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Beta-alanine: Design, synthesis and antimicrobial evaluation of synthesized derivatives

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ABSTRACT

The present study was planned with the objective to design and synthesis esters, amides and anilides derivatives of 3-benzamido propionic acid. All the derivatives were physicochemically characterized and the assigned structures were found to be in agreement with the spectral characterization. Further, in-vitro antimicrobial evaluation of synthesized compounds against Gram positive bacteria: Staphylococcus aureus, Bacillus subtilis; Gram negative bacteria: Pseudomonas aeruginosa, Escherichia coli and fungal strains Candida albicans and Aspergillus niger was carried out by tube dilution method. Compound D14 (N-(3-(benzhydrylamino)-3-oxopropyl)benzamide) was the most effective antifungal agent among all the synthesized derivatives and possessed highest antibacterial activity against P.aeruginosa & D21 (N-(3-oxo-3-(4-bromophenylamino)propyl)benzamide) showed significant antifungal activity against C.albicans and A.niger respectively.

Keywords: beta-alanine, propionic acid, antibacterial activity, antifungal activity, minimum inhibitory concentration (MIC)

INTRODUCTION

Beta-alanine is a naturally occurring beta amino acid, in which the amino group is at the β-position from the carboxylate group. It is a modified version of the amino acid alanine. It has been shown to enhance muscular endurance and its supplementation can also improve moderate to high intensity cardiovascular exercise performance, like rowing or sprinting [1]. Naturally occurring β-amino acid comprising propionic acid with the amino group in the 3-position. Propionic acid and its salt are broad-spectrum preservatives because of their bactericidal, fungicidal, insecticidal and antiviral effects. The antimicrobial activity of propionic acid is reported to be primarily against molds and bacteria [2, 3]. It is effective at reducing fungal growth especially at lower pH, by affecting fungal membranes at pH values below 4.5. Calcium and sodium propionate are natural antimicrobials show a similar effect against yeasts and filamatous molds at a low [4].

Keeping in view the above facts, we planned to synthesize different derivatives of beta-alanine to explore its potential as a better antimicrobial agent.

MATERIALS AND METHODS

Melting points were determined on an Elico melting point apparatus and are incorrected. Starting materials were obtained from the commercial sources and were used further without purification. Infrared spectra were recording using KBr pellets on a Perkin-Elmer FTIR spectrophotometer. ^{1}H NMR spectra were recorded at 400 MHz on Bruker Avance II 400 spectrometer using TMS as an internal standard. All compounds exhibited ^{1}H NMR and IR spectral data consistent with the proposed structures. The progress of the reaction was monitored by TLC using silica gel G as adsorbent.

General procedure for the synthesis of 3-benzamido propionic acid [5-7]
2.5 gm (0.02 mol) of β-alanine was dissolved in 25 mL of aqueous solution of 10% of 1N sodium hydroxide solution in 100 mL RBF and 4.5 mL (0.03mol) of benzoyl chloride was then added to it. The mixture was shaken vigorously for 1 hr. Continued the shaking for 2 minutes, filtered and acidified with conc. HCl to congo red. The resultant product was placed on the crushed ice until solidification occurred.

General procedure for the synthesis of esters from 3-benzamido propionic acid (D1-D7) [8]
In 250 mL RBF, 5gm (0.5 mol) of above synthesized acid was mixed with 10 mL (0.1 mol) of alcohol. 1 mL of conc. H_2SO_4 was added to it and refluxed until the completion of reaction. Poured the mixture into 15-25 mL of water in a separatory funnel and extracted with ether (3×20 mL) and washed the ethereal layers with 20 mL of water. Dried it over anhydrous sodium sulphate. Filtered it and evaporated under reduced pressure. The product obtained was recrystallized from ethanol.

General procedure for the synthesis of amides and anilides from 3- benzamido propionic acid
a) Synthesis of acid chloride [9, 10]
In a 100 mL two- necked RBF, 1 gm (0.025 mol) of acid was taken and 5 mL (0.05 mol) of thionyl chloride was added by means of a separatory funnel attached to the neck of the flask. This was heated on a water bath for 3 hrs at 70-80°C. The excess of acid chloride was removed by distillation and the crude acid chloride thus obtained.

b) Synthesis of amides (D8-D15) and anilides (D16-D21) from acid chloride [11]
The above synthesized acid chloride was mixed with respective amine/ anilides in an equimolar ratio (1:1) in 50 mL of ether and stirred at 0-10^{o}C for 15 min. The amides and anilides separated immediately which were further neutralized with 2N HCl solution and washed with saturated solution of sodium bicarbonate and water. The precipitates obtained were recrystallized from alcohol**.**

Spectral data
***3-benzamido propionic acid*:** IR (KBr cm^{-1}): 3340 (NH str.), 3064 (CH str., aromatic), 2938 (CH str.), 1727 (C=O, carboxylic acid), 1635 (C=O, amide str.), 1542 (C=C str., aromatic), 1464 (CH_2, bend).

***Methyl 3-benzamidopropanoate* (D1):** IR (KBr cm^{-1}): 3391 (NH str.), 3075 (CH str., aromatic), 2951 (CH str.), 1735 (C=O, ester str.), 1638 (C=O, amide str.), 1543 (C=C str., aromatic), 1440 (CH_3 bend).

***Ethyl 3-benzamidopropanoate* (D2)**: IR (KBr cm^{-1}): 3343 (NH str.), 3125 (CH str., aromatic), 2984 (CH str.), 1726 (C=O, ester str.), 1644 (C=O, amide str.), 1540 (C=C str., aromatic), 1375 (CH_3 bend). ^{1}H NMR ($CDCl_3$, δ ppm):7.45-7.28 (m, 5H, Ar-H), 6.74 (s, 1H, NH), 3.59 (t, 2H, CH_2), 4.09 (q, 2H, CH_2), 2.55 (t, 2H, CH_2), 1.17 (d, 3H, CH_3).

***Propyl 3-benzamidopropanoate* (D3):** IR (KBr cm^{-1}): 3394 (NH str.), 3175 (CH str., aromatic), 2982 (CH str.), 1731 (C=O, ester str.), 1620 (C=O, amide str.), 1578 (C=C str., aromatic), 1420 (CH_3 bend).

***Isopropyl-3-benzamidopropionate* (D4):** IR (KBr cm^{-1}): 3341 (NH str.), 3067 (CH str., aromatic), 2924 (CH str.), 1738 (C =O, ester str.), 1646 (C=O, amide str.), 1550 (C=C str., aromatic), 1437 (CH_3 bend).

Table 1: Physicochemical characterization of synthesized compound of beta-alanine

S.No	Compound	Mol. Formula	Mol. wt	Melting point	R_f value	% yield
1.	D1	$C_{11}H_{13}NO_3$	207.23	128-131°C	0.87	78.12%
2.	D2	$C_{12}H_{15}NO_3$	221.11	135-138°C	0.89	64.25%
3.	D3	$C_{13}H_{17}NO_3$	235.28	146-148°C	0.59	69.02%
4.	D4	$C_{13}H_{17}NO_3$	235.28	163-164°C	0.68	62.10%
5.	D5	$C_{14}H_{19}NO_3$	249.31	169-172°C	0.83	68.46%
6.	D6	$C_{14}H_{19}NO_3$	249.31	161-164°C	0.78	77.52%
7.	D7	$C_{16}H_{13}NO_3$	277.36	162-163°C	0.82	73.50%
8.	D8	$C_{11}H_{14}N_2O_2$	206.24	180-183°C	0.72	72.88%
9.	D9	$C_{12}H_{16}N_2O_2$	220.27	187-190°C	0.84	70.01%
10.	D10	$C_{13}H_{18}N_2O_2$	234.29	191-195°C	0.72	63.60%
11.	D11	$C_{13}H_{18}N_2O_2$	234.29	200-205°C	0.74	76.71%
12.	D12	$C_{14}H_{20}N_2O_2$	248.32	194-196°C	0.85	71.22%
13.	D13	$C_{14}H_{20}N_2O_2$	248.32	193-196°C	0.71	68.06%
14.	D14	$C_{22}H_{20}N_2O_2$	344.41	230-235°C	0.77	69.98%
15.	D15	$C_{12}H_{17}N_3O_2$	235.28	199-203°C	0.81	77.01%
16.	D16	$C_{16}H_{16}N_2O_2$	268.31	163-169°C	0.89	62.06%
17.	D17	$C_{16}H_{15}ClN_2O_2$	302.76	179-181°C	0.85	58.21%
18.	D18	$C_{16}H_{15}ClN_2O_2$	302.76	180-181°C	0.84	54.70%
19.	D19	$C_{16}H_{15}ClN_2O_2$	302.76	180-182°C	0.86	59.08%
20.	D20	$C_{16}H_{15}N_3O_4$	313.31	190-194°C	0.84	78.03%
21.	D21	$C_{16}H_{15}BrN_2O_2$	347.21	228-230°C	0.88	79.24%

TLC Mobile Phase : hexane:ethylacetate (7:3)

Butyl 3-benzamidopropanoate **(D5)**:IR (KBr cm^{-1}): 3341 (NH str.), 3075 (CH str., aromatic), 2946 (CH str.), 1741 (C=O, ester str.), 1646 (C=O, amide str.), 1550 (C=C str., aromatic), 1426 (CH_3 bend).

sec- Butyl 3-benzamidopropanoate **(D6)** : IR (KBr cm^{-1}): 3432 (NH str.), 3064 (CH str., aromatic), 2962 (CH str..), 1736 (C=O, ester str..), 1638 (C=O, amide str.), 1542 (C=C str., aromatic), 1349 (CH_3 bend); ^{1}H NMR ($CDCl_3$, δ ppm): 7.68-6.99 (m, 5H, Ar-H), 6.68 (s, 1H, NH), 3.59 (t, 2H, CH_2), 4.13 (m, 1H,CH), 2.55 (t, 2H, CH_2) , 2.12 (m, 2H, CH_2), 1.34 (t, 3H, CH_3), 1.46 (d, 3H, CH_3).

Hexyl 3-benzamidopropanoate **(D7):** IR (KBr cm^{-1}): 3448 (NH str.), 3064 (CH str., aromatic), 2957 (CH str.), 1739 (C=O, ester str.), 1645 (C=O, amide str.), 1541 (C=C str., aromatic), 1359 (CH_3 bend).

N-(3-oxo-3-(methylamino)propyl)benzamide **(D8):** IR (KBr cm^{-1}): 3345 (NH str.), 3068 (CH str., aromatic), 2977 (CH str.), 1658 (C=O, amide str.), 1577(C=C str., aromatic), 1577 (NH bend), 1420 (CH_3 bend); ^{1}H NMR ($CDCl_3$, δ ppm): 7.68-7.13 (m, 5H, Ar-H), 7.36 (s,1H, NH), 6.48 (s, 1H, NH), 3.38 (t, 2H,CH_2), 2.81 (s, 3H, CH_3), 2.38 (t, 2H, CH_2),.

N-(3-(ethylamino)-3-oxopropyl)benzamide **(D9):** IR (KBr cm^{-1}): 3299 (NH str.), 3063 (CH str., aromatic), 2971 (CH str.), 1633(C=O, amide str.), 1534 (C=C str., aromatic), 1548 (NH bend), 1365 (CH_3 bend).

N-(3-oxo-3-(propylamino)propyl)benzamide **(D10):** IR (KBr cm^{-1}): 3359 (NH str.), 3053 (CH str., aromatic), 2967 (CH str.), 1633(C=O, amide str.), 1577 (C=C str., aromatic), 1551 (NH bend), 1385 (CH_3 bend).

N-(3-(isopropylamino)-3-oxopropyl)benzamide **(D11):** IR (KBr cm^{-1}): 3308 (NH str.), 3084 (CH str., aromatic), 2965 (CH str.), 1635(C=O, amide str.), 1551 (C=C str., aromatic), 1600 (NH bend), 1374 (CH_3 bend); ^{1}H NMR ($CDCl_3$, δ ppm): 7.13-6.76 (m,5H,Ar-H), 6.75 (s,1H,NH), 6.77 (s,1H,NH), 3.34 (t,2H,CH_2), 3.99 (m,1H,CH), 3.34 (t,2H,CH_2), 2.48 (t,2H,CH_2), 1.09 (d,6H,CH_3).

N-(3-(butylamino)-3-oxopropyl)benzamide **(D12):** IR (KBr cm^{-1}): 3234 (NH str.), 3134 (CH str., aromatic), 2963 (CH str.), 1636 (C=O, amide str.), 1497 (C=C str., aromatic), 1541 (NH bend), 1380 (CH_3 bend).

N-(3-(tert-butylamino)-3-oxopropyl)benzamide **(D13):** IR (KBr cm^{-1}): 3325 (NH str.), 3125 (CH str., aromatic), 2978 (CH str.), 1636 (C=O, amide str.), 1541 (C=C str., aromatic), 1578 (NH bend); 1376 (CH_3 bend).

***N-(3-(benzhydrylamino)-3-oxopropyl)benzamide* (D14):** IR (KBr cm^{-1}): 3377 (NH str.), 3058 (CH str., aromatic), 2918 (CH str.), 1638 (C=O, amide str.), 1591 (C=C str., aromatic), 1547 (NH bend), 1493 (CH_3 bend). ^1H NMR: $CDCl_3$, δppm

***N-(3-(2-aminoethylamino)-3-oxopropyl)benzamide* (D15):** IR (KBr cm^{-1}): 3304 (NH str.), 3061 (CH str., aromatic), 2929 (CH str.), 1635 (C=O, amide str..), 1546 (C=C str., aromatic), 1532 (NH bend), 1446 (CH_3 bend); ^1H NMR ($CDCl_3$, δ ppm): 7.68-6.93 (m, 5H, Ar-H), 6.28 (s, 1H, NH), 6.75 (s, 1H, NH), 4.23 (t, 2H, CH_2), 3.26 (t, 2H, CH_2), 3.48 (t, 2H, CH_2), 2.48 (t, 2H, CH_2), 1.48 (s, 2H, NH).

***N-(3-oxo-3-(phenylamino)propyl)benzamide* (D16):** IR (KBr cm^{-1}): 3344 (NH str.), 3036 (CH str., aromatic), 2827 (CH str.), 1636 (C=O, amide str.), 1495 (C=C str., aromatic), 1441 (CH_3 bend).

***N-(3-oxo-3-(2-chlorophenylamino)propyl)benzamide* (D17):** IR (KBr cm^{-1}): 3422 (NH str.), 3126 (CH str., aromatic), 2836 (CH str.), 1638 (C=O, amide str.), 1513 (C=C str., aromatic), 1478 (CH_3 bend), 755 (C-Cl).

***N-(3-oxo-3-(3-chlorophenylamino)propyl)benzamide* (D18):** IR (KBr cm^{-1}): 3350 (NH str.), 3238 (CH str., aromatic), 2860 (CH str.), 1636 (C=O, amide str.), 1491 (C=C str., aromatic), 1399 (CH_3 bend), 717 (C-Cl).

***N-(3-oxo-3-(4-chlorophenylamino)propyl)benzamide* (D19):** IR (KBr cm^{-1}): 3428 (NH str.), 3058 (CH str., aromatic), 2866 (CH str.), 1653 (C=O, amide str.), 1549 (C=C str., aromatic), 1477 (CH_3 bend), 787 (C-Cl); ^1H NMR ($CDCl_3$, δ ppm): 7.85-7.24 (m, 9H, Ar-H), 8.23 (s, 1H, NH), 6.28 (s, 1H, NH), 3.58 (t, 2H, CH_2), 2.48 (t, 2H, CH_2).

***N-(3-oxo-3-(4-nitrophenylamino)propyl)benzamide* (D20):** IR (KBr cm^{-1}): 3362 (NH str.), 3081 (CH str., aromatic), 2952 (CH str.), 1637 (C=O, amide str.), 1598 (C=C str., aromatic), 1505 (C-NO_2); ^1H NMR ($CDCl_3$, δ ppm): 7.58-6.99 (m, 9H, Ar-H), 7.93 (s, 1H, NH), 6.75 (s, 1H, NH), 3.56 (t, 2H, CH2), 2.48 (t, 2H, CH2).

***N-(3-oxo-3-(4-bromophenylamino)propyl)benzamide* (D21):** IR (KBr cm^{-1}): 3307 (NH str.), 3170 (CH str., aromatic), 2854 (CH str.), 1649 (C=O, amide str.), 1524 (C=C str., aromatic), 693 (C-Br); ^1H NMR ($CDCl_3$, δ ppm): 7.57-7.30 (m, 9H, Ar-H), 6.75 (s, 1H, NH), 5.74 (s, 1H, NH). 3.23 (t, 2H, CH2), 2.58 (t, 2H, CH2).

Antimicrobial evaluation

The antimicrobial evaluation of synthesized compounds was performed by *in vitro* dilution method against Gram positive bacteria *Staphylococcus aureus* (MTCC 3160), *Bacillus subtilis* (MTCC 2063), Gram negative bacteria *Escherichia coli* (MTCC 40), *Pseudomonas aeruginosa* (MTCC 425) and fungal stains *Candida albicans* (MTCC 227), *Aspergillus niger* (MTCC 8189) respectively.

Antibacterial assay [12]

Fresh culture of respective bacteria was obtained by inoculation in double strength Nutrient Broth IP, followed by incubation at 37±1°C. The standard drug ciprofloxacin and the test compounds were dissolved in DMSO to obtain the concentration of 100µg/mL. 1mL of sterile media was poured into the sterile test tubes. The stock solution (100µg/mL) of beta –alanine derivatives were serially diluted to give the concentration 50-1.56 µg/mL and then inoculated with 100µl of suspension of respective organism in sterile saline and the tubes were incubated at 37±1°C for 24 hrs. The MIC was determined by the lowest concentration of the sample that prevented the development of turbidity.

Antifungal assay [12]

The activity was determined by *in vitro* serial dilution method similar to antibacterial assay using Sabouraud Dextrose Broth IP as nutrient medium. The inoculated test tubes were incubated at 37±1°C for 3 days for *C. albicans* and 25±1°C 7 days in case of *A. niger* respectively. The activity of synthesized compounds was compared with standard drug fluconazole.

RESULTS AND DISCUSSION

Chemistry

The synthesis of 3-benzamido propionic acid and their derivatives were synthesized using **scheme 1**(Fig. 2). The beta-alanine was reacted with benzoyl chloride by Schotten Baumann benzoylation reaction (Fig. 1) in the presence of NaOH to form 3-benzamido propionic acid **(I)** and the compound **(I)** was reacted with different alcohols in the presence of sulfuric acid and refluxed to form esters **(II).** Compound **(I)** was further reacted with thionyl chloride and then added drop wise to the ice cold amine solution to form amides **(III),** and with anilines to form anilides **(IV).** The completion of reaction was confirmed by single spot TLC. The synthesized derivatives were characterized by their physical parameters such as R_f value, melting point and % yield. The results are summarized in table 1.

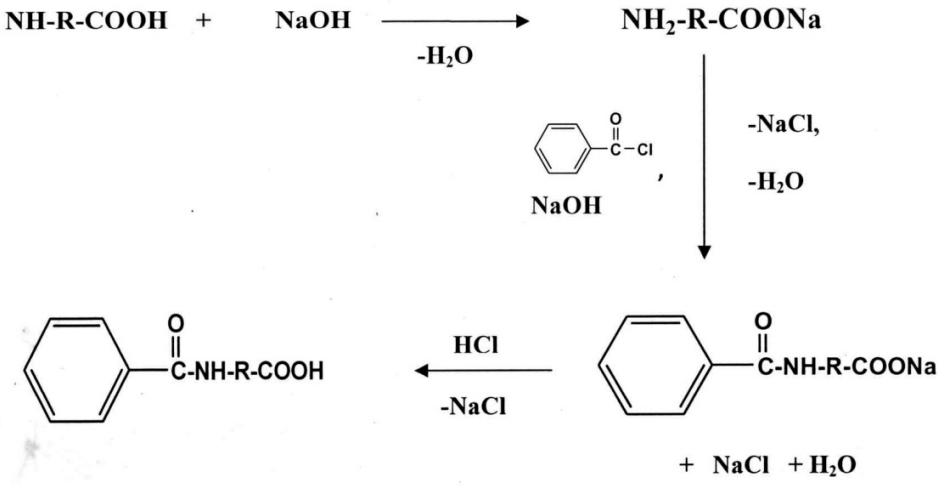

Fig. 1: Mechanism of N-benzoylamino acid by Baum's method [13]

Spectral analysis

The structure of synthesized compounds was confirmed by their consistent IR & ^{1}H NMR spectral peaks. The IR spectrum of 3-benzamido propionic acid illustrated the characteristic absorption bands of all functional groups. The COOH showed a very strong band for the C=O group that appeared at 1727 cm^{-1} and confirmed by OH stretch appeared in the spectrum as a very broad band extending from 3438 cm^{-1}. The presence of C=O amide bond at 1635 cm^{-1} confirmed the -NH linkage with carbonyl group. The IR bands in the region 3150-3050 cm^{-1} marked the presence of aromatic ring. The carbonyl stretching was observed at 1850-1630 cm^{-1}. The IR spectra of synthesized derivatives (D1-D7) exhibited C=O stretching at 1741-1735 cm^{-1} which confirmed the presence of ester formation. The formation of amide linkage was confirmed by presence of NH stretch at 3373-3308 cm^{-1} and NH bend at 1600-1532 cm^{-1} (D8-D15). In compounds (D16-D21) asymmetric stretch in the region of 1505 cm^{-1} indicated the presence of aromatic nitro compounds and 787-717 cm^{-1} for aromatic chloro compounds (D17-19).

In ^{1}H NMR the derivatives of 3-benzamido propionic acid displayed the characteristic peak at δ 7.85- 6.76 ppm for aromatic protons and appeared as multiplet (m). NH functional group was observed in the range of δ 6.75-5.74 ppm and appeared as singlet (s). In case of ester (D2, D6) proton group attached to ester linkage absorbed at δ 1.34-2.12 ppm. Amide and anilide confirmed by giving another peak of NH functional group which observed in the range of δ 7.93-6.28 ppm and appeared as singlet (s).

Anti-microbial activity

Minimum inhibitory concentration (MIC) is the lowest concentration of antimicrobial agent which will inhibit visible growth of micro-organism after their respective incubation. The *in vitro* antimicrobial activity of the novel synthesized beta-alanine derivatives were evaluated against Gram positive bacteria: *S. aureus, B. subtilis,* Gram negative bacteria: *P. aeruginosa, E.coli* and antifungal activity against *A. niger, C. albicans* by *in vitro* serial dilution method. The pMIC values of synthesized derivatives are given in the table 3.

The results obtained showed that **D14** was found to be most active against *P. aeruginosa* and *C. albicans* among all the synthesized derivatives with 2.04 µM/mL and with 1.74µM/mL, **D21** proved to be the most consistent derivative against all the bacterial as well as fungal stains. The derivatives were found to be less active against *E. coli*. The antifungal results showed that **D21** depicted the excellent activity against *C. albicans and A. niger* with 1.74µM/mL. From the result of anti-microbial evaluation, SAR can be discussed as follows:

1. The derivatives of beta-alanine revealed excellent anti-fungal activity**. D14** was found to be more potent than standard fluconazole with pMIC 2.04µM/mL against *C. albicans* and good activity against *P.aeruginosa*. This may be due to the aromatic sunstitution viz. amide derivative of 3-benzamido propanoyl chloride.

2. In case of esters, ethyl substitution displayed significant activity against all the stains except *E. coli* with pMIC 1.54µM/mL. Further, the activity chart revealed that the activity decreases with increase in chain length.

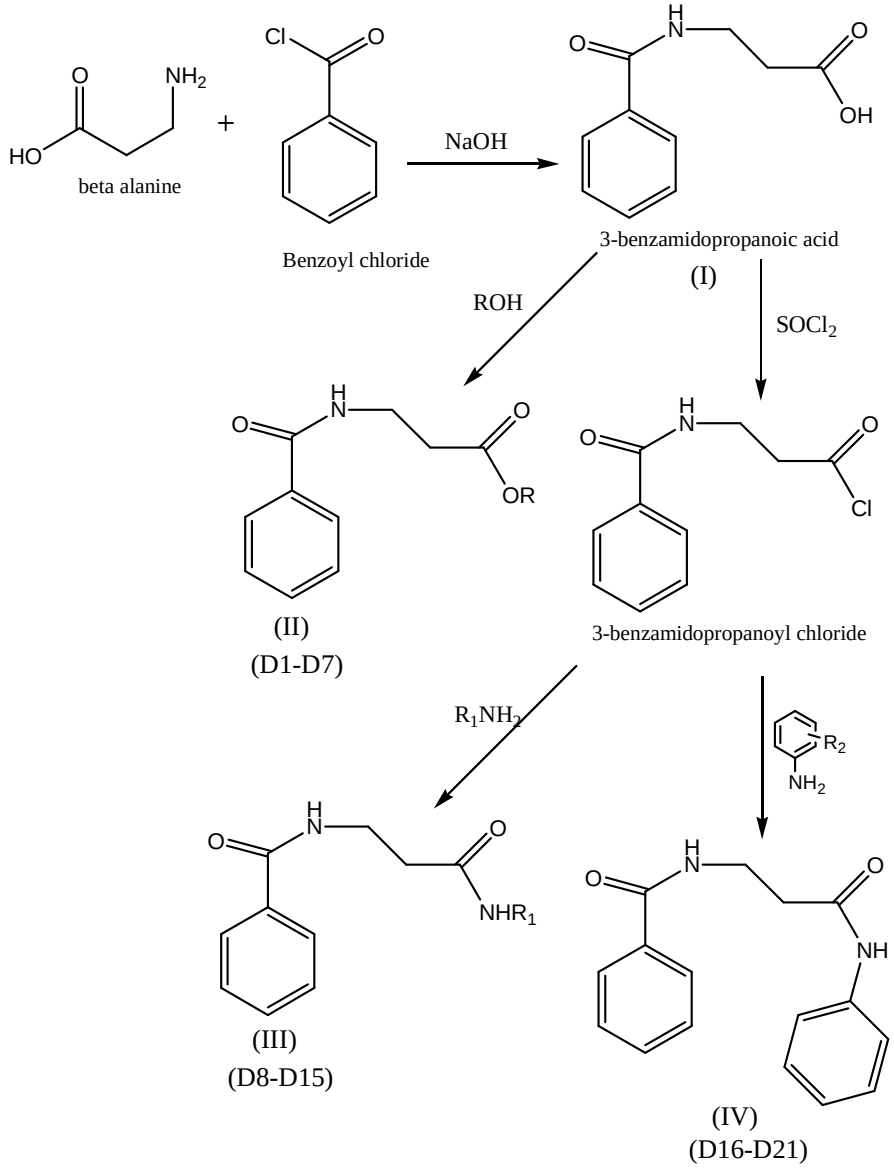

Fig 2. General synthetic scheme (1) for the synthesis of beta-alanine and their derivatives

Table 2: List of derivatives synthesized

S.NO	Comp	R	R_1	R_2
1.	D1	$-CH_3$	-	-
2.	D2	$-C_2H_5$	-	-
3.	D3	$-C_3H_7$	-	-
4.	D4	$-CH(CH_3)_2$	-	-
5.	D5	$-CH_2(CH_2)_2CH_3$	-	-
6.	D6	$-CH(CH_3)CH_2CH_3$	-	-
7.	D7	$-C_6H_{13}$	-	-
8.	D8	-	$-CH_3$	-
9.	D9	-	$-C_2H_5$	-
10.	D10	-	$-C_3H_7$	-
11.	D11	-	$-CH(CH_3)_2$	-
12.	D12	-	$-C_4H_9$	-
13.	D13	-	$-C(CH_3)_3$	-
14.	D14	-	$-C_{12}H_{10}$	-
15.	D15	-	$-C_2H_6N$	-
16.	D16	-	-	-H
17.	D17	-	-	2-Cl
18.	D18	-	-	3-Cl
19.	D19	-	-	4-Cl
20.	D20	-	-	$4\text{-}NO_2$
21.	D21	-	-	4-Br

3. Substitution of ethylene diamine at R^1 showed good activity against *S.aureus*, *P.aeruginosa* and *C. albicans* (**D15**) with pMIC 1.8, 1.57, 1.57µM/mL respectively.
4. Addition of electron withdrawing group (Cl,NO_2,Br) at para position of aromatic ring substitution at R^2 showed moderate to significant activity against bacterial and fungal stains (**D17, D18, D19, D20, D21** with pMIC 1.68, 1.68, 1.68, 1.70, 1.74µM/mL) respectively.
5. From these results it can be concluded that different structural requirements are required for a compound to be effective against different targets. This is similar to the results of Narasimhan *et al*. (2012) [14].
6. The above mentioned findings are summarized in **Fig. 3**.

Table 3: pMIC values of synthesized derivatives of Beta-alanine

S.NO.	Comp.	*S. aureus*	*B. subtilis*	*P. aeruginosa*	*E. coli*	*A. niger*	*C. albicans*
1.	D1	1.21	1.21	1.21	1.21	1.21	1.21
2.	D2	1.54	1.54	1.54	1.24	1.54	1.54
3.	D3	1.27	1.27	1.27	1.27	1.27	1.27
4.	D4	1.27	1.27	1.27	1.27	1.57	1.57
5.	D5	1.29	1.29	1.29	1.29	1.29	1.60
6.	D6	1.29	1.29	1.60	1.29	1.29	1.60
7.	D7	1.30	1.30	1.60	1.30	1.60	1.30
8.	D8	1.53	1.53	1.53	1.29	1.29	1.29
9.	D9	1.54	1.24	1.54	1.24	1.54	1.54
10.	D10	1.27	1.27	1.27	1.27	1.27	1.57
11.	D11	1.27	1.27	1.27	1.27	1.57	1.57
12.	D12	1.59	1.59	1.59	1.59	1.29	1.59
13.	D13	1.59	1.59	1.29	1.29	1.29	1.59
14.	D14	1.74	1.74	2.04	1.74	1.74	2.04
15.	D15	1.8	1.27	1.57	1.27	1.27	1.57
16.	D16	1.33	1.33	1.33	1.33	1.33	1.33
17.	D17	1.68	1.68	1.68	1.68	1.38	1.68
18.	D18	1.68	1.68	1.68	1.68	1.38	1.68
19.	D19	1.68	1.68	1.68	1.38	1.68	1.68
20.	D20	1.70	1.70	1.70	1.70	1.70	1.39
21.	D21	1.74	1.74	1.74	1.74	1.74	1.74
22.	STD	2.33^a	2.33^a	2.33^a	2.33^a	1.99^b	1.99^b

Standard a- ciprofloxacin, standard b- fluconazole

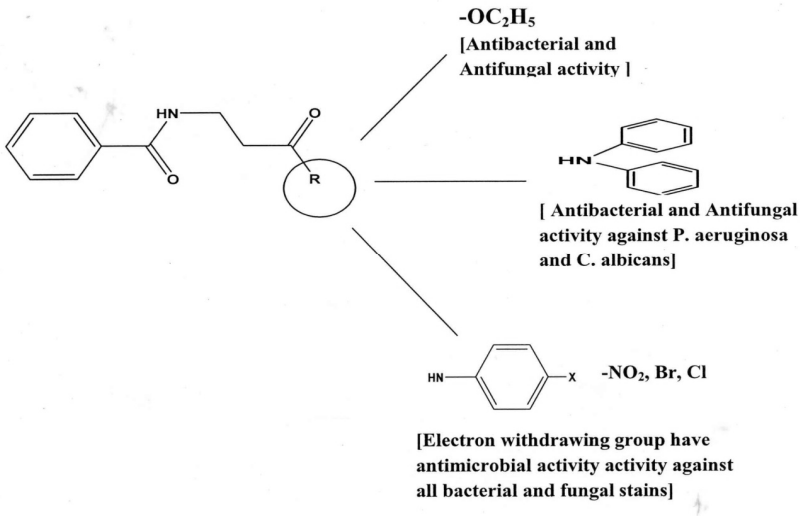

Figure 3: Various active sites of synthesized derivatives of beta-alanine

CONCLUSION

A novel series of beta-alanine derivatives **(1-21)** was synthesized and tested for *in vitro* antimicrobial activity against *S. aureus, B. subtilis, E. coli, C. albicans and A. niger*. The result of pMIC indicated that the compounds having diphenyl, 4-nitro, 4-Br, 4-Cl substituents were most active against all bacterial and fungal stains. The results revealed that the compound **D14** was active against *P. aeruginosa* and showed high antifungal potential against *C. albicans* with pMIC 2.04µM/mL. Compound **D21** was active against all bacterial and fungal stains with pMIC 1.74µM/mL.

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