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A REVIEW ON ANTICANCER POTENTIAL OF SUBSTITUTED PYRAZOLINE DERIVATIVES

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ABSTRACT
Pyrazoline is a versatile heterocyclic molecule which bears two nitrogen atoms. It possesses multiple biological and pharmacological activities. Scientists keep an effort to furnish the pyrazoline moiety as a flawless anticancer agent. The pyrazoline moiety when attached with different aromatic, alicyclic, alkyl and heterocyclic compounds at different positions on the ring may enhance the anticancer activity. The present review is an assortment of different derivatives of pyrazoline which exhibit anticancer activity.

KEYWORDS: Pyrazoline, Acetophenone, Aldehydes, Chalcones, Phenylhydrazine, Isoniazid, Anticancer activity.

INTRODUCTION

Cancer is a universal health predicament and the most frightening disease in humans. Environmental factors and carcinogens are the main causes of cancer. A key feature of cancerous cells is their uncontrolled proliferation, impending to march into or spread to other parts of the body.[1] Thus, the inhibition of proliferative pathways is believed to be an effective strategy to fight cancer. There are more than 100 types of cancers, including breast cancer, skin cancer, lung cancer, colon cancer, prostate cancer and lymphoma.[2] The different types of treatments available to treat cancer may include chemotherapy, radiation therapy and surgery.[3] Due to increasing toxic waste and the use of carcinogens, this lethal disease is increasing its pervasiveness. The majority of cancers are either resistant to chemotherapy or acquire resistance during treatment. As a result, the design and discovery of non-traditional, efficient and safe chemical classes of agents are the prime targets of contemporary medicinal chemistry.

Heterocyclic compounds widely occur in nature in the form of amino acids, alkaloids, hormones, vitamins, pigments and as constituents of plant and animal cell. Heterocyclic compounds play a foremost responsibility in each and every phase of life. Pyrazolines constitute an important heterocyclic family with electron rich nitrogen atoms, which play an important role in the diverse biological activities. Depending upon the substituted group on pyrazole ring, it shows multiple pharmacological activities like antimicrobial,[4] anti-inflammatory,[5] antioxidant,[6] analgesic,[7] anti-convulsant,[8] anticancer,[9] antimalarial,[10] anti-Alzheimer's,[11] antiamoebic activity[12] and many more. Many research articles revealed that pyrazolines exhibit anticancer activity and substantial research has been done to design new and supreme anticancer drugs. Huge attention has been focused on the development of substituted pyrazoline derivatives due to their remarkable cytotoxic activities. The present manuscript was a brief review of different methods for the synthesis of anticancer active pyrazoline derivatives.

ANTICANCER ACTIVE PYRAZOLINE DERIVATIVES

Furan linked with pyrazoline derivatives

Jadhav et al.,[13] reported the anticancer activity of a novel series of five 1(2,4-dintrophenyl)3(substitutedphenyl/furan)-5(4-substitutedphenyl)pyrazoline derivatives 1 (fig 1). The key intermediate chalcone was treated with 2,4-dinitrophenylhydrazine reagent to afford the title derivative. The synthesized pyrazoline derivatives were prospected for anticancer activity by MTT (thiazolyl blue tetrazolium bromide) assay using human cervical carcinoma (MCF 7) cell line maintained in MEM medium supplemented with 10% fetal bovine serum. The results were compared with the standard drug inhibitors 5-fluorouracil. All the synthesized derivatives showed moderate to considerable activity due to the presence of nitro group at C-2 and C-4 position of phenyl ring present on position-1 of pyrazoline (table 1).

3,4,5-trimethoxyphenyl linked with pyrazoline derivatives

Elmeligie et al.,[14] developed a new series of N1-substituted-5-aryl-3-(3,4,5-trimethoxyphenyl)-2-pyrazoline derivatives 2 as antitumor agents targeting the colchicine site on tubulin (fig 1). The chalcones have been synthesized by Claisen–Schmidt condensation of 3,4,5-trimethoxyacetophenone and different substituted benzaldehydes in ethanol containing potassium hydroxide as a catalyst. Cyclization of chalcone with hydrazine hydrate in formic acid furnished the desired pyrazoline. The cytotoxic activity of all new compounds was investigated *in vitro* against breast cancer cell lines (MCF-7) and colon cancer cell line (HCT-116) using sulphorhodamine B stain (SRB) colorimetric assay. Colchicine was used as a positive control. Furthermore, *in vivo* evaluation of the synthesized compounds was carried out against *Ehrlich's ascites* carcinoma (EAC) solid tumor grown in mice. The compounds containing 3,4-dimethoxy substitution on the ring B showed the highest antitumour activity against both tested cell lines, whereas, compounds with the 4-bromo and 3,4,5-trimethoxy substitution were the most active against MCF-7 cell line (table 1).

Thioxoimidazolidin linked with pyrazoline derivatives

Fahmy et al.,[15] synthesized (Z)-5-((3-(4-bromophenyl)-1-ethyl-1H-pyrazol-4-yl)methylene)-3-aryl-2-thioxoimidazolidin-4-one 3 and screened for their anti-cancer activity on five human cancer cell lines, namely: hepatocellular carcinoma HepG2, breast cancer MCF-7, lung carcinoma A549 and prostatic cancer PC3 (fig 1). The synthetic pathway employed to obtain new tri-substituted pyrazole derivatives was started by the formylation of semicarbazone via Vilsmeier–Haack reaction to give 3-(4-bromophenyl)-1H-pyrazole-4-carbaldehyde which upon treated with iodoethane in DMF at room temperature in the presence of anhydrous potassium carbonate. Cell viability was assessed by the mitochondrial dependent reduction of yellow MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazoliumbromide] to purple Formosan. The synthesized derivative with methylphenyl group at position-3 of pyrazoline showed higher activity than the standard reference doxorubicin (IC50 = 34.24 µM) on the HepG2 and MCF-7 cell lines with IC50 of 21.74 µM and 36.67 µM respectively. Concerning the lung carcinoma cell line A549, the derivative with phenyl group at position-3 showed activity with IC50 of 22.17µM compared to doxorubicin (IC50 = 5.93 µM). The synthesized compound with fluorophenyl ring at position-3 on pyrazoline ring showed activity on the MCF-7 and A549 cell lines. All the derivatives are inactive on the prostatic cancer PC3 cell line (table 1).

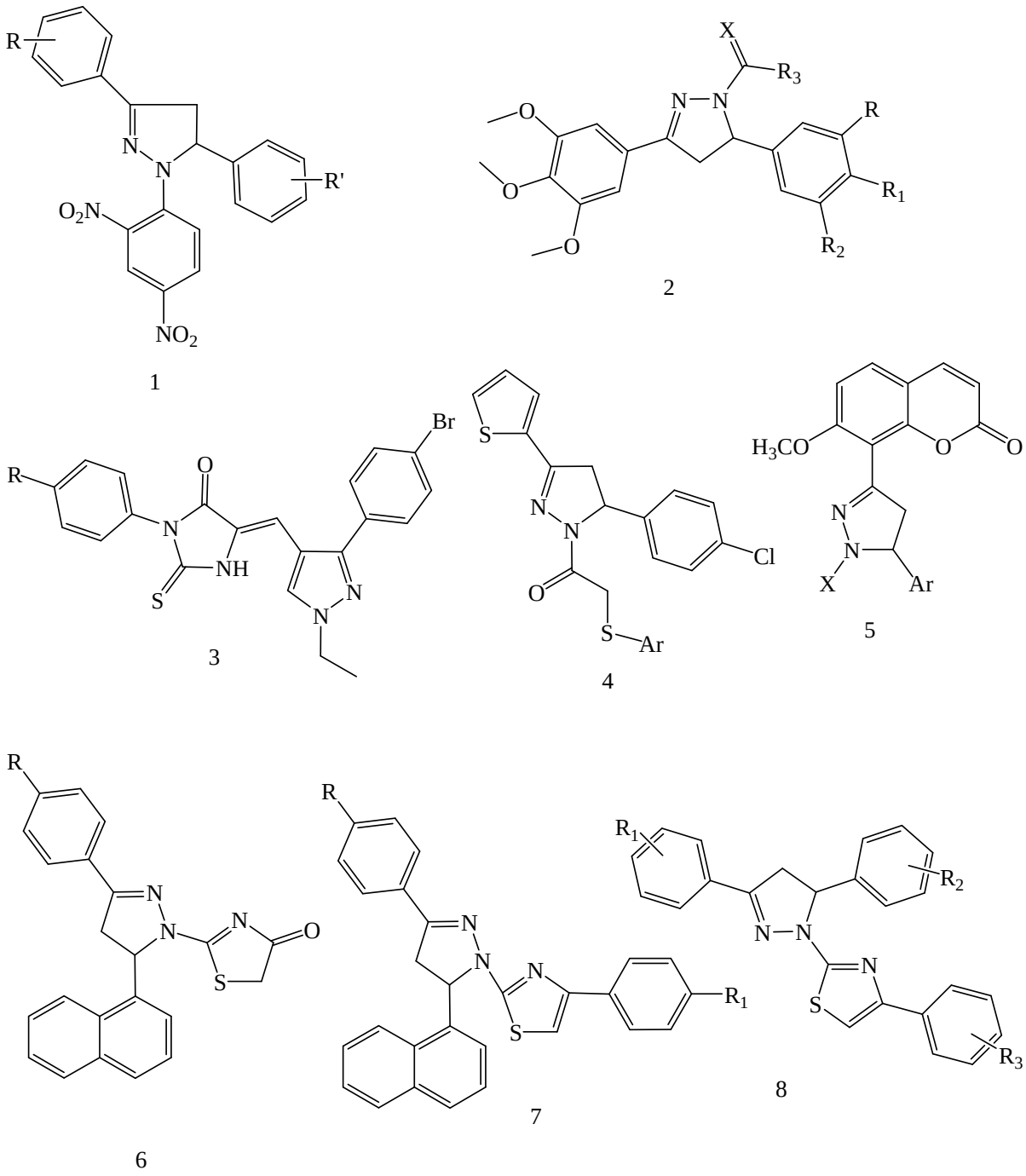
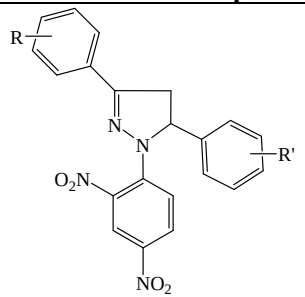
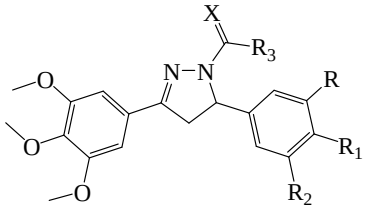
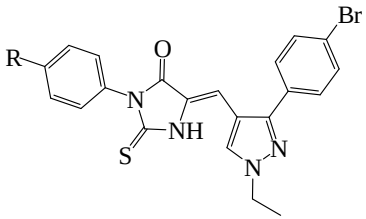
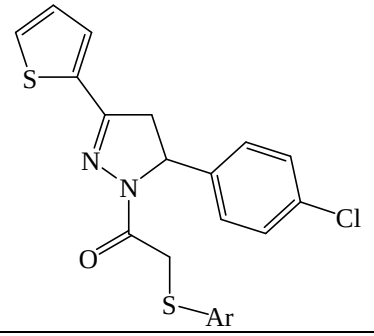
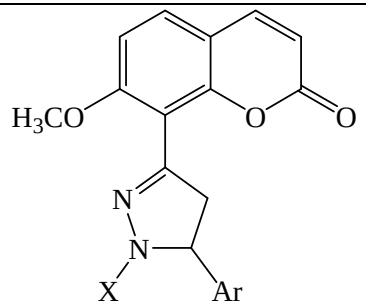
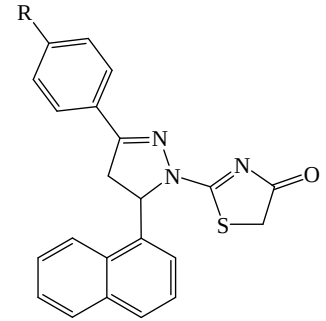
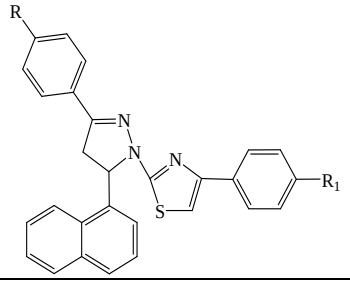
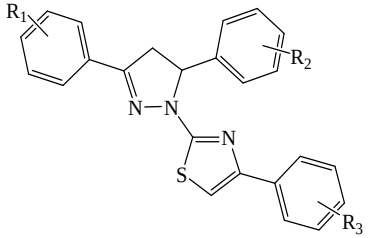


Fig. 1: Structures of anticancer active pyrazoline derivatives 1-8.

Table 1: Anticancer activity of pyrazoline derivatives.

S. No.	Name of the compound	Structure of the compound	Method used	Cell lines used	Result	Reference
1	1(2,4-dintrophenyl) 3(substitutedphenyl/ furan) -5(4-substituted phenyl) pyrazoline derivatives		MTT assay	MCF 7 (human cervical carcinoma)	Moderately active	[13]
2	N1-substituted-5-aryl-3-(3,4,5-trimethoxyphenyl) -2-pyrazoline derivatives		Sulphorhodamine B stain (SRB) colorimetric assay	MCF-7 HCT-116	Highly active Highly active	[14]
3	(Z)-5-((3-(4-bromophenyl) -1-ethyl-1H-pyrazol-4-yl) methylene)-3-aryl-2-thioxoimidazolidin-4-one		MTT assay	Hepatocellular carcinoma HepG2 Breast cancer MCF-7 Lung carcinoma A549 Prostatic cancer PC3	Highly active Highly active Highly active No active	[15]
4	1-[(aryl)thioacetyl]-3-(2-thienyl)-5-(4-chlorophenyl)-2-pyrazoline derivatives		MTT assay	AsPC-1 human pancreatic adenocarcinoma U87 and U251 human glioblastoma	Highly active Highly active	[16]

5	8-(5-substituted-1-phenyl-4,5-dihydro-1H-pyrazol-3-yl)-7-methoxy-2H-chromen-2-one		MTT assay	HepG2 cell lines	Highly active	[17]
6	pyrazolothiazol-4(5H)-one derivative pyrazolothiazole derivatives	 		MCF-7 breast carcinoma HCT-116colon carcinoma cell lines MCF-7 breast carcinoma HCT-116colon carcinoma cell lines	Highly active Highly active Highly active Highly active	[18]
7	3-(2,3,4-trimethylphenyl)-5-(fluorophenyl)-1-(5-(chlorophenyl)thiazol-1-yl)-4,5dihydro-pyrazoline		EGFR kinase inhibitory activity		Highly active	[19]

Thiophene linked with pyrazoline derivatives

Karabacak et al.,[16] designed and synthesized twelve new 1-[(aryl)thioacetyl]-3-(2-thienyl)-5-(4-chlorophenyl)-2-pyrazoline derivatives 4 (fig 1). Claisen-Schmidt condensation of 2-acetylthiophene with 4-chlorobenzaldehyde yields 1-(2-thienyl)-3-(4-chlorophenyl)-2-propen -1-one with hydrazine hydrate furnishes the desired compound. The synthesized compounds were screened for their cytotoxic studies on AsPC-1 human pancreatic adenocarcinoma, U87 and U251 human glioblastoma cell lines by MTT assay. Cisplatin was used as control. 1-[((5-(4-methylphenyl)-1,3,4-oxadiazol-2-yl)thio)acetyl]-3-(2-thienyl)-5-(4-chlorophenyl)-2-pyrazoline was found to be the most effective anticancer agent against AsPC-1 and U251 cell lines, with IC_{50} values of 16.8 μM and 11.9 μM, respectively. Hence the effective compound was chosen for apoptosis evaluation and DNA-cleavage analysis in U251 cells (table 1).

Coumarin linked with pyrazoline derivatives

Amin et al.,[17] reported the cytotoxicity of four series of coumarin derivatives 5 bearing diversely substituted pyrazoline moieties (fig 1). The targeted compounds were synthesized from 8-acetyl-7-methoxycoumarin that underwent Claisen-Schmidt condensation with various aldehydes to give the chalcones, followed by reaction with hydrazine hydrate, phenylhydrazine and semicarbazide under the appropriate conditions. The anticancer activity of synthesized compounds was evaluated *in vitro* test against liver HepG2 cell lines using the MTT method in presence of doxorubicin as standard. All the synthesized compounds demonstrated IC_{50} values in the nanomolar range. Compounds bearing lipophilic moieties and unsubstitution at N1 of pyrazoline ring showed potent anticancer activity. The most active compounds were deliberated to understand the mechanism of action for their telomerase inhibitory activity where the percent reduction in telomerase activity ranged from 61.7-78.6% (table 1).

Thiazole linked with pyrazoline derivatives

Zakaria et al.,[18] reported the synthesis of some new pyrazolothiazole 6 and pyrazolothiazol-4(5H)-one 7 derivatives (fig 1). Cyclization of N-thiocarbamoyl pyrazole derivative with phenacyl bromide yields pyrazolothiazole 6, where as cyclization with ethylbromo acetate yields pyrazolothiazol-4(5H)-one 7. The synthesized compounds were investigated for their anticancer activity against breast carcinoma (MCF-7) and colon carcinoma (HCT-116) cell lines. Doxorubicin was used as standard. The pyrazoline derivatives with bromophenyl, methoxyphenyl and chlorophenyl substituents showed potent anticancer activity against both the cell lines used. The compound pyrazolothiazole derivative with bromophenyl and methylphenyl substituent displayed the most potent antitumor effect against the two cell lines with IC_{50} (1.01, 1.22μg/ml) (table 1).

Lv et al.,[19] reported forty-two thiazolyl-pyrazoline derivatives 8 and screened for their EGFR kinase inhibitory activity (fig 1). The key intermediate chalcone when treatment with thiosemicarbazide under basic condition led to the formation of pyrazoline derivatives containing thiourea skeleton which upon treated with substituted 2-bromoacetophenone furnishes the targeted compound. The structure–activity relationships in the synthesized compounds demonstrated that compounds bearing 4-methoxyphenyl group at 3-position of pyrazoline ring showed better EGFR inhibitory activity (IC_{50}:5.07–8.63 lM) than bromophenyl substituent (IC_{50}:8.95–28.17 lM) at the same position. Further modification of the same position with 3,4-dimethoxyphenyl group showed a remarkable increase in the inhibitory activity of EGFR kinase. The derivatives with electron withdrawing substituents at 4-position of phenyl ring, which was linked to pyrazoline ring at 5-position had more potent EGFR inhibitory activities (IC_{50}: 0.06–0.63 lM) than the electron-donating substituents (IC_{50}: 0.82–1.04 lM) at the same position (table 1).

Thiazolidine linked with pyrazoline derivatives

Abdullah et al.,[20] synthesized two novel series of (2-{4-[5-(4-substituted-phenyl)-1H-pyrazol-3-yl]-phenylimino}-4-oxo-3-substitutedthiazolidin-5-yl)-acetic acid 9 and (2-{4-[5-(4-substituted-phenyl)-1-hydrazinothiocarbonyl-4,5-dihydro-1Hpyrazol-3yl]-phenylimino}-4-oxo-3-substituted-thiazolidin-5-yl)-acetic acid 10 (fig 2). The compound (2-{4-[3-(4-substituted-phenyl)-acryloyl]-phenylimino}-4-oxo-3-substituted-thiazolidin-5-yl)-acetic acid upon condensation with aromatic aldehydes yields (2-{4-[5-(4-substituted-phenyl)-1H-pyrazol-3-yl]-phenylimino}-4-oxo-3-substituted-thiazolidin-5-yl)-acetic acid. The yielded compound when treated with phenylhydrazine and thiocarbohydrazide furnishes the title compounds respectively. Their anticancer activity was screened by Sulforodamine B(SRB) standard method against human mammary carcinoma cell line (MCF7) in comparison with doxoruobicin as the reference drug. The derivatives (2-{4-[5-(4-methoxyphenyl)-1H-pyrazol-3-yl]-phenylimino}-4-oxo-3-ethyl-thiazolidin-5-yl)-acetic acid and (2-{4-[5-(4-methoxy-phenyl)-1-hydrazino thiocarbonyl-4,5-dihydro-1H-pyrazol-3yl]-phenylimino}-4-oxo-3-ethyl-thiazolidin-5-yl)-acetic acid exhibited promising anticancer activity with IC_{50} values 3.22, 3,30 μM respectively (table 2).

Naphthalene linked with pyrazoline derivatives

Lu et al.,[21] furnished a new disubstituted pyrazoline analogue 11 (fig 2). Claisen–Schmidt condensation between intended acetophenone compound and differently substituted aldehydes resulted in the formation of corresponding chalcones which were cyclized by hydrazine hydrate to yield the pyrazoline intermediates. These pyrazoline intermediates were treated with α-naphthyl isothiocyanate which led to the formation of the title compound. The synthesized

analogues were evaluated for their *in vitro* anticancer efficacies against human non-small-cell lung cancer cell line A549 by MTT assay with reference to control drug adriamycin. It was confirmed that compounds with the substitution of fluorine and alkoxy functionalities showed increased potencies than unsubstituted analogs. The derivative 5-(4-fluorophenyl)-N-(naphthalen-1-yl)-3-(3,4,5-trimethoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide exhibited maximum activity due to the presence of highly electronegative fluorine substitution. Further the derivatives 5-(4-(methylthio)phenyl)-N-(naphthalen-1-yl)-3-(3,4,5-trimethoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide and 5-(4-methoxyphenyl)-N-(naphthalen-1-yl)-3-(3,4,5-trimethoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbo thioamide showed considerable activity compared to the standard drug (table 2).

Al-Abdullah[22] designed 1-acetyl-3-tetrahydronaphthalene-2-pyrazoline derivatives 12 by the treatment of aryl-1-(1,2,3,4-tetrahydronaphthalen-6-yl)prop-2-en-1-ones with phenylhydrazine in acetic acid. The synthesized compounds anticancer activity was investigated against human cervix carcinoma cell line (Hela) and human breast carcinoma cell line (MCF7) in comparison with 5-fluorouracil (5-FU) as a reference standard (fig 2). The synthesized compound 1-acetyl-4-(2,6-difluorophenyl)-3-(1,2,3,4-tetrahydro naphthalen-6-yl)-2-pyrazoline was shown marginal anticancer activity towards the cell lines used (table 2).

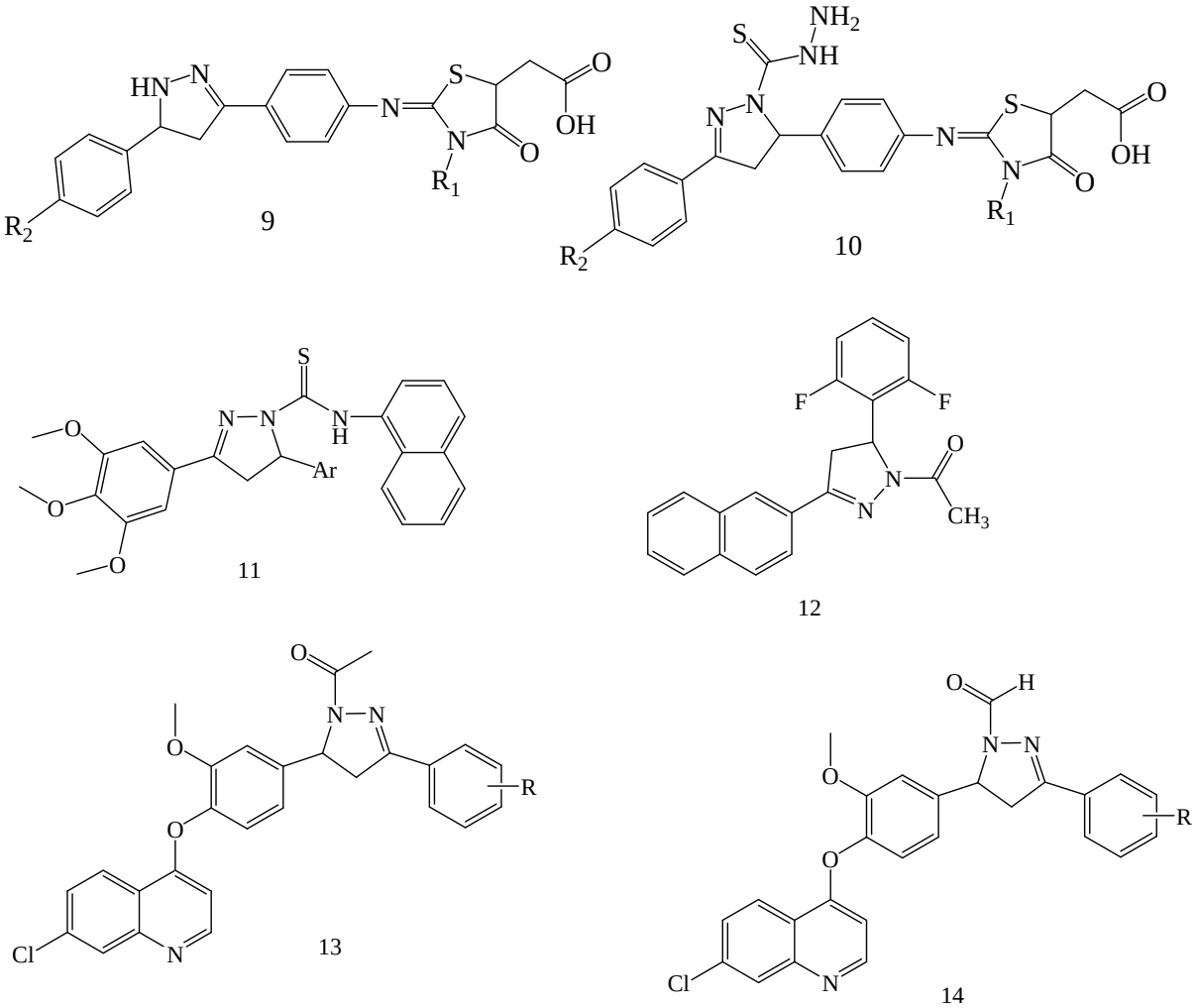
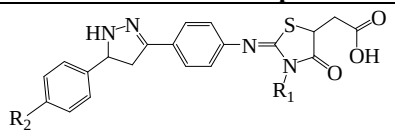
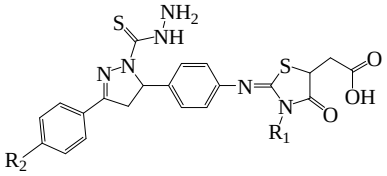
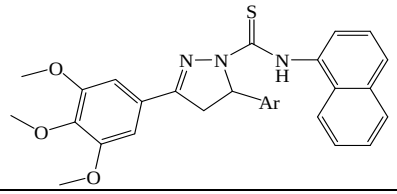
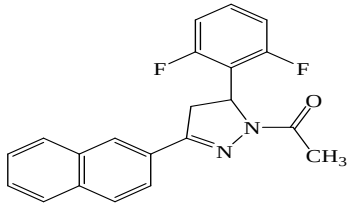
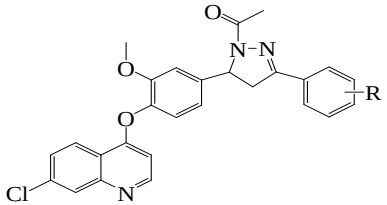
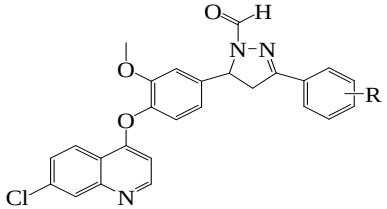


Fig. 2: Structures of anticancer active pyrazoline derivatives 9-14.

Table 2: Anticancer activity of pyrazoline derivatives

S. No.	Name of the compound	Structure of the compound	Method used	Cell lines used	Report of the study	Reference
1	(2-{4-[5-(4-substituted-phenyl)-1H-pyrazol-3-yl]-phenylimino}-4-oxo-3-substitutedthiazolidin-5-yl)-acetic acid		Sulforodamine B (SRB) standard method	MCF 7 (human mammary carcinoma)	Moderately active	[20]
	(2-{4-[5-(4-substituted-phenyl)-1-hydrazinothio carbonyl-4,5-dihydro-1Hpyrazol-3yl]-phenylimino}-4-oxo-3-substituted-thiazolidin-5-yl)-acetic acid		Sulforodamine B (SRB) standard method	MCF 7 (human mammary carcinoma)	Moderately active	
2	5-(4-substituted phenyl)-N-(naphthalen-1-yl)-3-(3,4,5-trimethoxyphenyl)-4,5-dihydro-1H-pyrazole-1-carbothioamide		Sulforodamine B stain (SRB) colorimetric assay	MCF-7 HCT-116	Highly active Highly active	[21]
3	1-acetyl-3-tetrahydronapthalene-2-pyrazoline derivative 12		-	Hela human cervix carcinoma cell line MCF7 Human breast carcinoma cell line	Moderately active Moderately active	[22]
4	N-acetylpyrazoline derivatives		MTT assay	AsPC-1 human pancreatic adenocarcinoma U87 and U251 human glioblastoma	Moderately active Moderately active	[23]
	N-formylpyrazoline derivatives		MTT assay	AsPC-1 human pancreatic adenocarcinoma U87 and U251 human glioblastoma	Moderately active Moderately active	

Quinoline linked with pyrazoline derivatives

Alba et al.,[23] reported two new series of N-acetyl and N-formylpyrazoline derivatives 13 & 14 (fig 2). The intermediate pyrazolines were synthesized by cyclo condensation reaction of novel [(7-chloroquinolin-4-yl)oxy]chalcones with hydrazine hydrate carried out in microwave irradiation for 6 min at a power of 100 W and temperature of 100°C. The synthesized pyrazolines upon treatment with acetic anhydride or formic acid yields the desired compound. The synthesized derivatives were screened for their antitumor activity against different cell lines. The antitumor evaluation data revealed that N-acetylpyrazoline derivatives with 4-chlorophenyl, 4-methoxyphenyl and 4-methylphenyl substituents and N-formylpyrazoline derivatives with 4-methylphenyl substituent at position-3 on pyrazoline ring exhibited remarkable activity with GI_{50} values in the range from 10^{-7} to 10^{-6} M against different cancer cell lines (table 2).

Steroid linked with pyrazoline derivative

Shamsuzzaman et al.,[24] designed steroidal pyrazoline derivatives 15 and evaluated their in-vitro anticancer activity (fig 3). The pyrazoline derivatives were synthesized by the treatment of steroidal α,β-unsaturated ketone in DMSO with 2,4-dinitrophenylhydrazine in presence of few drops of acetic acid. Anticancer activity was performed against human cancer cell lines viz., SW480 (human colon adenocarcinoma cells), HeLa (human cervical cancer cells), A549 (human lung carcinoma cells), HepG2 (human hepatic carcinoma cells), HL-60 (human Leukaemia) by MTT [3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide] assay. The compound 3β-chloro2'-(2",4"-dinitrophenyl)-5α-cholestano[5,7-c d]pyrazoline showed minimum IC_{50}= 15.39 (HL-60), 18.31 (A549), 23.52 (HepG2). While compound 3β-Acetoxy2'-(2",4"-dinitrophenyl)-5α-cholestano[5,7-c d] pyrazoline showed minimum IC_{50}= 26.53 (HepG2), 27.63 (HL-60), 31.71 (A549). The compound 2'-(2'',4''-Dinitrophenyl)-5a-cholestano [5,7-c d] pyrazoline was not showing effective IC_{50} values. Thus the synthesized compound with chloro substituent can be considered as better anticancer agent [IC_{50} =15.39 (HL-60)] (table 3).

Iqbal Choudhary et al.,[25] synthesized a new series of fifty-nine pyrazoline derivatives of pregnenolone 16 from differently substituted phenylhydrazines and different benzylidene derivatives in the presence of hydrochloric acid through parallel synthesis approach (fig 3). All the synthesized derivatives were screened by cytotoxicity assay which was performed against human breast (MDA-MB-231) and liver (HepG2) cancer cell lines by MTT [3-(4,5-dimethyl thiazole-2-yl)-2,5-diphenyltetrazoliumbromide]colorimetric method. The cytotoxicity data of pyrazoline derivatives revealed that only furanyl bearing pyrazolines exhibited significant anticancer activity (table 3).

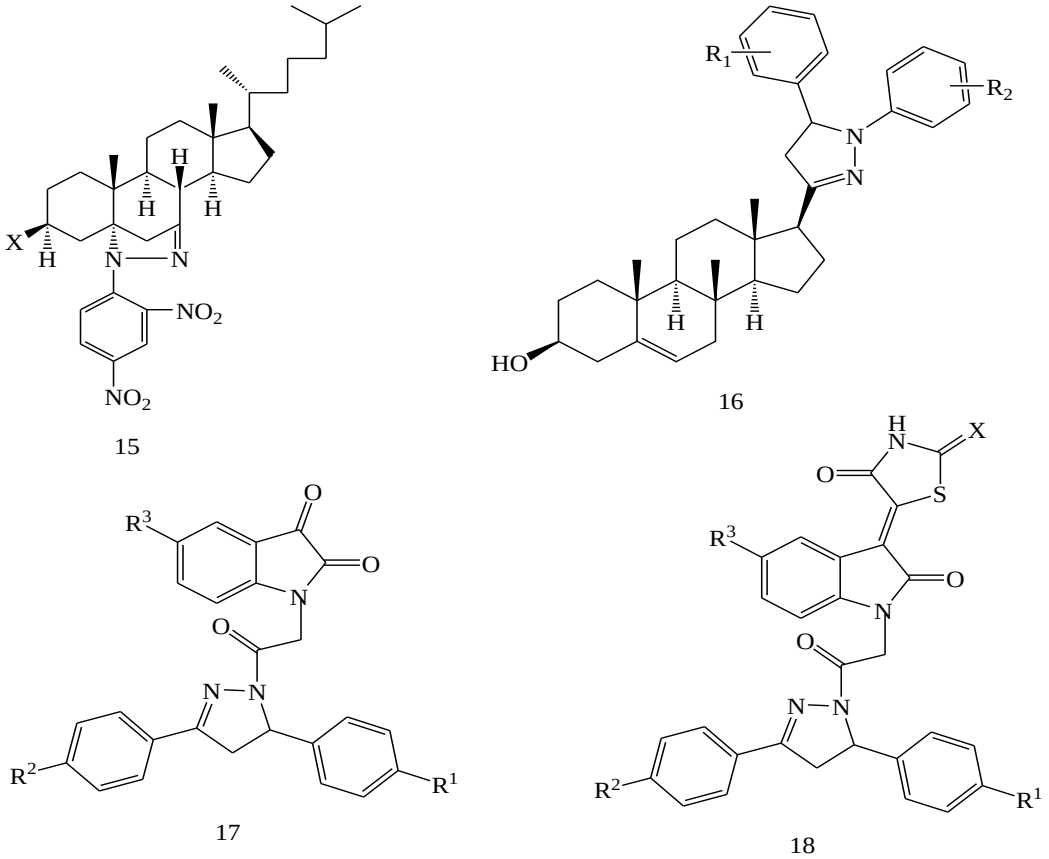
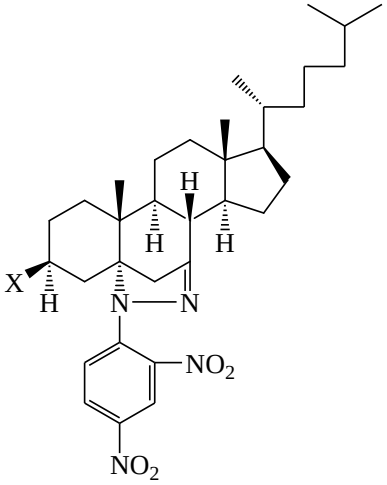
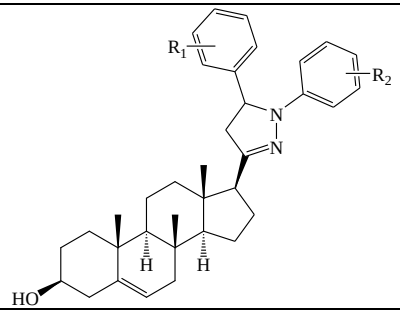
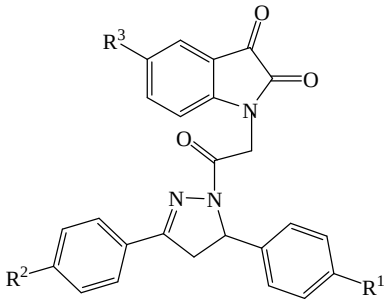
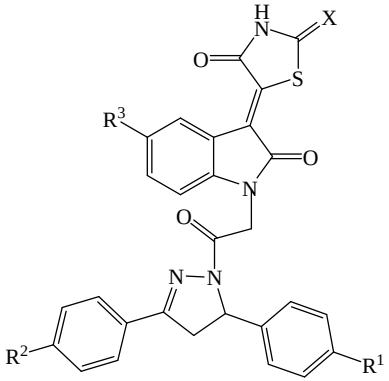


Fig. 3: Structures of anticancer active pyrazoline derivatives 15-18.

Table 3: Anticancer activity of pyrazoline derivatives

S. No.	Name of the compound	Structure of the compound	Method used	Cell lines used	Report of the study	Reference
1	3β-substituted 2'-(2",4"-dinitrophenyl)-5α-cholestano[5,7-c d] pyrazoline		MTT assay	SW480 (human colon adenocarcinoma cells) HeLa (human cervical cancer cells) A549 (human lung carcinoma cells) HepG2 (human hepatic carcinoma cells) HL-60 (human Leukaemia)	Moderately active Moderately active Highly active Moderately active Moderately active	[24]
2	Pregnenolone pyrazoline derivatives		MTT assay	MDA-MB-231 human breast HepG2 liver cancer cell lines	Highly active Highly active	[25]

3	1-[2-(3,5-diaryl-4,5-dihydropyrazol-1-yl)-2-oxoethyl]-1H-indole-2,3-diones		-	NCI60 cell lines	Highly active	[26]
	5-(1-{2-[3,5-diaryl-4,5-dihydropyrazol-1-yl]-2-oxoethyl}-2-oxo-1,2-dihydroindol-3-ylidene)-4-substituted thiazolidinones		-	NCI60 cell lines	Moderately active	

Isatin linked with pyrazoline derivatives

Havrylyuk et al.,[26] screened the antitumor activity of novel isatin based conjugates with pyrazoline 17 and thiazolidine moieties 18 (fig 3). The compounds 3,5-diaryl-4,5-dihydropyrazoles were synthesized by condensation reaction of corresponding chalcones and phenyl hydrazine. Then the reaction of 3,5-diaryl-4,5-dihydropyrazoles with chloroacetyl chloride yielded 2-chloro-1-(3,5-diaryl-4,5-dihydropyrazol-1-yl)-ethanones which were utilized in alkylation of isatin and 5-bromoisatin. Thus the corresponding 1-[2-(3,5-diaryl-4,5-dihydropyrazol-1-yl)-2-oxoethyl]-1H-indole-2,3-diones was obtained. The obtained compounds were used in Knoevenagel condensation with 4-thiazolidinones to yield a series of 5-ylidenederivatives. The anticancer activity was evaluated against NCI60 cell lines at the single concentration of 10^{-5} M towards a panel of approximately sixty cancer cell lines. The human tumor cell lines were derived from nine different cancer types: Leukemia, melanoma, lung, colon, CNS, ovarian, renal, prostate, and breast cancers. From the anticancer investigations of the synthesized compounds, it was revealed that the derivative 5-bromo-1-{2-[5-(4-chlorophenyl)-3-(4-methoxyphenyl)-4,5-dihydropyrazol-1-yl]-2-oxoethyl}-1H-indole -2,3-dione was found to be the most active compound with selective influence on leukaemia subpanel tumour cell lines with GI50 values range of 0.69–3.35 mM (table 3).

CONCLUSION

Pyrazolines are well recognized and significant nitrogen containing 5-membered heterocyclic compounds which exhibit versatile therapeutic potential towards many diseases. Diverse methods have been worked out for the synthesis of potential anticancer pyrazoline derivatives. Pyrazoline attached with different moieties at different positions on the ring have been found to possess considerable anticancer activity, which inspired the research activity in the field of synthetic and medicinal chemistry.

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AUTHORS CONTRIBUTION

The complete review work was suggested and designed by Raja S and Asha Deepti C. Literature collection and written works were carried out by Muralidharan V. The review manuscript was drafted by Muralidharan V. The manuscript was edited by Raja S and Asha Deepti C. Authors read and approved the final manuscript.

CONFLICT OF INTERESTS

Authors declare no conflict of interest.

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