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Antifeedant Activity of Pyrazolin-5-One Derivatives

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Authors' contributions

This work was carried out in collaboration among all authors. Author RP designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors GS and SM managed the analyses of the study. Author MKS managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A series of substituted 4-{1-aza-2-[(aryl) amino)]}-3-methyl-2-pyrazolin-5-ones has been synthesized and evaluated for their biological activity. The title compounds (4a-l) were prepared by the diazotization of substituted anilines (1a-l) to form substituted phenyl hydrazine derivatives (2a-l) which synthesized substituted 4-{1-aza-2-[(aryl) amino)]}-3-methyl-2-pyrazolin-5-ones (4a-l) by Michael addition reaction, which is a nucleophilic addition of enolate anion to the carbon-carbon double bond of a α, β–unsaturated carboxylic acid derivatives. Twelve different pyrazolinone derivatives (4a to 4l) were synthesized. Structural assignments of these compounds have been made by elemental analysis, FTIR, ^{1}HNMR and Mass spectral data and the purity of the compounds was determined by TLC. The antifeedant activity of the newly isolated heterocyclic compounds was evaluated against agriculture pest *Achoea janata*. Compound 4d found to be very effective as antifeedant while rest of the compounds showed a moderate to good degree of antifeedant activity.

Keywords: Antifeedant activity; carbindazime; diazotization; michael addition reaction; Pyrazolin-5-ones.

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1. INTRODUCTION

Plants are the storehouse of a variety of bioactive chemicals such as secondary plant metabolites that are used in defense mechanism against herbivores. These secondary metabolites such as terpenes, alkaloids, steroids, phenolics, tannins etc. Mazid M et al. [1] have multiple modes of action and deleterious to insects in multiple ways, as acute toxicity, affecting insect behavior disrupting growth and development of insects and acting as repellents, anti-feedants and oviposition deterrents [2]. Our interest in pyrazoline derivatives is inspired mainly by their activity as insect feeding deterrents; many natural antifeedants contain the lactone moiety and have isoprenoid structures [3,4]. Though, their low concentrations in plants and their typically composite syntheses have limited the large-scale submission of natural antifeedants. Consequently, in our judgment, synthetic feeding deterrents with simple structures tender better possible for practical use in insect pest population control. Thus, we have synthesized a number of pyrazoline derivatives by using various substituted aniline as the starting materials.

On the other hand, the pyrazolinone ring that contains a five membered heterocyclic organic compound with two adjacent nitrogen atoms is a prominent heterocyclic scaffold in lots of bioactive molecules. They are important substances and have gained widespread attention in agrochemical, pharmaceutical and chemical industries [5]. They possess a wide range of biological activities [6-9], including antimicrobial [10,11], antiviral [12,13], anticancer [14,15], anti-inflammatory [16,17], antihistaminic [18], pesticidal [19], antifungal [20], rheumatoid arthritis [21], anticonvulsant [22], antidepressant [23], antipyretic [24], antibacterial [25] agents, etc. and these bio-activities have inspired chemists to synthesize substituted pyrazolinone systems to explore the usefulness of this heterocyclic template. In view of these reports the present research deals with a novel synthesis of substituted 4-{1-aza-2-[(aryl) amino)]}-3-methyl-2-pyrazolin-5-ones and evaluated their antifeedant activity.

2. MATERIALS AND METHODS

2.1 Experimental

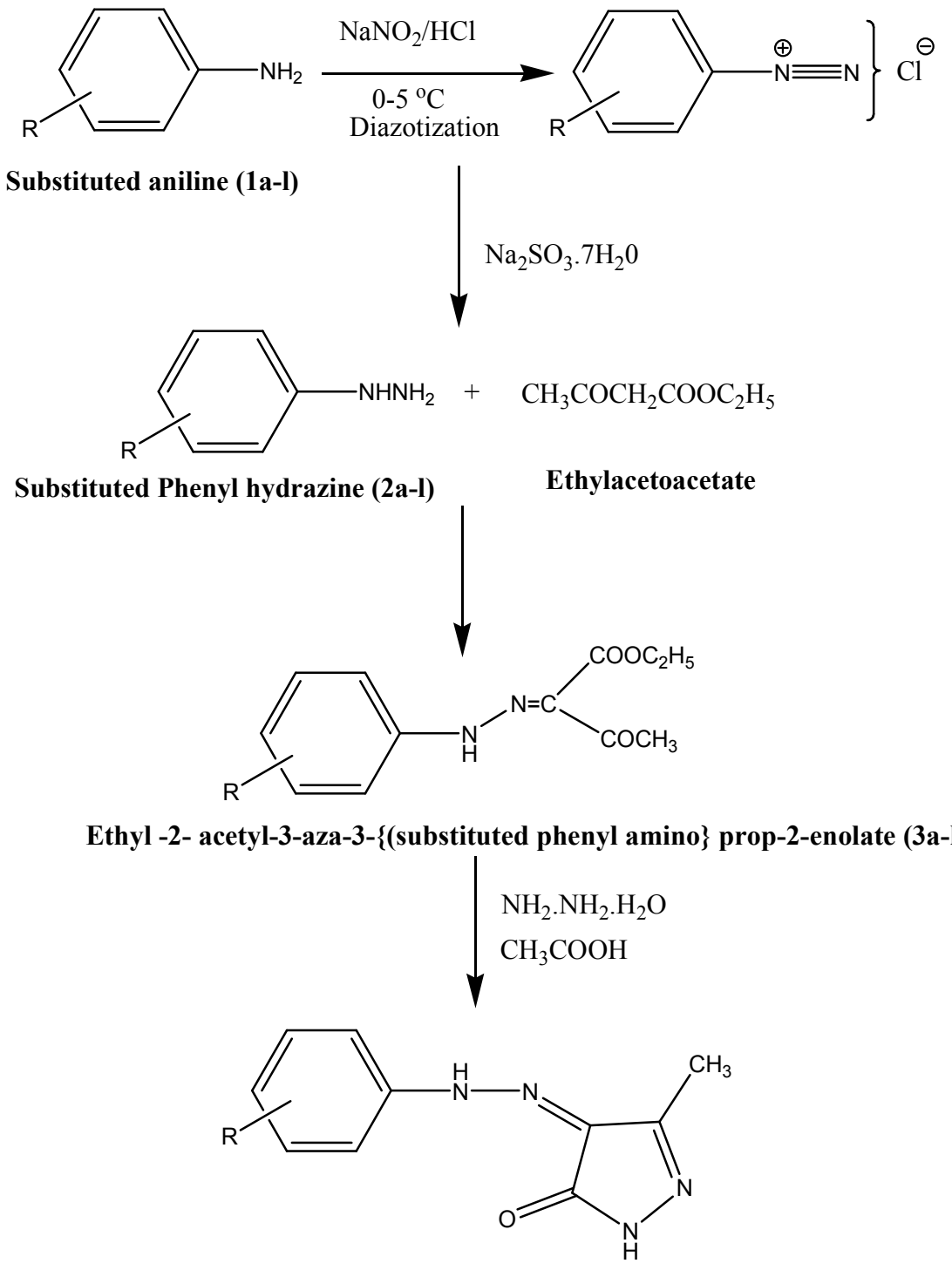
This experiment and research where perform in the Institute laboratory Indore Institute of Pharmacy Indore, MP India. All the chemicals used in the synthesis of the intermediates and final products were of A.R. grade. Melting points of all the compounds were recorded in Digital melting point apparatus and were uncorrected. The IR spectra were recorded on Perkin Elmer FTIR spectrometer with KBr. ^{1}HNMR spectra were recorded on Bruker Avance II 400MH_Z NMR. The chemical shifts were reported for the estimation as parts per million downfield from tetra methyl silane as a internal standard. Mass spectrums also were performed on LC-MSD-Tranp-SL2010A SHIMADZU using $CDCl_3$ as a solvent system. The purity of the compound was checked by TLC using precoated silica gel G plate method (R_f value given in Table 1) using ethyl acetate: petroleum ether: chloroform in the ratio of 0.6:0.8:8.6 and iodine vapors as visualizing agent.

Substituted aniline (0.03 mol) was dissolved in a mixture of 10.5 ml of concentrated HCl and an equal volume of water, cooled rapidly to 0°C in order to obtain the hydrochloride of the base in a fine state of division. Gradual addition of a solution of sodium nitrite (0.03 mol) in 6 ml of water was performed for diazotization. Stirring was continued for a few minutes, and the solution was filtered and added by using a separatory funnel to an ice-cold solution of sodium sulphite (96% $Na_2SO_3{\cdot}7H_2O$) (0.15 mol) in 100 ml of water containing 4 g of NaOH. The solution was allowed to stand for 5 minutes, acidify with 35 ml of concentrated HCl, and heat on a water bath at 25°C for 3 minutes, when yellow needles commence separating. This solution was set aside overnight, filtered off the crystals, heated with 10 ml of concentrated HCl on a water bath for 7 minutes, and permitted to cool. The impetuous was filtered off and dissolved in water and the solution was treated with a concentrated solution of sodium acetate. The gratis base separated out in an approximately pure state. Recrystallized the product with methylated spirit.

2.1.1 Synthesis of Ethyl -2- acetyl-3-aza-3-{(substituted phenyl amino} prop-2-enolate (3a-l)

Substituted phenyl hydrazine (0.002 mol) was dissolved in minimum amount of cold water then ethanolic KOH was added. The solution was then refluxed for 40 min at 70°C in the presence of ethylacetoacetate. The impetuous was filtered, washed through water and dried up. Recrystallized the product with methylated spirit.

Scheme of Synthesis



Scheme. 1. Procedure for the synthesis of substituted phenyl hydrazine from substituted anilines (2a-l)

2.1.2 Synthesis of 4-{1-aza[(substituted phenyl) amino)]}-3-methyl-2-pyrazolin-5-ones (4a-l)

Ethyl-2-acetyl-3-aza-3-{(substituted phenyl amino}prop-2-enolate (0.002 mol) was dissolved in glacial acetic acid (25ml) and hydrazine hydrate (0.002 mol) in glacial acetic acid was added. The mixture was refluxed for 6 hr, cooled and allowed to stand overnight. The consequential solid was dried and re crystallized from ethanol. Similarly other members of 4a-l were prepared and their physical and analytical data were recorded.

2.1.3 4-(2-(2-chlorophenylhydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4a)

Molecular formula: $C_{10}H_9ClN_4O$, Molecular weight: 236.66 Yield: 64.53%, M.P.: 166-168°C, R_f value: 0.71, FT-IR (KBr, υ, cm-1): 3476.89 (N-H Str.), 3145.57 (=C-H str.), 2966.78 (C-H str.), 1706.67 (C=O str.), 1602.97 (C=C str.), 1225.67 (C-N str.), 743.35 (Ar C-H Bend.), 782.03 (C-Cl Bend). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 6.40-6.79 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 238.57 (M^{+2}). Anal. Calcd.: C, 50.75; H, 3.83; Cl, 14.98; N, 23.67; O, 6.76. Found: C, 50.43; H, 3.91; Cl, 14.54; N, 23.02; O, 6.97.

2.1.4 4-(2-(3-chlorophenylhydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4b)

Molecular formula: $C_{10}H_9ClN_4O$, Molecular weight: 236.66 Yield: 65.92%, M.P.: 176-179°C, R_f value: 0.69, FT-IR (KBr, υ, cm-1): 3407.25 (N-H Str.), 3157.35 (=C-H str.), 2972.35 (C-H str.), 1714.97 (C=O str.), 1612.25 (C=C str.), 1234.73 (C-N str.), 739.29 (Ar C-H Bend.), 778.27 (C-Cl Bend) . ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 6.34-6.91 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 238.76 (M^{+2}). Anal. Calcd.: C, 50.75; H, 3.83; Cl, 14.98; N, 23.67; O, 6.76. Found: C, 50.67; H, 4.02; Cl, 14.93; N, 22.98; O, 6.91.

2.1.5 4-(2-(4-chlorophenylhydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4c)

Molecular formula: $C_{10}H_9ClN_4O$, Molecular weight: 236.66 Yield: 70.55%, M.P.: 181-183°C, R_f value: 0.52, FT-IR (KBr, υ, cm-1): 3389.57 (N-H Str.), 3146.78 (=C-H str.), 2936.86 (C-H str.), 1712.35 (C=O str.), 1607.57 (C=C str.), 1238.54 (C-N str.), 749.78 (Ar C-H Bend.), 774.59 (C-Cl Bend). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 6.31-6.86 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 238.93 (M^{+2}). Anal. Calcd.: C, 50.75; H, 3.83; Cl, 14.98; N, 23.67; O, 6.76. Found: C, 50.96; H, 3.67; Cl, 14.78; N, 23.06; O, 6.56.

2.1.6 4-(2-tolylhydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4d)

Molecular formula: $C_{11}H_{12}N_4O$, Molecular weight: 216.24 Yield: 68.19%, M.P.: 155-157°C, R_f value: 0.67, FT-IR (KBr, υ, cm-1): 3423.57 (N-H Str.), 3178.70 (=C-H str.), 2956.56 (C-H str.), 1710.67 (C=O str.), 1603.68 (C=C str.), 1278.94 (C-N str.), 752.43 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 2.35 (s, 3H, CH_3) 6.34-6.82 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 217.67 (M^+1). Anal. Calcd.: C, 61.10; H, 5.59; N, 25.91; O, 7.40. Found: C, 61.56; H, 5.76; N, 25.43; O, 7.50.

2.1.7 4-(3-tolylhydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4e)

Molecular formula: $C_{11}H_{12}N_4O$, Molecular weight: 216.24 Yield: 69.22%, M.P.: 152-154°C, R_f value: 0.56, FT-IR (KBr, υ, cm-1): 3405.59 (N-H Str.), 3136.93 (=C-H str.), 2963.63 (C-H str.), 1707.73 (C=O str.), 1600.67 (C=C str.), 1209.94 (C-N str.), 743.93 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 2.35 (s, 3H, CH_3) 6.30-6.77 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 217.18 (M^{+1}). Anal. Calcd.: C, 61.10; H, 5.59; N, 25.91; O, 7.40. Found: C, 61.53; H, 5.98; N, 25.09; O, 7.73.

2.1.8 4-(4-tolylhydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4f)

Molecular formula: $C_{11}H_{12}N_4O$, Molecular weight: 216.24 Yield: 66.93%, M.P.: 159-161°C, R_f value: 0.62, FT-IR (KBr, υ, cm-1): 3476.84 (N-H Str.), 3133.75 (=C-H str.), 2922.45 (C-H str.), 1711.44 (C=O str.), 1608.35 (C=C str.), 1256.77 (C-N str.), 758.67 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 2.35 (s, 3H, CH_3) 6.29-6.70 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 217.88 (M^{+1}). Anal. Calcd.: C, 61.10; H, 5.59; N, 25.91; O, 7.40. Found: C, 61.23; H, 5.87; N, 25.67; O, 7.69.

2.1.9 4-(2-(2-methoxyphenyl)hydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4g)

Molecular formula: $C_{11}H_{12}N_4O_2$, Molecular weight: 232.24 Yield: 69.47%, M.P.: 169-171°C, R_f value: 0.88, FT-IR (KBr, υ, cm-1): 3411.24 (N-

H Str.), 3108.67 (=C-H str.), 2975.66 (C-H str.), 1719.76 (C=O str.), 1618.54 (C=C str.), 1234.56 (C-N str.), 1145.32 (C-O str.), 767.76 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 3.73 (s, 3H, OCH_3) 6.35-6.57 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 233.45 (M^{+1}). Anal. Calcd.: C, 56.89; H, 5.21; N, 24.12; O, 13.78. Found: C, 57.01; H, 5.29; N, 24.53; O, 13.90.

2.1.10 4-(2-(4-methoxyphenyl)hydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4h)

Molecular formula: $C_{11}H_{12}N_4O_2$, Molecular weight: 232.24 Yield: 63.74%, M.P.: 176-178°C, R_f value: 0.67, FT-IR (KBr, υ, cm- 1): 3433.64 (N-H Str.), 3134.45 (=C-H str.), 2955.76 (C-H str.), 1709.67 (C=O str.), 1606.46 (C=C str.), 1245.87 (C-N str.), 1123.98 (C-O str.), 756.94 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 3.73 (s, 3H, OCH_3) 6.29-6.75 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 233.92 (M^{+1}). Anal. Calcd.: C, 56.89; H, 5.21; N, 24.12; O, 13.78. Found: C, 56.76; H, 5.87; N, 24.69; O, 13.56.

2.1.11 4-(2-(2-nitrophenyl)hydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4i)

Molecular formula: $C_{10}H_9N_5O_3$, Molecular weight: 247.21 Yield: 67.87%, M.P.: 201-203°C, R_f value: 0.59, FT-IR (KBr, υ, cm- 1): 3389.62 (N-H Str.), 3101.36 (=C-H str.), 2967.12 (C-H str.), 1713.89 (C=O str.), 1609.37 (C=C str.), 1273.98 (C-N str.), 1535.72 (N-O str.), 787.27 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 6.48-6.82 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 248.34 (M^{+1}). Anal. Calcd.: C, 48.58; H, 3.67; N, 28.33; O, 19.42. Found: :C, 48.98; H, 3.88; N, 28.76; O, 19.27.

2.1.12 4-(2-(4-nitrophenyl)hydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4j)

Molecular formula: $C_{10}H_9N_5O_3$, Molecular weight: 247.21 Yield: 52.03%, M.P.: 207-209°C, R_f value: 0.63, FT-IR (KBr, υ, cm- 1): 3414.37 (N-H Str.), 3167.98 (=C-H str.), 2947.76 (C-H str.), 1711.56 (C=O str.), 1605.78 (C=C str.), 1276.48 (C-N str.), 1515.76 (N-O str.), 767.22 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 6.32-6.78 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 248.99 (M^{+1}). Anal. Calcd.: C, 48.58; H, 3.67; N, 28.33; O, 19.42. Found: C, 49.12; H, 3.56; N, 28.87; O, 19.67.

2.1.13 4-(2-(2-hydroxyphenyl)hydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4k)

Molecular formula: $C_{10}H_{10}N_4O_2$, Molecular weight: 218.21 Yield: 49.85%, M.P.: 187-189°C, R_f value: 0.58, FT-IR (KBr, υ, cm- 1): 3512.85 (O-H Str.), 3456.57 (N-H Str.), 3189.34 (=C-H str.), 2967.34 (C-H str.), 1719.47 (C=O str.), 1600.17 (C=C str.), 1243.56 (C-N str.), 777.38 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 5.0 (s, 1H, OH) 6.29-6.57 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 219.56 (M^{+1}). Anal. Calcd.: C, 55.04; H, 4.62; N, 25.68; O, 14.66. Found: C, 55.67; H, 4.87; N, 25.48; O, 14.87.

2.1.14 4-(2-(4-hydroxyphenyl)hydrazono)-3-methyl-1H-pyrazol-5(4H)-one (4l)

Molecular formula: $C_{10}H_{10}N_4O_2$, Molecular weight: 218.21 Yield: 52.03%, M.P.: 196-198°C, R_f value: 0.63, FT-IR (KBr, υ, cm- 1): 3543.76 (O-H Str.), 3433.85 (N-H Str.), 3145.75 (=C-H str.), 2976.78 (C-H str.), 1711.84 (C=O str.), 1610.67 (C=C str.), 1249.83 (C-N str.), 766.39 (Ar C-H Bend.). ^{1}H NMR (400 MHz, $CDCl_3$) δ (ppm): 0.9 (s, 3H, CH_3), 5.0 (s, 1H, OH) 6.32-6.72 (m, 4H, Ar-H), 7.0 (s, 2H, NH). MS [m/z]: 219.89 (M^{+1}). Anal. Calcd.: C, 55.04; H, 4.62; N, 25.68; O, 14.66. Found: C, 56.23; H, 4.60; N, 25.87; O, 14.77.

2.2 Biological Evaluation

2.2.1 Evaluation of Insect-antifeedant activity

Organism: The test insect *Achoea janata* larvae were collecting in laboratory and maintained under laboratory conditions of 27 ± 1°C and 70 ± 5% RH. The test larvae were fed on natural food - castor leaves. The antifeedant activity was assessed by using leaf discs in an on-choice test method of Ascher and Rones [26].

Antifeedant Test: Circular leaf discs of 9 cm diameter were cut from fresh castor leaves and treated with the solution of test compound from 100 to 3.125 μg/cm^2 by using serial dilutions. These leaf discs were air dried for 2-5 sec in acetone and were kept in petri dishes. Control discs were treated with acetone and Carbindazime and set aside in alone petri dishes. Potted IV instar larvae of *Achoea janata* were unconfined concurrently into petri dishes. The utilization of leaf by the insect was deliberate after 48 h. The leaf area obsessive by the insect

(in both control and treated) was deliberate by planimeter and the percentage of protection (antifeedant activity) was assessed by Singh and Panth formula. [27,28].

$$\%\ \textbf{of antifeedant} = \frac{(\%\ \text{of protection in treated}) - (\%\ \text{of protection in control})}{100 - (\%\ \text{of protection in control})} \times 100$$

3. RESULTS AND DISCUSSION

The main focus of this research work was to synthesize novel series of pyrazolinone derivatives, purify, characterize and evaluate their anti-feedant activity. The synthesized compounds were characterized by spectral data (^{1}HNMR, IR, Mass) and elemental analysis.

3.1 Anti-feedant Activity

After 48 h, antifeedant activity of compounds against *Achoea janata* was deliberate by using the planimeter and sheltered area (antifeedant activity) was intended by using Singh and Panth formula. Similarly, all the experiments were accepted out in triplicate and the average is reported in Table 2.

Table 1. Physico-chemical characteristics of synthesized pyrazolinone derivatives

Compound name	Name of substituted aniline (R)	Molecular formula	Molecular weight	M.P. (°C)	Yield %	R_f value
4a	o-chloro aniline	$C_{10}H_9ClN_4O$	236.66	166-168	64.53	0.71
4b	m-chloro aniline	$C_{10}H_9ClN_4O$	236.66	176-179	65.92	0.69
4c	p-chloro aniline	$C_{10}H_9ClN_4O$	236.66	181-183	70.55	0.52
4d	o-methyl aniline	$C_{11}H_{12}N_4O$	216.24	155-157	68.19	0.67
4e	m-methyl aniline	$C_{11}H_{12}N_4O$	216.24	152-154	69.22	0.56
4f	p-methyl aniline	$C_{11}H_{12}N_4O$	216.24	159-161	66.93	0.62
4g	o-methoxy aniline	$C_{11}H_{12}N_4O_2$	232.24	169-171	69.47	0.88
4h	p-methoxy aniline	$C_{11}H_{12}N_4O_2$	232.24	176-178	63.74	0.67
4i	o-nitro aniline	$C_{10}H_9N_5O_3$	247.21	201-203	67.87	0.59
4j	p-nitro aniline	$C_{10}H_9N_5O_3$	247.21	207-209	52.03	0.63
4k	o-hydroxy aniline	$C_{10}H_{10}N_4O_2$	218.21	187-189	49.85	0.58
4l	p-hydroxy aniline	$C_{10}H_{10}N_4O_2$	218.21	196-198	52.03	0.63

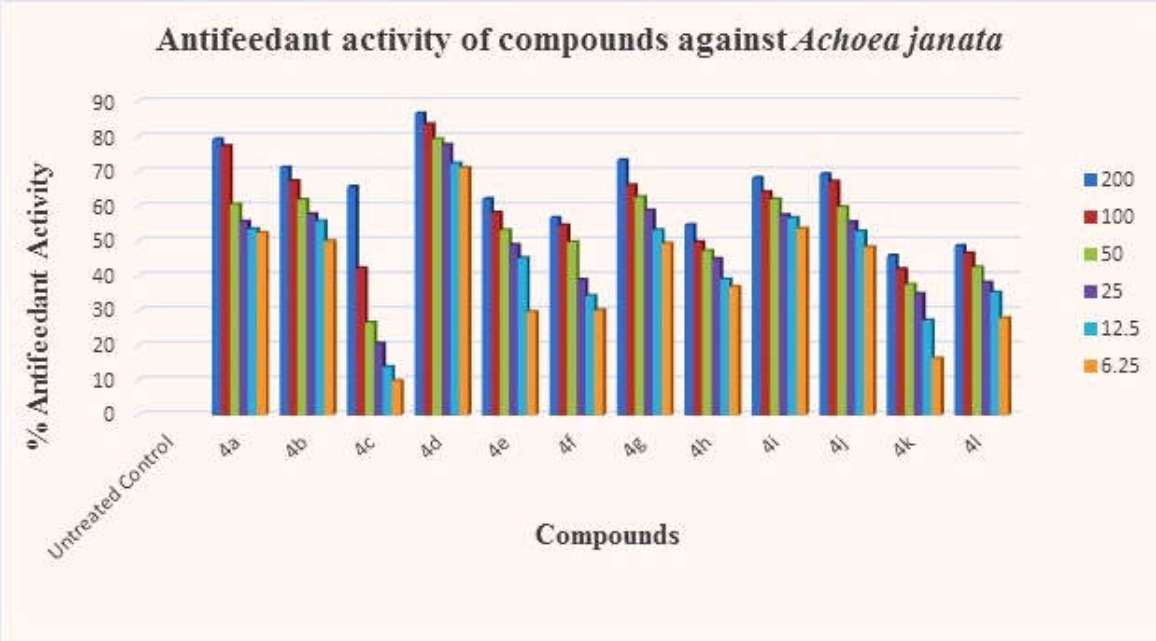


Fig. 1. Antifeedant activity of pyrazolinone derivatives

Table 2. Antifeedant activity of compounds against *Achoea janata* after 48 hrs of treatment

Compound code	% of Anti-feedant activity after 48 hrs of treatment					
	Concentration in µg/cm^2					
	200	**100**	**50**	**25**	**12.5**	**6.25**
Untreated Control	4.09 ± 0.00 (0.00)	4.09 ± 0.00 (0.00)	4.09 ± 0.00 (0.00)	4.09 ± 0.00 (0.00)	4.09 ± 0.00 (0.00)	4.09 ± 0.00 (0.00)
4a	80.12 ± 7.23 (79.27%)	78.23 ± 6.54 (77.30%)	62.24 ± 5.45 (60.62%)	57.41 ± 5.36 (55.59%)	55.36 ± 7.12 (53.45%)	54.34 ± 6.37*** (52.39%)
4b	72.34 ± 3.13 (71.16%)	68.59 ± 4.10 (67.25%)	63.47 ± 4.39 (61.91%)	59.51 ± 3.78 (57.78%)	57.53 ± 7.41 (55.71%)	52.10 ± 6.51*** (50.05%)
4c	67.11 ± 8.29 (65.70%)	44.56 ± 8.18 (42.19%)	29.57 ± 10.05 (26.56%)	23.78 ± 9.56 (20.52%)	17.41 ± 8.74 (13.88%)	13.58 ± 7.47** (9.89%)
4d	87.19 ± 2.23 (86.64%)	84.28 ± 1.19 (83.60%)	80.09 ± 4.39 (79.24%)	78.56 ± 2.45 (77.64%)	73.47 ± 3.23 (72.33%)	72.25 ± 1.18*** (71.06%)
4e	63.69 ± 9.63 (62.14%)	59.83 ± 8.34 (58.11%)	55.13 ± 8.47 (53.21%)	51.04 ± 11.02 (48.95%)	47.45 ± 10.26 (45.20%)	32.49 ± 9.21** (29.61%)
4f	58.43 ± 4.36 (56.65%)	56.37 ± 7.61 (54.50%)	51.86 ± 5.87 (49.80%)	41.36 ± 5.12 (38.85%)	37.02 ± 9.18 (34.33%)	33.05 ± 7.41** (30.19%)
4g	74.35 ± 11.02 (73.25%)	67.41 ± 13.36 (66.02%)	64.18 ± 12.23 (62.65%)	60.50 ± 9.51 (58.81%)	55.18 ± 8.04 (53.26%)	51.39 ± 12.21** (49.31%)
4h	56.61 ± 8.21 (54.75%)	51.79 ± 7.87 (49.73%)	49.31 ± 6.69 (47.14%)	47.19 ± 7.14 (44.93%)	41.52 ± 9.48 (39.02%)	39.45 ± 10.09** (36.86%)
4i	69.48 ± 4.56 (68.17%)	65.51 ± 6.51 (64.03%)	63.59 ± 7.19 (62.03%)	59.23 ± 8.70 (57.49%)	58.49 ± 8.74 (56.71%)	55.54 ± 6.59*** (53.64%)
4j	70.52 ± 11.15 (69.26%)	68.49 ± 12.53 (67.14%)	61.47 ± 11.52 (59.82%)	57.31 ± 10.29 (55.48%)	54.80 ± 7.84 (52.87%)	50.37 ± 9.73** (48.25%)
4k	48.12 ± 6.36 (45.90%)	44.38 ± 5.32 (42.00%)	40.09 ± 4.19 (37.53%)	37.55 ± 8.11 (34.88%)	30.19 ± 10.65 (27.21%)	19.78 ± 7.57** (16.35%)
4l	50.78 ± 3.12 (48.68%)	48.67 ± 4.26 (46.48%)	44.85 ± 5.20 (42.49%)	40.67 ± 4.81 (38.13%)	37.96 ± 5.45 (35.31%)	30.88 ± 6.13** (27.93%)

*Values are expressed as mean ± SEM of triplicate. **Statistically significant (P<0.05). ***Statistically significant (P<0.01)*

All the compounds tested (**4a** to **4l**) exhibited moderate to good antifeedant activity against *Achoea janata* at 200 to 6.25 µg/cm^2 concentrations. The activity persisted even after 48 h, though it generally recedes after 24 h. Of the twelve compounds tested, Compound 4d is the most promising with 71.06% antifeedant activity even at 6.25 µg/cm^2 concentration and can be considered as a potent antifeedant. Compound 4a, 4b and 4i showed more than 50% leaf protection at 6.25 µg/cm^2 concentration.

4. CONCLUSION

The main focus of this research work was to synthesize novel series of pyrazolinone derivatives, purify, characterize and evaluate their antifeedant activity. The synthesized compounds were characterized by spectral data (^{1}HNMR, IR, Mass) and elemental analysis. The compounds were subjected *to in –vitro* antifeedant activity against *Achoea janata.* The results showed that the synthesized compounds

possessed weak to good antifeedant activities against the tested pest, with compounds 4d displaying potent activity. Further studies are currently underway to establish a definite structure activity relationship.

DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

CONSENT

It is not applicable.

ETHICAL APPROVAL

It is not applicable.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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