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Microwave Assisted Synthesis of 5-[4-(3-Phenyl-4,5-dihydro-1*H*-pyrazol-5-yl)phenyl]-1*H*-tetrazole Derivatives and Their Antimicrobial Activity

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Abstract—In the present study, we report the synthesis of 5-[4-(3-phenyl-4,5-dihydro-1*H*-pyrazol-5-yl)phenyl]-1*H*-tetrazole derivatives by the Michael addition of chalcones to hydrazine hydrate in presence of acetic acid under conventional heating and microwave irradiation. All the synthesized compounds are characterized by IR, NMR, and mass spectra. The products are screened for their *in vitro* antimicrobial activity against strains such as *Staphylococcus aurous, Bacillus subtilis, Klebsiella pneumonia, Escherichia coli*, *Aspergillus Niger*, *Aspergillus flavus*, and *Fusarium oxysporum*. Most of the compounds exhibit high activity.

Keywords: acetophenone, 4-(1*H*-tetrazol-5-yl)benzaldehyde, microwave irradiation, antimicrobial activity

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INTRODUCTION

Tetrazole derivatives are broadly screened and well documented as biologically active compounds. Fairly recently the drugs Pemirolast [1] and Pranlukast [1] containing the NH unsubstituted tetrazole ring were introduced as a new generation of antihistaminic drugs, that effectively acted on both H1 and H2 receptors of mast cells. Pyrazoles are present as a core structural block in a wide variety of compounds that demonstrate important pharmaceutical activities including antimicrobial [2], antiviral [3], anti-inflammatory [4, 5], cytotoxic [6], and many more.

Synthesis of heterocyclic compounds under microwave irradiation is usually characterized by enhanced reaction rate, higher yield and purity of products making this approach to be a powerful tool for rapid and efficient synthesis [7–9].

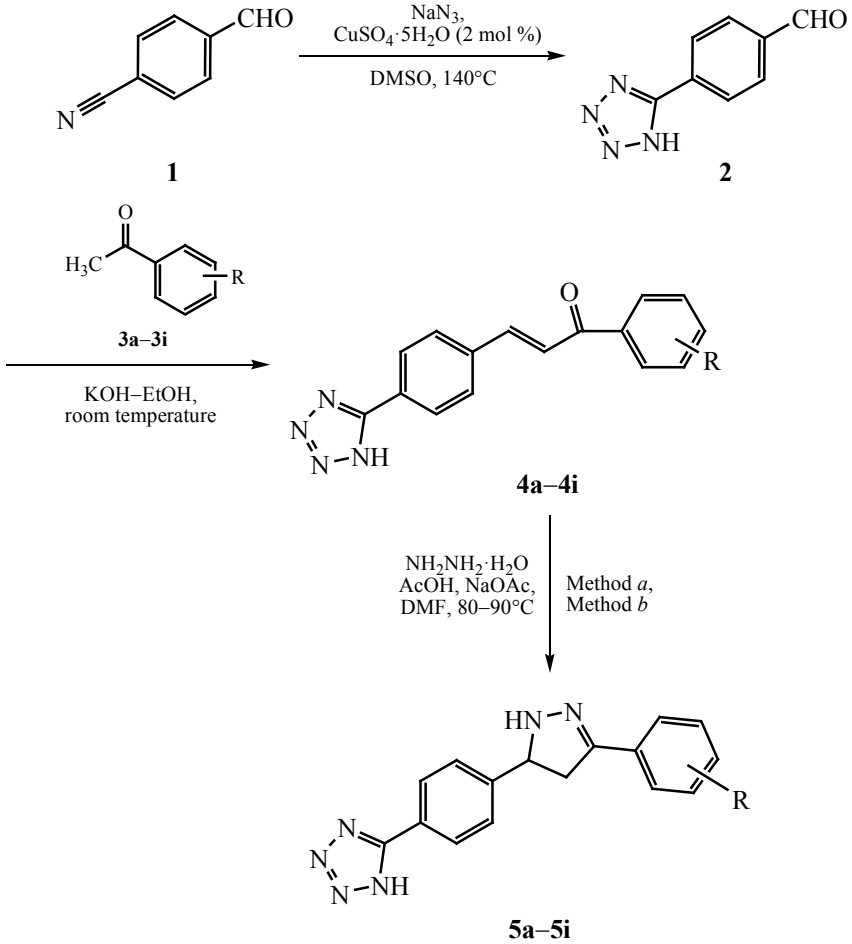
Inspired by the above and in continuation to our earlier studies of synthesis of tetrazoles derivatives, we have developed the synthetic approach to novel hybrid molecules containing tetrazole and pyrazole active pharmacophores under conventional and microwave irradiation methods. All the synthesized compounds were screened for their *in vitro* antimicrobial activity.

RESULTS AND DISCUSSION

4-(1*H*-Tetrazol-5-yl)benzaldehyde (**2**) was derived from 4-formylbenzonitrile (**1**) and sodium azide in the presence of $CuSO_4 \cdot 5H_2O$. Its following reaction with acetophenones **3a**–**3i** under basic conditions gave the corresponding chalcones **4a**–**4i** (Scheme 1). The latter semiproducts were cyclised with hydrazine hydrate in acidic media under conventional heating and microwave irradiation to furnish the title compounds **5a**–**5i** in high yields. Microwave irradiation led to higher yield of the products within shorter reaction time than conventional heating (Table 1).

Antibacterial activity. The synthesized compounds **5a**–**5i** were tested *in vitro* for their antibacterial activity against gram-positive strains [*Staphylococcus aureus* (ATCC 6538), *Bacillus subtilis* (ATCC 6633)] and gram-negative strains [*Escherichia coli* (ATCC 25922), *Klebsiella pneumonia* (ATCC 13883)] using gatifloxacin as the standard drug. The activity was determined using filter paper disc method by measuring the zone of inhibition in mm. The compounds were tested at the concentrations of 20 and 40 μg/mL in DMSO (Table 2). The compound **5f** exhibited good activity against all bacterial strains. The compounds **5b**, **5c**, **5d**, and **5g** demonstrated promising

Scheme 1. Synthesis of 5-[4-(3-phenyl-4, 5-dihydro-1*H*-pyrazol-5-yl)phenyl]-1*H*-tetrazole derivatives (**5a–5i)** under conventional (method *a*) and microwave irradiation (method *b*) conditions.



R = 4-H (**3a**–**5a**), 4-F (**3b**–**5b**), 4-Cl (**3c**–**5c**), 4-Br (**3d**–**5d**), 4-CH_3 (**3e**–**5e**), 4-OCH_3 (**3f**–**5f**), 3-OH (**3g**–**5g**), 3-Cl (**3h**–**5h**), 3-Br (**3i**–**5i**). Method *a*: conventional heating; method *b*: microwave irradiation.

activity, whereas compounds **5a**, **5e**, **5h**, and **5i** were of moderate activity.

Antifungal activity. Antifungal activity of the synthesized compounds **5a**–**5i** was tested against three pathogenic fungi, *Aspergillus niger*, *Aspergillus flavus*, and *Fusarium oxysporum* using amphotericin B as the standard drug. Activity was determined using the cup plate agar diffusion method by measuring the zone of inhibition in mm. The compounds were screened at concentration of 50 μg/mL in DMSO (Table 2). The fluorine substituted compound **5b** and methoxy derivative **5f** demonstrated the highest activity against the other compounds characterized as moderately activite.

EXPERIMENTAL

All reagent grade chemicals were purchased from Sigma Aldrich and used without further purification. Microwave initiated reactions were carried out in a Milestone multi SYNTH microwave system. All reactions were monitored by TLC on Merck Kieselgel 60 F524, and visualized under UV light and/or by spraying 5% solution of H_2SO_4 in ethanol followed by heating. Column chromatography was carried out on Silica Gel 60 (60–120 mesh). Melting points were determined in open glass capillaries on a Stuart SMP30 apparatus and are uncorrected. Element analysis was carried out on a Thermofinnigan CHNS analyzer. IR spectra were recorded in KBr on a Shimadzu FTIR 8400S spectrophotometer. NMR spectra were measured on a Bruker 400 NMR spectrometer using DMSO-d_6 as a solvent and TMS as an internal standard. Mass spectra were measured on a Shimadzu mass spectrometer.

Synthesis of substituted 5-[4-(3-phenyl-4,5-dihydro-1*H*-pyrazol-5-yl)phenyl]-1*H*-tetrazole de-

Table 1. Reaction time and yield of compounds **5a–5i** synthesized under different conditions

Product	mp, °C	Time		Yield, %	
		conventional heating, h	microwave irradiation, min	conventional heating	microwave irradiation
5a	172–174	8	8	60	75
5b	161–163	7	9	65	77
5c	155–157	8	8	62	80
5d	172–174	7	10	63	79
5e	192–194	7	9	50	76
5f	186–188	7	10	61	72
5g	171–173	8	10	62	80
5h	184–186	7	9	65	72
5i	178–180	8	8	69	75

Table 2. *In vitro* antibacterial and antifungal activity data for compounds **5a**–**5i**

Compound	Inhibition zone, mm										
	gram-positive bacteria				gram-negative bacteria				fungi		
	S. aureus		*B. subtilis*		*E. coli*		*K. pneumoniae*		*A. niger*	*A. flavus*	*F.oxysporum*
	concentration, μg/mL										
	20	40	20	40	20	40	20	40	50	50	50
5a	14	14	16	25	13	12	5	12	4.6	13.6	5.5
5b	18	23	18	38	16	23	9	11	14.5	4.9	17.0
5c	17	21	17	28	15	16	8	16	4.5	6.5	12.4
5d	15	19	16	24	13	18	6	13	2.6	6.4	4.5
5e	13	21	14	22	11	15	6	14	8.6	8.0	7.2
5f	22	32	23	40	16	21	14	20	15.5	4.8	17.7
5g	17	20	17	23	11	24	8	16	10.2	7.4	10.0
5h	13	21	14	22	11	15	6	14	8.1	8.4	9.0
5i	13	21	14	20	15	12	6	12	12.4	7.7	9.0
Gatifloxacin	20	30	20	40	15	20	10	18	–	–	–
Amphotericin B	–	–	–	–	–	–	–	–	14.0	12.5	15.2

rivatives (5a–5i). *Method a. Conventional heating.* To a mixture of a (*E*)-3-[4-(1*H*-tetrazol-5-yl)phenyl]-1-phenylprop-2-en-1-one derivative **4a**–**4i** (1 mmol) in DMF (5 mL) containing sodium acetate (1 mmol), hydrazine hydrate (1 mmol), few drops of acetic acid were added, and the reaction mixture was heated at 80–90°C for 7–8 h. Progress of the reaction was monitored by TLC. Upon completion of the process, ice cold water was added to the reaction mixture. A solid product was filtered off, washed with water and dried. The crude product was purified by

column chromatography using a mixture EtOAc–hexane (6 : 4 v/v) to afford the corresponding pure product **5a**–**5i** as a pale yellow solid.

Method b. Microwave irradiation. A mixture of a (*E*)-3-[4-(1*H*-tetrazol-5-yl)phenyl]-1-phenylprop-2-en-1-one derivative **4a**–**4i** (1 mmol) in DMF (5 mL), sodium acetate (1 mmol), hydrazine hydrate (1 mmol), and few drops of acetic acid was filled in a quartz tube and inserted into a Teflon vial with screw cap and exposed to microwave irradiation at 180W for 8–10 min, with intervals of 30 s. After completion of the process (TLC), the reaction mixture was poured over crushed ice. The solid thus obtained was filtered off, washed with water and dried. The crude product was purified by column chromatography on silica gel using EtOAc–hexane (6:4 v/v) as an eluent to give the corresponding pure product **5a**–**5i** as a pale yellow solid.

5-[4-(3-Phenyl-4,5-dihydro-1*H*-pyrazol-5-yl) phenyl]-1*H*-tetrazole (5a). IR spectrum, ν, cm^{-1}: 1624 (C=N), 3325, 3425 (NH). ^{1}H NMR spectrum, δ, ppm: 3.04–3.13 d.d (1H, J = 8.2 Hz, J = 16.0 Hz, H_A), 3.57–3.65 d.d (1H, J = 10.1 Hz, J = 16.0 Hz, H_B), 4.93–4.99 m (1H, H_X), 7.30–7.44 m (5H, Ar-H), 7.90 d (2H, J = 7.8 Hz, Ar-H), 8.04 d (2H, J = 7.8 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 40.1, 61.8, 115.6, 117.6, 119.1, 119.6, 123.5, 125.9, 127.1, 128.1, 129.8, 145.6, 152.7, 156.9. MS: 291 [M + H]$^+$. Found, %: C 66.18; H 4.85; N 28.64. $C_{16}H_{14}N_6O$. Calculated, %: C 66.19; H 4.86; N 28.95.

5-{4-[3-(4-Fluorophenyl)-4,5-dihydro-1*H*-pyrazol-5-yl]phenyl}-1*H*-tetrazole (5b). IR spectrum, ν, cm^{-1}: 1620 (C=N), 3325, 3421 (NH). ^{1}H NMR spectrum, δ, ppm: 2.92–3.01 d.d (1H, J = 8.1 Hz, J = 16.2 Hz, H_A), 3.67–3.73 d.d (1H, J = 10.2 Hz, J = 16.2 Hz, H_B), 4.83–4.90 m (1H, H_X), 6.91 d (2H, J = 7.5 Hz, Ar-H), 7.33 d (2H, J = 7.5 Hz, Ar-H), 7.91 d (2H, J = 7.8 Hz, Ar-H), 8.10 d (2H, J = 7.8 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 40.7, 60.9, 115.4, 117.2, 119.0, 119.9, 123.1, 125.9, 127.1, 128.7, 132.8, 145.5, 153.0, 156.7. 158.1. MS: 309 [M + H]$^+$. Found, %: C 62.31; H 4.21; N 27.20. $C_{16}H_{13}FN_6$. Calculated, %: C 62.33; H 4.25; N 27.26.

5-{4-[3-(4-Chlorophenyl)-4,5-dihydro-1*H*-pyrazol-5-yl]phenyl}-1*H*-tetrazole (5c). IR spectrum, ν, cm^{-1}: 1624 (C=N), 3315, 3422 (NH). ^{1}H NMR spectrum, δ, ppm: 3.07–3.19 d.d (1H, J = 8.7 Hz, J = 15.8 Hz, H_A), 3.55–3.69 d.d (1H, J = 10.1 Hz, J = 15.8 Hz, H_B), 4.90–4.99 m (1H, H_X), 6.90 d (2H, J = 7.6 Hz, Ar-H), 7.30 d (2H, J = 7.6 Hz, Ar-H), 7.81 d (2H, J = 8.1 Hz, Ar-H), 8.04 d (2H, J = 8.1 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 40.8, 61.4, 115.1, 117.0, 119.1, 119.3, 123.0, 125.9, 127.1, 127.7, 129.8, 145.7, 152.5, 156.9. MS: 325 [M + H]$^+$. Found, %: C 59.10; H 4.01; N 25.81. $C_{16}H_{13}ClN_6$. Calculated, %: C 59.17; H 4.03; N 25.88.

5-{4-[3-(4-Bromophenyl)-4,5-dihydro-1*H*-pyrazol-5-yl]phenyl}-1*H*-tetrazole (5d). IR spectrum, ν, cm^{-1}: 1624 (C=N), 3325, 3425 (NH). ^{1}H NMR spectrum, δ, ppm: 3.02–3.09 d.d (1H, J = 8.2 Hz, J = 16.0 Hz, H_A), 3.67–3.73 d.d (1H, J = 10.1 Hz, J = 16.0 Hz, H_B), 4.95–4.99 m (1H, H_X), 7.10 d (2H, J = 7.7 Hz, Ar-H), 7.30 d (2H, J = 7.7 Hz, Ar-H), 7.91 d (2H, J = 8.1 Hz, Ar-H), 8.20 d (2H, J = 8.1 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 40.1, 61.8, 116.4, 118.6, 119.1, 120.6, 123.5, 125.9, 127.2, 128.1, 129.5, 145.5, 152.9, 158.9. MS: 369 [M + H]$^+$. Found, %: C 52.15; H 3.52; N 22.66. $C_{16}H_{13}BrN_6$. Calculated, %: C 52.05; H 3.55; N 22.76.

5-{4-[3-(*p*-Tolyl)-4,5-dihydro-1*H*-pyrazol-5-yl] phenyl}-1*H*-tetrazole (5e). IR spectrum, ν, cm^{-1}: 1619 (C=N), 3315, 3420 (NH). ^{1}H NMR spectrum, δ, ppm: 3.07–3.13 d.d (1H, J = 8.0 Hz, J = 15.8 Hz, H_A), 3.47–3.55 d.d (1H, J = 10.1 Hz, J = 15.8 Hz, H_B), 4.93–4.99 m (1H, H_X), 7.30–7.44 m (5H , Ar-H), 7.90 d (2H, J = 7.8 Hz, Ar-H), 8.04 d (2H, J = 7.8 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 26.1, 43.1, 62.8, 114.9, 116.9, 119.0, 119.9, 123.5, 126.9, 127.5, 128.5, 129.8, 146.6, 153.7, 157.1. MS: 305 [M + H]$^+$. Found, %: C 67.18; H 5.45; N 28.64. $C_{17}H_{16}N_6$. Calculated, %: C 67.09; H 5.30; N 27.61.

5-{4-[3-(4-Methoxyphenyl)-4,5-dihydro-1*H*-pyrazol-5-yl]phenyl}-1*H*-tetrazole (5f). IR spectrum, ν, cm^{-1}: 1624 (C=N), 3325, 3425 (NH). ^{1}H NMR spectrum, δ, ppm: 3.02–3.09 d.d (1H, J = 8.2 Hz, J = 16.0 Hz, H_A), 3.67–3.73 d.d (1H, J = 10.1 Hz, J = 16.0 Hz, H_B), 3.8 s (3H, OCH_3), 4.93–4.99 m (1H, H_X), 6.91 d (2H, J = 7.5 Hz, Ar-H), 7.33 d (2H, J = 7.5 Hz, Ar-H), 7.84 d (2H, J = 8.3 Hz, Ar-H), 8.18 d (2H, J = 8.3 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 40.8, 55.1, 61.4, 116.1, 117.7, 119.8, 120.3, 123.0, 125.8, 126.1, 127.4, 129.8, 146.7, 152.5, 156.4. MS: 321 [M + H]$^+$. Found, %: C 63.64; H 5.23; N 26.01. $C_{17}H_{16}N_6O$. Calculated, %: C 63.74; H 5.03; N 26.23.

2-{5-[4-(1*H*-Tetrazol-5-yl)phenyl]-4,5-dihydro-1*H*-pyrazol-3-yl}phenol (5g). IR spectrum, ν, cm^{-1}: 1624 (C=N), 3325, 3425 (NH), 3451 (OH). ^{1}H NMR spectrum, δ, ppm: 3.02–3.09 d.d (1H, J = 8.2 Hz, J = 16.0 Hz, H_A), 3.67–3.73 d.d (1H, J = 10.1 Hz, J = 16.0 Hz, H_B), 4.93–4.99 m (1H, H_X), 6.90 d (2H, J = 7.6 Hz, Ar-H), 7.30 d (2H, J = 7.6 Hz, Ar-H), 7.64 d (2H, J = 8.1 Hz, Ar-H), 8.04 d (2H, J = 8.1 Hz, Ar-H), 11.13 s (1H, -OH).

^{13}C NMR spectrum, δ, ppm: 40.8, 61.6, 115.7, 116.6, 119.1, 119.3, 123.0, 125.9, 127.1, 127.7, 129.8, 145.6, 152.6, 156.8. MS: 307 [*M* + H]$^+$. Found, %: C 62.68; H 4.55; N 27.34. $C_{16}H_{14}N_6O$. Calculated, %: C 62.74; H 4.61; N 27.44.

5-{4-[3-(3-Chlorophenyl)-4,5-dihydro-1*H*-pyrazol-5-yl]phenyl}-1*H*-tetrazole (5h). IR spectrum, ν, cm^{-1}: 1614 (C=N), 3325, 3435 (NH). ^{1}H NMR spectrum, δ, ppm: 3.00–3.11 d.d (1H, *J* = 8.3 Hz, *J* = 16.5 Hz, H_A), 3.55–3.69 d.d (1H, *J* = 10.1 Hz, *J* = 16.5 Hz, H_B), 4.75–4.83 m (1H, H_X), 6.79–7.23 m (4H, Ar-H), 7.84 d (2H, *J* = 8.3 Hz, Ar-H), 8.18 d (2H, *J* = 8.3 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 41.1, 63.4, 116.1, 117.0, 119.1, 119.9, 123.0, 125.9, 126.7, 127.7, 129.8, 145.7, 153.5, 156.9. MS: 325 [*M* + H]$^+$. Found, %: C 59.10; H 4.01; N 25.81. $C_{16}H_{13}ClN_6$. Calculated, %: C 59.17; H 4.03; N 25.88.

5-{4-[3-(3-Bromophenyl)-4,5-dihydro-1*H*-pyrazol-5-yl]phenyl}-1*H*-tetrazole (5i). IR spectrum, ν, cm^{-1}: 1624 (C=N), 3325, 3415 (NH). ^{1}H NMR spectrum, δ, ppm: 3.02–3.09 d.d (1H, *J* = 8.2 Hz, *J* = 16.0 Hz, H_A), 3.67–3.73 d.d (1H, *J* = 10.1 Hz, *J* = 16.0 Hz, H_B), 4.95–4.99 m (1H, H_X), 6.77–7.27 m (4H, Ar-H), 7.97 d (2H, *J* = 8.1 Hz, Ar-H), 8.20 d (2H, *J* = 8.1 Hz, Ar-H). ^{13}C NMR spectrum, δ, ppm: 40.1, 61.8, 116.4, 118.6, 119.1, 120.6, 123.5, 125.9, 127.2, 128.1, 129.5, 145.5, 152.7, 156.9. MS: 369 [*M* + H]$^+$. Found, %: C 52.15; H 3.52; N 22.66. $C_{16}H_{13}BrN_6$. Calculated, %: C 52.05; H 3.55; N 22.76.

Antibacterial activity. The synthesized compounds **5a**–**5i** were tested for their antibacterial activity against bacterial strains including gram-negative *Klebsiella pneumonia* and *Escherichia coli* and gram-positive *Bacillus subtilis* and *Staphylococcus aeureus* at concentrations of 10 and 20 μg/mL. The cultures were diluted with 5% saline, autoclaved, and the final volume was adjusted (concentration ca 10^5–10^6 CFU/mL). The synthesized compounds were diluted by DMSO for antibacterial biological assays. For agar disc diffusion method, the liquid form of a test compound was soaked on to the disc and then allowed to air dry, to make the disc completely saturated with the test compound. The saturated by a chemical disc was introduced onto the upper layer of the medium evenly flooded with the bacteria. The disc was dipped in different chemical samples, placed over the evenly spread bacterial nutrient media and incubated at 37°C for 24–48 h for more efficient inhibition of bacteria. The zones of inhibition were measured after 24–48 h. All the experiments were carried out in triplicates, and the results were expressed as zone of inhibition in mm. The zones of inhibition of compounds **5a**–**5i** were compared with those of the standard antibiotic gatifloxacin (10 and 20 μg/mL).

Antifungal activity. Antifungal activity of compounds **5a**–**5i** was tested against three pathogenic fungi, namely *Aspergillus Niger*, *Aspergilus flavus*, and *Fusarium oxysporum* by the poison plate technique at a concentration of 50 μg/mL. Three kinds of fungi were incubated in PDA at 25±1°C for 5 days to get new mycelium for antifungal assay, then mycelium as discs of approximately 0.45 cm diameter were cut from the culture medium, picked up with a sterilised inoculation needle and inoculated in the center of PDA plate. Test compounds were dissolved in DMSO (10 mL) and added into the potato dextrose agar medium (PDA, 90 mL). The final concentration of compounds in the medium was adjusted to 50 μg/mL. The inoculated plates were incubated at 25±1°C for 5 days. Acetone was diluted with sterilised distilled water and used as a control, while clotrimazole (50 μg/mL) was used as a standard control for each treatment. The experiments were carried out in triplicates. The radial growth of the fungal colonies was measured on the 5th day.

CONCLUSIONS

A new series of 5-[4-(3-phenyl-4,5-dihydro-1*H*-pyrazol-5-yl)phenyl]-1*H*-tetrazole derivatives is synthesized under conventional and microwave irradiation methods. Under MWI conditions the reaction time was much shorter leading to higher yields of products than under conventional conditions. The synthesized compounds are tested *in vitro* for determining their antimicrobial activity. The compound **5f** was found to be equipotent with the standard drug gatifloxacin. The compounds **5b** and **5f** exhibit the promising activity against pathogenic fungi.

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CONFLICT OF INTEREST

No conflict of interest was declared by the authors.

REFERENCES

1. Ostrovskii, V.A., Koldobskii, G.I., and Trifonov, R.E., *Comprehensive Heterocycl. Chem. III*, 2008, vol. 6, p. 257. https://doi.org/10.1016/B978-008044992-0.00517-4
2. Ashok,D.,Ganesh,A.,Ravi,S.,Lakshmi,B.V.,andRamesh, B., *Russ. J. Gen. Chem*., 2014, vol. 84, p. 2248. https://doi.org/10.1134/S1070363214110346
3. Azarifar, D. and Shaebanzadeh, M., *Molecules.*, 2002. vol. 7(12), p. 885. https://doi.org/10.3390/71200885
4. Shoman, M.E., Abdel Aziz, M., Aly, O.M., Farag, H.H., and Morsy, M.A., *Eur. J. Med. Chem.*, 2009, vol. 44, p. 3068. https://doi.org/10.1016/j.ejmech.2008.07.008
5. Barsoum, F.F., Hosni, H.M., and Girgis, A.S., *Bioorg. Med. Chem.*, 2006, vol. 14, p. 3929. https://doi.org/10.1016/j.bmc.2006.01.042
6. Bhat, B.A., Dhar, K.L., Puri, S.C., Saxena, A.K., Shanmugavel, M., and Qazi, G.N., *Bioorg. Med. Chem. Lett.*, 2005, vol. 15(12), p. 3177. https://doi.org/10.1016/j.bmcl.2005.03.121
7. Uchida, H., Tanikoshi, H., Nakamura, S., Reddy, P.Y., and Toru, T., *Synlett*., 2003, vol. 8, p. 1117. https://doi.org/10.1055/s-2003-39906
8. Adib, M., Mahdavi, M., Mahmoodi, N., Pirelahi, H., and Bijanzadeh, H.R., *Synlett*., 2006, vol. 11, p. 1765. https://doi.org/10.1055/s-2006-944200
9. Ashok, D., Madhuri, E.L., Sarasija, M., Sree Kanth, S., Vijjulatha, M., Malini Alaparthi, D., and Sagurthi, S.R., *RSC Adv.*, 2017, vol.7, p. 25710. https://doi.org/10.1039/c7ra01550j