Synthesis and Pharmacological Investigation of 5-Substituted-3-methylsulfanyl-1H-pyrazole-4-carboxylic Acid Ethyl Esters as New Analgesic and Anti-inflammatory Agents

Abstract

Purpose: To synthesize a new series of 5-substituted-3-methylsulfanyl-1H-pyrazole-4-carboxylic acid ethyl esters for their analgesic and anti-inflammatory activity.

Methods: The title compound synthesized by reacting the amino group of 5-amino-3-methylsulfanyl-1H-pyrazole-4-carboxylic acid ethyl ester with acid anhydrides, acid chlorides and phenyl dithiocarbamates. The synthesized compounds were characterized by IR, 1H-NMR and mass spectral data; the purity of the compounds was determined by elemental analysis. The title compounds were investigated for analgesic, anti-inflammatory and ulcerogenic behaviour.

Results: The compound 5-benzoylamino-3-methylsulfanyl-1-phenyl-1H-pyrazole-4-carboxylic acid ethyl ester (4c) emerged as the most active compound and exhibiting imperative analgesic and anti-inflammatory activities. Interestingly the test compounds showed only mild ulcerogenic potential when compared to indomethacin.

Conclusion: The compound (4c) could serve as a lead molecule for further modification to obtain a clinically useful novel class of analgesic and anti-inflammatory agents.

Introduction

Nonsteroidal anti-inflammatory drugs (NSAIDs) are widely used for the choice treatment in various inflammatory diseases such as arthritis, rheumatisms and relieve body aches and pain of everyday life [1–4]. However, long-term use of the NSAIDs has been associated with gastrointestinal ulceration, bleeding and nephrotoxicity [1–4]. Therefore the discovery of new safer anti-inflammatory drugs represents a challenging goal for such a research area. The currently available NSAIDs belong to different chemical classes [5]. The pyrazole and substituted pyrazole derivatives have occupied a prominent place in medicinal chemistry because of their significant therapeutic properties in clinical applications [5–7]. In particular, it has been reported for diverse range of pharmacological activities including antihistamin, anti-arrhythmic, anti-ulcer, leishmanicidal, HIV-RT inhibitor, anti-cancer, antimalarial, anti-microbial, and cytotoxicity [7–13]. In addition to this several pyrazole analogs were also reported to exhibit analgesic and anti-inflammatory activities. Therefore, it was thought worthwhile to explore analgesic and anti-inflammatory activity of tetra substituted pyrazole derivatives. Accordingly the present work is concerned with the synthesis of tetra substituted pyrazole derivatives with the objective of discovering novel and potent analgesic and anti-inflammatory agents that might be devoid of gastrointestinal side effects. The synthesized compounds were tested for their analgesic, anti-inflammatory and ulcerogenic index behaviour.

Materials and Methods

Chemistry

Melting points (mp) were taken in open capillaries on Thomas Hoover melting point apparatus (Thomas Hoover, Philadelphia, USA) and are uncorrected. The IR spectra were recorded in film or in potassium bromide disks on a Perkin-Elmer 398 spectrometer (Bio Engineering, Wald, Switzerland). The 1H NMR spectra were recorded on a DPX-300 MHz Bruker FT-NMR spectrometer (Pacific Northwest, Richland, Washington, USA). The chemical shifts were reported as parts per million (ppm).
Ethyl 2-cyano-3,3-bis(methylthio)acrylate (2)  
To a solution of dimethylformamide (30 mL) and 1.13 g (0.01 mol) of ethyl cyanoacetate (1), and sodium hydroxide (0.2 g, 0.02 mol) in a minimum amount of water at 0 °C, was added. The reaction mixture was treated drop wise 0.6 mL of carbon disulphide for 3 h and then the pyridine was removed by high vacuum rotavapor and the reaction mixture was refluxed for 1 h. After the completion of addition, the mixture was stirred for further 1 h and then the pyridine was removed by high vacuum rotavapor and the reaction mixture was heated at 115–117 °C; Rf 0.37 (CHCl3; CH2OH, 9: 1); IR (KBr, cm⁻¹): 3 230 (Pyrazole NH Str), 3 190 (Amide NH Str), 1 697 (Ester C = O Str), 1 670 (Amide C = O Str), 1 710 (Ester C = O Str), 1 630 (C = N Str), 1 550 (Amide C = O Str), 1 278 (M + ); Anal. Calcd for C9H12ClN3O3S: C, 38.92; H, 4.36; N, 15.11.  

5-Amino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (3a)  
A mixture of 2.17 g (0.01 mol) of ethyl 2-cyano-3,3-bis(methylthio) acrylate (2) and 0.5 g (0.01 mol) of phenyl hydrazine in 30 mL of ethanol was refluxed for 2 h. The reaction mixture was cooled and poured into ice-water and filtered. The precipitated product was filtered and dried; the precipitated was recrystallized from ethanol (75:25) mixture. Yield 80 %; m. p. 150–152 °C; IR (CHCl3; CH2OH, 9: 1); IR (KBr, cm⁻¹): 3 277 (M + ); Anal. Calcd for C11H11O2NS: C, 56.41; H, 5.37; N, 13.16; Found C, 56.38; H, 5.35; N, 13.14.

5-Acetylamino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (3b)  
A mixture of 0.01 mol of 5-acetylamino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (2) (0.21 g, 0.01 mol) and acetic anhydride (0.05 mol) was placed in a round bottom flask and refluxed for 3 h. The reaction mixture was cooled and poured into ice-water and filtered. The precipitated product was filtered and washed with water and dried; the precipitated was recrystallized from ethanol (75:25) mixture. Yield 93 %; m. p. 180–182 °C; IR (CHCl3; CH2OH, 9: 1); IR (KBr, cm⁻¹): 3 242 (M + ); Anal. Calcd for C12H12ClNO3S: C, 57.22; H, 5.1; N, 13.73.  

5-Chloroacetylamino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (3c)  
A mixture of 0.01 mol of 5-chloroacetylamino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (2) (0.21 g, 0.01 mol) was dissolved in 0.02 mol of glacial acetic acid, to this chloroacetyl chloride (1.12 g, 0.01 mol) was added and reaction mixture was refluxed for 1 h. The remaining procedure was the same as for compound 3a. Yield 82 % m. p. 115–117 °C; IR (CHCl3; CH2OH, 9: 1); IR (KBr, cm⁻¹): 3 315 (Pyrazole NH Str), 3 279 (Amide NH Str), 1 690 (Ester C = O Str), 1 664 (Amide C = O Str), 1 585 (C-S-C Str), 1 289 (Ester C = O Str), 1 197 (C-S-C Str), 1 068 (C-S-C Str); IR (KBr, cm⁻¹): 1 638–1.40 (t, 3H, CH2CH2), 2.27 (s, 3H, SCH3), 4.22 (s, 2H, CICH2CONH), 4.34–4.39 (q, 2H, CH2CH2), 9.68 (br s, 1H, NH), 10.66 (br s, 1H, NH), 6.70 (br s, 1H, NH); MS (m/z) 277 (M + ); Anal. Calcd for C9H10Cl2N3O3S: C, 38.92; H, 4.36; N, 15.13.  

5-Benzyloamino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (3d)  
A mixture of 0.01 mol of 5-benzyloamino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (2) (0.21 g, 0.01 mol) was dissolved in 5 mL of pyridine to this was added benzoyl chloride (0.013 mol) drop wise with stirring. After the completion of addition, the mixture was stirred for further 1 h and then the pyridine was removed by high vacuum rotavapor and the reaction mixture was dried to obtain the precipitated product. It was crystallized with chloroform-ethanol mixture. Yield 74 %; m. p. 123–125 °C; IR (CHCl3; CH2OH, 9: 1); IR (KBr, cm⁻¹): 3 220 (Pyrazole NH Str), 3 190 (Amide NH Str), 1 680 (Ester C = O Str), 1 602 (C-S-C Str), 1 550 (Amide C = O Str), 1 250 (Ester C = O Str), 1 660 (C-S-C Str); IR (KBr, cm⁻¹): 1 380–1.39 (t, 3H, CH2CH2), 2.27 (s, 3H, SCH3), 4.22 (s, 2H, CICH2CONH), 4.34–4.39 (q, 2H, CH2CH2), 9.68 (br s, 1H, NH), 10.66 (br s, 1H, NH), 6.70 (br s, 1H, NH); MS (m/z) 306 (M + ); Anal. Calcd for C12H12Cl2N3O3S: C, 55.07; H, 4.95; N, 13.76; Found C, 55.04; H, 4.93; N, 13.73.

3-Methylsulfonyl-5-(3-phenyl-thioureido)-1H-pyrazole-4-carboxylic acid ethyl ester (3e)  
A mixture of compound 5-amino-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl ester (3) (0.01 mol) and methyl-(N-phenyl) dithiocarbamate (0.01 mol) was dissolved in ethanol...
and a pinch potassium carbonate was added and refluxed for 9 h.
Yield 81%; m. p. 232–233°C; RF 0.39 (CHCl₃; CH₃OH, 9: 1); IR (KBr, cm⁻¹): 3431 (NH Str), 3233 (Amide NH Str), 1713 (Ester C=O Str), 1668 (Amide C=O Str), 1608 (C=N Str), 1278 (Ester C-O Str), 688 (C-S-C Str); ¹³C NMR (500 MHz, CDCl₃): δ 1.30–1.33 (t, 3H, CH₂CH₃), 2.51 (s, 3H, SCHR₂), 3.70–3.73 (s, 3H, CH₂CH₃), 6.82–6.91 (s, 2H, Ar-H), 7.50–7.53 (s, 2H, Ar-H), 7.88 (br s, 1H, NH), 8.05 (br s, 1H, NH), 9.92 (br s, 1H, NH); MS (m/z) 336 (M⁺); Anal. Calcld for C₃H₇NO₂S: C, 53.61; H, 5.41; N, 11.36; Found C, 53.83; H, 5.43; N, 11.14.

5-Benzoylamo-no-3-methylsulfonyl-1-phenyl-1H-pyrazole-4-carboxylic acid ethyl ester (4c)
A mixture of 5-aminoo-3-methylsulfonyl-1-phenyl-1H-pyrazole-4-carboxylic acid ethyl ester (4) (2.77 g, 0.01 mol) was dissolved in 5 mL of pyridine to this was added benzoyl chloride (0.013 mol) drop wise with stirring. After the completion of addition, the mixture was stirred for further 1 h and then the pyridine was removed by suction and the reaction mixture was dried to obtain the precipitated product. It was crystallized with chloroform-ethanol mixture. Yield 79%; m. p. 152–155°C; RF 0.65 (CHCl₃; CH₃OH, 9: 1); IR (KBr, cm⁻¹): 3290.82 (Amide NH Str), 1713 (Ester C=O Str), 1701 (Amide C=O Str), 1589 (C=N Str), 1236 (Ester C-O Str), 692 (C-S-C Str); ¹³C NMR (500 MHz, CDCl₃): δ 1.22–1.25 (t, 3H, CH₂CH₃), 2.53 (s, 3H, SCHR₂), 2.47–4.31 (q, 2H, CH₂CH₃), 7.25–7.46 (m, 5H, Ar-H), 7.80 (br s, 1H, CONH); MS (m/z) 432(M⁺); Anal. Calcld for C₂₀H₁₉N₃O₃S: C, 62.97; H, 5.02; N, 11.02; Found C, 62.94; H, 4.98; N, 10.99.

Pharmacology

The synthesized compounds were evaluated for analgesic, anti-inflammatory and ulcerogenic index. The test compounds and the standard drugs were administered in the form of a suspension (using 1% carboxymethylcellulose as a vehicle) by oral route of administration for analgesic and anti-inflammatory. For ulcerogenicity studies the drug were administered by intraperito-
neally as suspension in 10% V/V Tween 80. Each group consisted of six animals. The animals were procured from the Tetrex Biological Center, Madurai, India, and were maintained in colony cages at 25±2°C, relative humidity 45–55%, under a 12 h light and dark cycle; they were fed standard animal feed. All the animals were acclimatized for a week before use. The Institutional Animal Ethics committee has approved the protocol adopted for the experimentation of animals.

**Analgesic activity**

Test for analgesic activity was performed by tail-flick technique using Wistar albino mice (25–35 g) of either sex selected by a random sampling technique \[17–19\]. The test compounds and pentazocine at a dose level of 5 mg kg\(^{-1}\) was administered orally. The reaction time was recorded at 30 min and 1, 2 and 3 h after the treatment, and the cut-off time was 10 s. The percentage analgesic activity (\(\text{PAA}\)) was calculated by the following formula,

\[
PAA = \left(\frac{T_2 - T_1}{10 - T_1}\right) \times 100\%
\]

where \(T_1\) is the reaction time (s) before treatment, and \(T_2\) is the reaction time (s) after treatment.

**Anti-inflammatory activity**

Anti-inflammatory activity was evaluated by carrageenan-induced paw oedema test in rats [20]. The test compounds and Diclofenac sodium at a dose level of 5 mg kg\(^{-1}\) was administered. The paw volumes were measured using the mercury displacement technique with the help of a plethysmograph immediately before and 1, 2 and 3 h after carrageenan injection. The percentage inhibition of paw oedema was calculated using (\(\text{Table 2}\)) the following formula

\[
\text{Percent inhibition } I = 100\left[1 - \frac{(a - x)}{(b - y)}\right]
\]

Where \(x\) is the mean paw volume of rats before the administration of carrageenan and test compounds or reference compound (test group), \(a\) is the mean paw volume of rats after the administration of carrageenan in the test group (drug treated), \(b\) is the mean paw volume of rats after the administration of carrageenan in the control group and \(y\) is the mean paw volume of rats before the administration of carrageenan in the control group.

**Evaluation of ulcerogenicity index**

Ulceration in rats was induced as described by reported protocol [21]. Albino rats of the Wistar strain weighing 150–200 g of either sex were divided into various groups each of 6 animals. The control groups of animals were administered only 10% V/V Tween 80 suspension intraperitoneally. One group was administered with indomethacin intraperitoneally at a dose of 5 mg kg\(^{-1}\) once daily for 3 days. The remaining group of animals was administered with test compounds intraperitoneally at a dose of 5 mg kg\(^{-1}\). On the fourth day, pylorus was ligated as per the method of Shay et al. [22]. Animals were fasted for 36 h before the pylorus ligation procedure. 4 h after the ligation, animals were sacrificed. The stomach was removed and opened along with

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**Fig. 1** Synthesis of pyrazole derivatives 3a–e and 4a–e.

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**Reagents and conditions:**
(a) NaOH, CS\(_2\), DMF, 0 °C for 1 h, 30 min; (b) (CH\(_3\))\(_2\)SO\(_4\), 10-15 °C, 3 h; (c) R-NH-NH\(_2\), ethanol reflux; (d) For compounds 3a and 4a (CH\(_3\))CO\(_2\)O reflux; For compounds 3b and 4b: gla CH\(_3\)COOH, Cl-CH\(_2\)COCl reflux; For compounds 3c and 4c pyridine, benzoyl chloride reflux; For compounds 3d, 3e, 4d and 4e RCSNH K\(_2\)CO\(_3\), ethanol reflux.
Values are expressed as mean ± SD (standard deviations). For statistical analysis, the means of individual groups were performed using Tukey’s test. A one-way analysis of variance (ANOVA). In all cases, post-hoc comparisons of the compounds on animals was evaluated using a one-way analysis of variance (ANOVA). The compound 5-benzoylamino-3-methylsulfanyl-1-phenylpyrazole-4-carboxylic acid ethyl ester (3 and 4) by 1,3-dipolar cycloaddition. The desired pyrazole derivatives (3a–e and 4a–e) were obtained by the reaction of 5-amino-3-methylsulfanyl-1-substituted-1H-pyrazole-4-carboxylicacid ethyl ester with different reagents and conditions (Fig. 1). The synthesized compounds were characterized by IR, 1H-NMR, and mass spectral data. Elemental analysis satisfactorily confirmed elemental composition and purity of the synthesized compounds.

The greater curvature. Ulcer index was determined by the method of Ganguly and Bhatnagar [23] and is recorded in Table 3.

Table 1 Analgesic activity of synthesized compounds (3a–e and 4a–e) by tail-flick technique.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Dose (mg/kg)</th>
<th>Percent analgesic activity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 min</td>
<td>1 h</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3a</td>
<td>5</td>
<td>23.61 ± 0.65d</td>
</tr>
<tr>
<td>3b</td>
<td>5</td>
<td>20.24 ± 0.66a</td>
</tr>
<tr>
<td>3c</td>
<td>5</td>
<td>33.00 ± 0.80c</td>
</tr>
<tr>
<td>3d</td>
<td>5</td>
<td>14.88 ± 0.50a</td>
</tr>
<tr>
<td>3e</td>
<td>5</td>
<td>13.89 ± 1.34c</td>
</tr>
<tr>
<td>4a</td>
<td>5</td>
<td>30.62 ± 1.11d</td>
</tr>
<tr>
<td>4b</td>
<td>5</td>
<td>27.68 ± 0.94d</td>
</tr>
<tr>
<td>4c</td>
<td>5</td>
<td>47.62 ± 0.87c</td>
</tr>
<tr>
<td>4d</td>
<td>5</td>
<td>20.24 ± 1.12a</td>
</tr>
<tr>
<td>4e</td>
<td>5</td>
<td>23.31 ± 0.96a</td>
</tr>
<tr>
<td>Pentazocine</td>
<td></td>
<td>39.25 ± 0.79c</td>
</tr>
<tr>
<td>Control</td>
<td>–</td>
<td>1.46 ± 0.69</td>
</tr>
</tbody>
</table>

Each value represents the mean ± SD (n = 6). Statistical analysis of the biological activity of the synthesized compounds on animals was evaluated using a one-way analysis of variance (ANOVA). In all cases, post-hoc comparisons of the means of individual groups were performed using Tukey’s test. A significance level of p < 0.05 denoted significance in all cases. All values are expressed as mean ± SD (standard deviations). For statistical analysis we have used GraphPad Prism version 3.0. (GraphPad Software, Inc. San Diego, CA 92130 USA).

The target compounds were synthesized according to steps outlined in Fig. 1. The precursor of ethyl 2-cyano-3,3-bis(methylthio)acrylate (2) was easily synthesized by treatment of ethyl cyanoacetate (1) with carbon disulphide and sodium hydroxide in DMF to give sodium dithiocarbamate, which was methylated with dimethyl sulphate to afford the dithiocarbamic acid methyl ester (2). The compound (2) reacted with hydrazine and substituted hydrazine that gives 5-amino-3-methylsulfanyl-1-substituted-1H-pyrazole-4-carboxylic acid ethyl ester (3 and 4) by 1,3-dipolar cycloaddition. The desired pyrazole derivatives (3a–e and 4a–e) were obtained by the reaction of 5-amino-3-methylsulfanyl-1-substituted-1H-pyrazole-4-carboxylicacid ethyl ester with different reagents and conditions (Fig. 1). The synthesized compounds were characterized by IR, 1H-NMR, and mass spectral data. Elemental analysis satisfactorily confirmed elemental composition and purity of the synthesized compounds.

Pharmacology

Test for analgesic activity was performed by tail-flick technique using Wistar albino mice [17–19]. The results of analgesic testing indicate that the test compounds exhibited moderate analgesic activity after 30 min of reaction time and an increase in activity after 1 h which reached a peak level after 2 h. Decline in activity was observed after 3 h (Table 1). According to the structure–activity relationship (SAR) studies, all the compounds have shown moderate analgesic activity when compared with reference drug pentazocine. Further results indicated that different substituents on the 5th position and N-1 pyrazole ring, exerted varied biological activity. Among the various amide (acetamide (3a), chloroacetamide (3b) and benzyol amide (3c)) substitution on the 5th position, benzyol amide substituted group (3c) showed significant activity. Compounds having 1-methyl-3-phenylthiourea (3d) and 1-methyl-3-p-tolylthiourea substitution (3e) on the 5th position of pyrazole ring system leads to abolish the analgesic activity. The phenyl substitution on N-1 pyrazole ring system led to significant increases in analgesic activity when compared to unsubstituted compounds. Among the series, 5-benzoylamino-3-methylsulfanyl-1-phenyl-1H-pyrazole-4-carboxylic acid ethyl ester (4c) is found to equipotent with the reference drug pentazocine (Table 1).

Anti-inflammatory activity was evaluated by carrageenan induced paw oedema test in rats [20]. The anti-inflammatory activity data (Table 2) indicated that all the test compounds protected rats from carrageenan-induced inflammation moderately after 30 min of reaction time with increased activity after 1 h that reached a peak level after 2 h. Decline in activity was observed after 3 h. The SAR studies indicated that different substituents on the 5th position and N-1 pyrazole ring, exerted varied protection effect from carrageenan-induced inflammation. The compound 5-benzoylamino-3-methylsulfanyl-1-phenyl-1H-pyrazole-4-carboxylic acid ethyl ester (4c) showed moderate anti-inflammatory activity when compared to the reference standard diclofenac sodium.

Table 2 Anti-inflammatory activity of synthesized compounds (3a–e and 4a–e) determined by Carrageenan induced paw oedema test in rats.

<table>
<thead>
<tr>
<th>Compound</th>
<th>Dose (mg/kg)</th>
<th>Percent Protection</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>30 min</td>
<td>1 h</td>
</tr>
<tr>
<td>Control</td>
<td></td>
<td>54.07 ± 0.66c</td>
</tr>
<tr>
<td>3a</td>
<td>5</td>
<td>28.57 ± 1.1c</td>
</tr>
<tr>
<td>3b</td>
<td>5</td>
<td>21.77 ± 0.8c</td>
</tr>
<tr>
<td>3c</td>
<td>5</td>
<td>31.98 ± 1.0c</td>
</tr>
<tr>
<td>3d</td>
<td>5</td>
<td>21.77 ± 0.8c</td>
</tr>
<tr>
<td>3e</td>
<td>5</td>
<td>25.17 ± 1.6c</td>
</tr>
<tr>
<td>4a</td>
<td>5</td>
<td>31.98 ± 0.5c</td>
</tr>
<tr>
<td>4b</td>
<td>5</td>
<td>25.17 ± 0.7c</td>
</tr>
<tr>
<td>4c</td>
<td>5</td>
<td>38.78 ± 0.9c</td>
</tr>
<tr>
<td>4d</td>
<td>5</td>
<td>21.77 ± 0.3c</td>
</tr>
<tr>
<td>4e</td>
<td>5</td>
<td>21.77 ± 0.8c</td>
</tr>
<tr>
<td>Pentazocine</td>
<td></td>
<td>39.25 ± 0.79c</td>
</tr>
<tr>
<td>Control</td>
<td>–</td>
<td>1.17 ± 0.08</td>
</tr>
</tbody>
</table>

Each value represents the mean ± SD (n = 6). Significant difference relative to control at same time points and comparison were measured: *p<0.001, **p<0.01, ***p<0.05.
Two selected compounds (3c and 4c) of the series were evaluated for their ulcerogenic behaviour (Table 3). The ulcer index of the test compounds showed negligible ulcer index, when compared to reference standard indomethacin. The indomethacin induced ulcer model animals had ulcers and hemorrhagic streaks, whereas in animals treated with the pyrazole derivatives compounds of (3c and 4c) at 5 mg/kg dose level, there was a significant reduction in ulcer index. Furthermore the pyrazole derivatives (3c and 4c) significantly reduces the total volume of the gastric juice, free and total acidity of gastric secretion and also has higher activity against gastric ulcers in rats when it was compared with indomethacin.

## Conclusion

In the present study, synthesis of a new series of 5-substituted-3-methylsulfonyl-1H-pyrazole-4-carboxylic acid ethyl esters (3a-e and 4a-e) has been described. The results of the analgesic and anti-inflammatory activities of the 5-substituted-3-methylsulfonyl-1H substituted)-pyrazole-4-carboxylic acid ethyl esters series showed that moderate enhancement of activity. The compounds 5-benzyloamino-3-methylsulfonyl-1-phenyl-1H-pyra- zole-4-carboxylic acid ethyl ester (4c) emerged as the most active compound. Hence this series could be developed as a novel class of analgesic and anti-inflammatory agents. Further structural modification is planned to obtain compounds with increased analgesic and anti-inflammatory activities with minimal ulcerogenic behaviour.

## Acknowledgements

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## Conflict of Interest Statement

The authors report no conflicts of interest to declare in connection with the contents of this manuscript.

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