total and phenolic extracts (400 mg/kg) of *O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora* to colitis rats (induced by acetic acid) resulted in a significant reduction in the exhilarated level of plasma TNF-alpha (Table 6). Alcohol extract of *O. basilicum* var. *thyrsiflora* produced the best activity in this study (61.45% inhibition of control colitis).

Table (6). Effect of total alcohol extracts total and phenolic content extracts of *Ocimum americanum*, *Ocimum basilicum* and *Ocimum basilicum* var. *thyrsiflora* on plasma TNF-α (Tumor Necrosis Factor- alpha) level on acetic acid-induced ulcerative colitis rats.

Groups	TNF-α (pg/ml)	Protection of control colitis (%)
Control colitis	14.50 ± 1.01	-
Dexamesathone 0.1 (mg/kg)	6.75* ± 1.05	53.45
Alcohol extract of *O. americanum* 400 (mg/kg)	5.85* ± 0.80	59.65
Total phenolic content extract of *O. americanum* 400 (mg/kg)	6.08* ± 1.05	58.07
Alcohol extract of *O. basilicum* 400 (mg/kg)	7.05* ± 1.03	51.38
Total phenolic content extract of *O. basilicum* 400 (mg/kg)	6.95* ± 1.50	52.07
Alcohol extract of *O. basilicum var. thyrsiflora* 400 (mg/kg)	5.59* ± 1.06	61.45
Total phenolic content extract of *O. basilicum var. thyrsiflora* 400 (mg/kg)	6.28* ± 1.09	56.69

* Significantly different from the control colitis at $p< 0.05$. n=6

CONCLUSION

As a conclusion, the three investigated *Ocimum* species (*O. americanum*, *O. basilicum* and *O. basilicum* var. *thyrsiflora*) might be considered as strong anti-ulcerative colitis agents with potentials comparable to that of the standard drug dexamethasone as standard drug with no significant effect on liver and kidney functions. The activity of the total alcohol extracts could be accredited to the phenolic content with minimal effect of volatile oil. Antioxidant potential and anti-TNF-α could explain the anti-ulcerative colitis potentials of the examined extracts.

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التأثير المضاد لإلتهاب القولون التقرحي للمستخلصات والزيوت الطيارة لثلاثة أنواع من الريحان

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تهدف الدراسة إلى تقييم التأثير المضاد لالتهاب القولون التقرّحي لثلاثة أنواع مختلفة من الريحان، وهي أوكيموم أمريكانوم (حوك)، وأوكيموم بازيليكم (الريحان الملكي أو الحبق)، وأوكيموم بازيليكم فار. ثيريسفلورا (الريحان التايلاندي)، من العائلة الشفوية. تمّ دراسة المستخلص الكحولي والمستخلص الفينولي بتركيزين ٢٠٠ و٤٠٠ مجم/كجم، والزيت الطيّار بتركيز ٥٠ مجم/كجم. تمّ عمل مجموعات مختلفة من الجرذان وإعطاؤها الجرعات المذكورة للنباتات موضع الدراسة عن طريق الفم لمدة خمسة أيام متتالية، وذلك بعد إحداث التهاب القولون التقرّحي في الجرذان باستخدام ٤٪ حمض الأسيتيك. وتشير النتائج إلى أنّ النباتات موضع الدراسة لها تأثير فعّال في علاج التهاب القولون التقرّحي بنسب متفاوتة ومعتمدة على الجرعات. وُجد أن تأثير المستخلصات الكحولية بجرعة ٤٠٠ مجم/كجم مساوٍ لتأثير دواء ديكساميثازون المستخدم في العلاج بجرعة ٠,١ مجم/كجم، حيث أعطت نسبة حماية لكلٍ من أوكيموم أمريكانوم ٦٥,٩٢٪ وأوكيموم بازيليكم ٦٧,٢٪ وأوكيموم بازيليكم فار. ثيريسفلورا ٦٦,٥١٪، بينما كانت نسبة الحماية لدواء ديكساميثازون ٧١,٥٤٪. بالإضافة إلى ذلك، وُجد أن تأثير المستخلصات الفينولية للنباتات الثلاثة كان كالتالي: أوكيموم أمريكانوم ٥٨,٢٠٪، وأوكيموم بازيليكم ٦٠,١١٪، وأوكيموم بازيليكم فار. ثيريسفلورا ٥٩,١٥٪، بينما وُجد أن تأثير الزيوت الطيّارة ضعيف في جميع النباتات موضع الدراسة، حيث أعطت نسب حماية ٥,٩٥، ٦,٩٠، ٦,٢٧٪ على التوالي. بدراسة آلية عمل المستخلصات الفعّالة للنباتات موضع الدراسة، تشير النتائج الحالية إلى أن المستخلصات المدروسة نجحت في تثبيط بيروكسيد الدهون الناتج عن حمض الأسيتيك، ووفّرت تأثيرات وقائية ضد التهاب القولون التقرّحي، من خلال انخفاض كبير في محتوى MDA القولوني المرتفع بنسبة تتراوح من ٤٢,٤٩ إلى ٤٧,٠٥٪ مقارنة بمجموعة التهاب القولون التحكّمية. بالإضافة إلى الانخفاض الملحوظ في مستوى عامل نخر الورم ألفا المرتفع في البلازما، يمكن تفسير فعالية المستخلصات المدروسة في مكافحة التهاب القولون التقرّحي. كانت المستخلصات الكحولية الكليّة للأنواع الثلاثة آمنة حتى جرعة ٤٠٠٠ مجم/كجم، دون أي آثار جانبية على وظائف الكبد والكلى بعد تناولها عن طريق الفم لمدة ١٤ يومًا متتالية بجرعة ٤٠٠ مجم/كجم.