DOI: 10.55522/jmpas.V13I2.6249 **ISSN NO. 2320 – 7418**

International peer reviewed open access journal

Journal of Medical Pharmaceutical and Allied Sciences

Journal homepage: www.jmpas.com CODEN: JMPACO

Research article

In-silico design and synthesis of curcumin derivatives with enhanced antibacterial and anti-inflammatory activities

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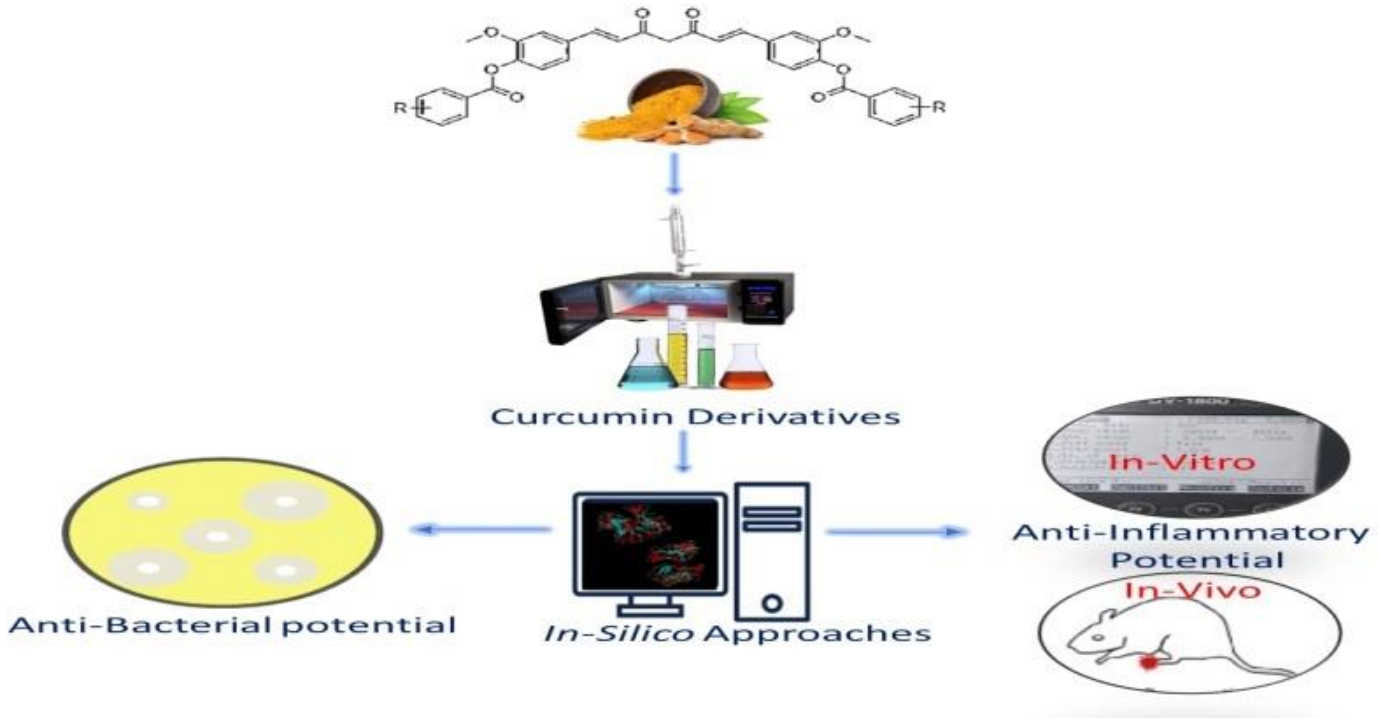
Received - 02-02-2024**, Revised** - 16-03-2024, **Accepted** - 08-04-2024 **(DD-MM-YYYY)**

Refer This Article

Manish Kamble, Prafulla Sabale, Rina Ikhar, Vidya Sabale, 2024. *In-silico* design and synthesis of curcumin derivatives with enhanced antibacterial and anti-inflammatory activities. Journal of medical pharmaceutical and allied sciences, V13 - I2, Pages - 6489 – 6500. Doi: https://doi.org/10.55522/jmpas.V13I2.6249.

ABSTRACT

Since curcumin and curcuminoids include potential functional groups (such as α, β-unsaturated β-diketone, α, β-unsaturated ketone, and β 0-hydroxy-α, β-unsaturated ketone linked with aromatic rings on both sides), they have been the subject of much discussion. These groups have anti-inflammatory, anti-cancer, and antioxidant qualities, among other bioactivities. Using spectroscopic techniques, novel compounds of curcumin were created and described. This study assessed the antibacterial and anti-inflammatory properties of PDB ID:1IU 4 and PDB ID: 4LHF molecular docking, utilizing in silico models. In terms of binding affinity, compounds C-04 and C-05 they had a greater affinity for the 1IU4 and 4LHF, respectively.



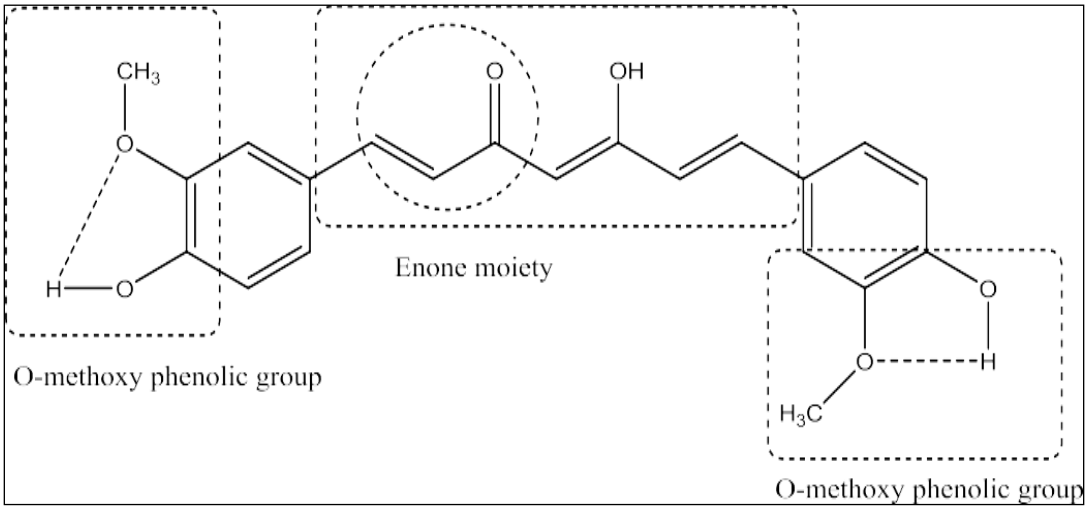
Using the Agar disc diffusion plate method (500µg/mL), the derivatized compounds were evaluated for their in-vitro antibacterial properties against two strains: S. Aureus and E. coli. When compared to conventional ciprofloxacin, compound C-04 demonstrated good to exceptional antibacterial efficacy against two distinct strains. they were further tested utilizing the carrageenan-induced paw edema method for anti-inflammatory efficacy. By using the HRBC membrane stabilizing test method, Compound C-05 showed strong anti-inflammatory action, while Compounds C-05 &and C-06 demonstrated noteworthy anti-inflammatory activity.

Keywords: Curcumin, Antibacterial, *In-Silico*, Molecular Docking, Anti-inflammatory.

INTRODUCTION

Since the mid-1900s, when drug discovery was at its peak, natural products have been the main building block for the development of the majority of pharmaceuticals currently in clinical use [1]. The bulk of people in poor nations mostly receive their medical care from traditional herbal medicine practitioners. A huge surge in interest in herbal remedies as a path towards medication discovery occurred in the early to mid-20th century [2]. A large portion of the world's population lacks access to conventional pharmaceutical treatment, which is one of the main causes of conventional medicine's ineffectiveness. Synthetic drug abuse and inappropriate usage, as well as their cytotoxicity, side effects, and effectiveness—and, most all, their exorbitant cost are other contributing causes. Due to the limitations of synthetic chemistry, new drugs must be created to battle the growth of multi-resistant germs and manage a wide range of chronic illnesses, including cancer, diabetes, and AIDS. Because of their unmatched structural variety, natural goods can be made more useful by looking into biological mechanisms [3]. The creation of novel curcumin derivatives and an assessment of their increased pharmacological properties are the subjects of the current investigation. Chemically speaking, 1, 7-bis (4-hydroxy-3-methoxyphenyl)-1, 6-heptadiene-3, 5-dione is known as curcumin. It demonstrates biological actions such as antioxidant, anti-inflammatory, and anti-tumour effects [4]. The main source of curcumin is the rhizome of the Curcuma Longa L. belonging to family Zingiberaceae, often known as turmeric. Curcumin has been shown to have positive health effects in both in vitro and in vivo investigations. These effects are mainly attributed to curcumin's strong antioxidant and anti-inflammatory qualities [5]. Additionally, this natural compound demonstrates antiviral [6]. Antibacterial, antifungal, antiprotozoal, and antiparasitic qualities [7]. Broad-spectrum antibacterial activity of curcumin against both Gram-positive and Gram-negative bacteria has been demonstrated [8]. Its various biological effects are thought to be based on its anti-inflammatory qualities, which are also important for treating illnesses [9]. Although curcumin has a wide spectrum of pharmacological properties, its low bioavailability due to its hydrophobic structure, quick metabolism, and restricted intestinal absorption presents a significant obstacle to its intended medicinal uses. Its oral administration results in a relatively low systemic bioavailability. Nonetheless, studies have demonstrated that systemically accessible curcumin, even at low doses, can have a major therapeutic impact [10]. According to this study, curcumin is thought to be a promising agent for the synthesis of novel natural products that will change their bioactivities and increase their stability against the factors found. Two ferulic acid residues connected by a methylene bridge are present in curcuminis1, 7-bis (4-hydroxy-3-methoxyphenyl)-1, 6heptadiene-3, 5-dione. The, β-unsaturated β-diketomoiety, an aromatic o-methoxy phenolic group, and a seven-carbon linker are crucial for the biological activity and functional groups that underlie it [11]. The structure of curcumin is depicted in Figure 1, along with potential interaction sites and functional groups that are involved in its biological activity.

Figure 1: The chemical structure of Curcumin and its different functionalities



MATERIAL AND METHOD

Curcuma longa (rhizome) was collected from a local market and was identified by Dr. Nitin Dongarwar, Professor, Department of Botany, RTMNU Nagpur with specimen number 13016.

Chemicals

All chemicals were purchased from Merck, S.D. Fine Chemicals, and Loba Chemicals. The chemicals and solvents were purified using standard laboratory procedures before being employed. All moisture-free procedures were used on oven-dried glassware. Melting temperatures were calculated using the capillary tube method. On a Shimadzu 1700 UV-visible spectrophotometer, the ultraviolet spectrum was obtained using methanol as a solvent. Potassium bromide discs were used to record IR spectra (wave numbers in cm−1) on a BRUKER ALPHAFT-IR spectrophotometer. Chromatographic separations employing silica gel 100-200 mesh were carried out on columns. The actions were observed by TLC on 2cm x 5 cm cm-coated silica gel 60F254 (Merck) plates with a 0.25mm thickness. The chromatograms were visible when exposed to iodine vapors or UV 200–400 nm light.

Extraction and Isolation of Curcumin from Turmeric

The various literature studied and have showed that the extraction of curcumin from turmeric is done in several different ways like solvent extraction, simple maceration, digestion, infusion, soxhlet extraction, ultrasonic extraction, microwave, zone refining and dipping methods. Among these the Soxhlet, ultrasonic and microwave extractions are the most commonly employed methods.

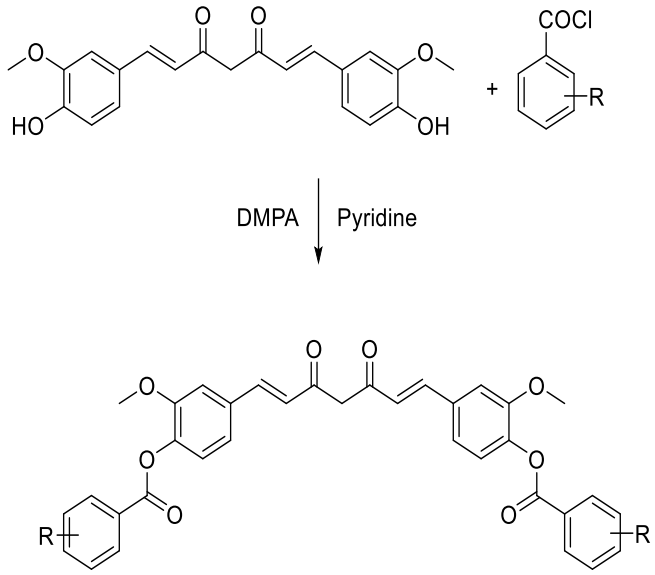
Turmeric rhizomes were collected from Maharashtra region, India. The collected rhizomes were boiled in water and then air dried in shade, under normal environmental conditions and then subjected to size reduction to get coarse powder and shifted through mesh of fine size. In the present study extraction of curcumin from turmeric powder was done by Soxhlation.

Before extraction of Curcumin, Turmeric powder was defatted with n-hexane overnight. Later the turmeric powder was air dried. Turmeric powder (20 g) was placed into a filter paper thimble in soxhlet apparatus, and set up with various solvent from non-polar to polar for successive extraction. 200 ml of solvent was heated and refluxed for extraction according to their boiling point until all the colouring matter is extracted. For extraction ethyl acetate, methanol, and acetone solvents were used [12]. After completion of extraction the extract was then cooled, concentrated at reduced pressure and temperature in a rotary evaporator to get a crude dried extract which was reddish orange in colour. When being stored Curcumin is more prone to chemical deterioration, particularly in the presence of light, high temperatures, and alkaline environments hence isolation of curcumin required during the study.

Further, crude curcumin was subjected to fractionation using column chromatographic technique with solvent combinations. The ethanol/methanol and chloroform/dichloromethane combinations are used as eluents to further purify the curcumin fraction on silica gel [13]. This process produces three distinct fractions from a crude curcumin mainly curcumin, dimethoxy curcumin, and bis-demethoxycurcumin by using column chromatography with good yield (58.8 mg/g) of curcumin.

Synthetic Scheme

Derivatization of Curcumin



RC(1-12)

Code	R	Code	R
01	4-Chloro	06	2-Bromo
02	2-Chloro	07	3-Bromo
03	4-Methoxy	08	2-Fluoro
04	4-Methyl	09	2-Hydroxy
05	4-Nitro	10	3-Bromo

Reaction Procedure

Curcumin (100mg) was dissolved in dry pyridine (4ml) and then followed by the addition of substituted benzoyl chloride (3ml) and DMAP (100mg). The reaction mixture was placed in a microwave synthesizer at 510 watts for 15 mins. After completion of the reaction, place in chilled water for 10 min. Crystals are obtained after some time and then this was recrystallized from ethanol. The percentage yield found for compound C-01. C-02, C-03, C-05, C-06 was found to be 100%, 98.23%, 71.20%, 81.23% and 65.13% respectively.

Molecular docking

After being used in molecular docking research, PyRx software is now widely used to identify effective treatments for specific drug targets in fatal illnesses. PyMOL was used to clean up the crystal structures of PDB IDs 1IU4, and 4LHF before molecular docking for antibacterial and anti-inflammatory activities, respectively, due to their complex structures with the inhibitor. Once undesirable molecules such as ions and water were removed, it was docked to inhibitors that were specifically developed to examine the interaction and binding energy of amino acids. The grid box's

specifications were altered. The ligand-viral protein interaction was visualized and analyzed using Pymol and Discovery Studio. The scoring function was utilized in molecular docking to predict the interactions between the previously listed ligands and inhibitors, including all of these recently developed inhibitors. Table 1 displays the outcomes of molecular docking using PyRx.

Evaluation of Antimicrobial Potential

The antibacterial activities of the recommended compounds were evaluated using a disc diffusion experiment, which was conducted using two separates, carefully chosen microbial strains: *S. aureus* and *E. coli* [14]. Utilizing the agar well diffusion method, nutrient agar plates containing 500 µg/ml of ciprofloxacin served as a positive control [15]. As indicated in Table 2, inhibition zones were assessed for each of the contents and activities.

Evaluation of Anti-Inflammatory Potential
Carrageenan-Induced Paw Edema Method

The anti-inflammatory effects of the derived compounds were examined using method [16]. which involved inducing rat paw edema with carrageenan and measuring the edema using a modified plethysmometer. Albino rats of both genders weighing 120–160 grams were used in this investigation. Five groups, each with seven randomly chosen animals, were present. They had nothing to eat for the rest of the night, but water was freely available. The rats were given medicines by mouth the following morning.

Group I (Control): 1% CMC (Carboxy Methyl Cellulose) (1 ml/100g body weight).

Group II (Standard): Aspirin (300mg/kg body weight) suspended in 1% CMC [17].

Group III (Test group 01): Derived compounds (250 mg/kg body weight) suspended in 1% CMC.

Group IV (Test group 02): Derived compounds (500mg/kg body weight) suspended in 1% CMC.

Group V (Test group 03): Derived compounds (1000mg/kg body weight) suspended in 1% CMC.

Following an hour-long medication administration interval, a 26 G needle was used to inject 0.1 ml of 1% carrageen suspended in sterile 0.9% NaCl into the plantar region of the left hind paw [18]. The volume of the injected paw was then measured using the plethysmometer[19]. Thus, the initial paw volume (IPV) was measured. To ascertain the final paw volume (FPV) after carrageen was administered for three hours, the paw volume was measured again. The algorithm below (Table 3) was used to determine the percentage of inhibition.

$$\% \text{ Inhibition} = \frac{(X - Y) \times 100}{X}$$

X= average variation in the paw volume of the rats in the control group.

Y = mean variation in the rats' paw volumes in the drug-treated group.

Human Red Blood Cell (HRBC) Membrane Stabilization Assay

The HRBC membrane stabilization method is employed to assess a drug's *in vitro* anti-inflammatory efficacy [20]. The anti-inflammatory activity was measured as a percentage of RBC lysis, with NSAIDs used as a control. Similar functions are carried out on both the lysosomal and HRBC membranes [21]. It will stabilize the lysosomal membrane if the chemical is used to stabilize it. The hemoglobin concentration in suspension was measured using a UV-visible spectrophotometer Shimadzu-1700 set at 560 nm. A healthy human volunteer gave blood, and the main exclusion criterion was thought to be the use of NSAIDs during the two weeks before the study. The blood was treated with sodium oxalate to stop it from clotting. Before being used, all blood samples were stored at 4°C for a full day. Centrifugation was used to extract the supernatant for five minutes at 2500 rpm. Centrifugation was used for five minutes at 2500 rpm while a sterile saline solution (0.9% w/v NaCl) was used for washing. Three times the supernatant extraction procedure was carried out, and each time the packed cell volume was ascertained. 40% (v/v) suspension combined with 10 mM, pH 7.4) phosphate-buffered saline in 1 liter of distilled water. NaH_2PO_4. $2H_2O$–0.26 g; Na_2HPO_4–1.15 g; and NaCl–9 g was utilized for the reconstruction of the cellular components. Add 0.5 ml of HRBC suspension, 2 ml of hyposaline, and 1 ml of phosphate buffer to each concentration to make derived drug samples (100 to 1000 µg/ml). It was distilled. It was incubated for 30 minutes at 37 °C before being centrifuged for 20 minutes at 3000 rpm. Spectrophotometry was used to measure the amount of hemoglobin in the supernatant solution at a wavelength of 560 nm. The reference standard used was ibuprofen (1000 µg/ml), while control was made by not including the drug sample. Table 4 shows the percentage suppression of hemolysis or membrane stabilization, which was calculated using a modified technique [22].

RESULTS AND DISCUSSION

Using several computational techniques, a molecular docking investigation of all the suggested derivatives of curcumin was conducted. After being used in molecular docking research, PyRx software is now widely used to identify effective treatments for specific drug targets in fatal illnesses. PyMOL was employed to clean up the protein crystal structure because of its intricate arrangement with the inhibitor. The binding affinity and interface of amino acids were studied by docking them to chosen inhibitors after undesired components like water and ions were removed. Pymol and Discovery Studio were utilized to visualize and examine the ligand-viral protein interaction. These newly developed inhibitors were all employed in molecular docking, and the interaction between the inhibitors and the ligand above was predicted using the scoring function. Curcumin was created in nine different forms and docked on different enzymes. Table

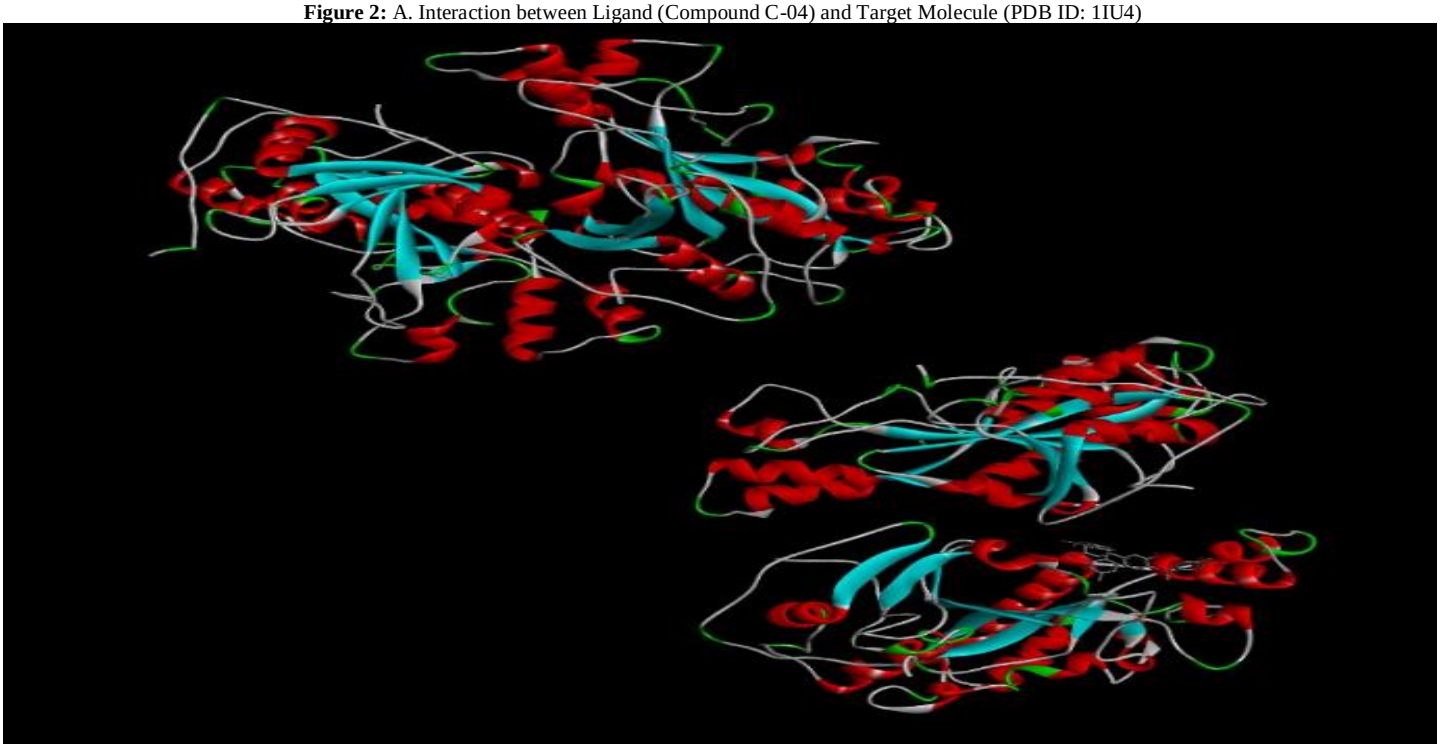
1. Displays the docking score for each docked ligand as well as the standard Celecoxib.

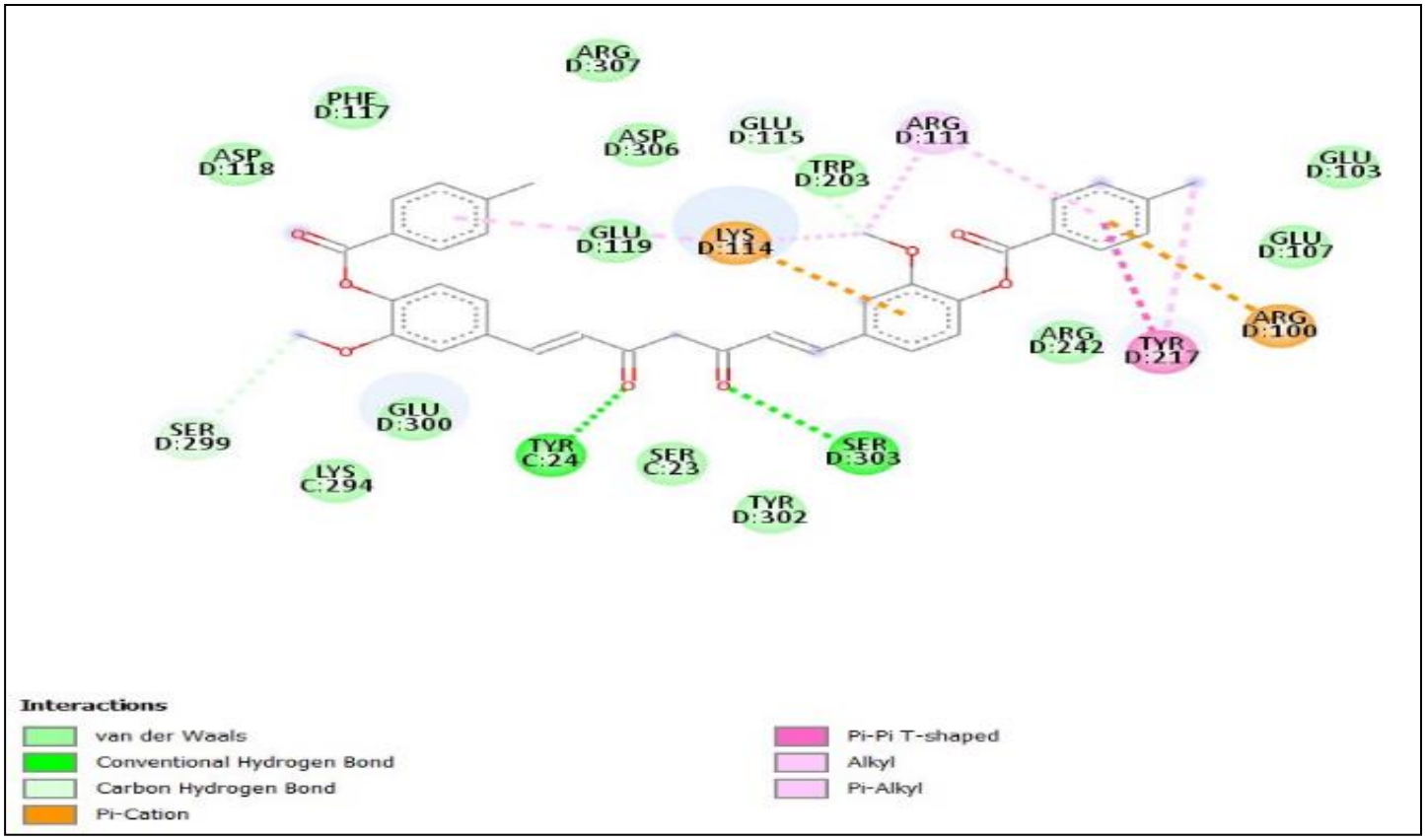
Table 1: Molecular Docking showing binding affinity with amino acid using PDB ID: 1IU4 and PDB ID: 4LHF

Compound	Binding Affinity	Amino Acid Residue	Distance [Hydrogen bond]	Binding Affinity	Amino Acid Residue	Distance [Hydrogen bond]
PDB ID: 1IU4				**IDB ID: 4LHF**		
Designed Inhibitor				**Designed Inhibitor**		
C-01	-8.6	SER:C 303, TYRC: 302, HISC:201	ARGD294	-7.8	MET A: 31, PHE A 17, LEU A:37, LYSA:23	LEUA:66, TRPA:62
C-02	-8.1	ASPC:237, PHEC:254, ASNC:253	TYRC:75, ASNC:239ARGC:238	-7.6	LYSA;67, ILEA: 21	TYRA:70, ASNA:63
C-03	-7.5	ASNB;52, ASPB:88, GLUA264	ARGB:98	-6.3	GLUA:71, ARGA:78, LEUA:66	TYRA:70
C-04	-8.9	ARGD:307, ASPD:118, GLUD:119	SERD:303, TYRC:24	-7.1	ALAA:69, GLUA:71	ARGA:73
C-05	-8.7	GLYB:301, PHEB305, ASPB:356, GLUB:119	ARGA:296, TYRA:24, RGB:150	-8.3	ARGA: 78, ARGA: 73. ILEA:77, ALAA:69	LEUA:66
C-06	-7.9	TYRD:302, SERC:23, LYSD14,	ARGC:294	-7.9	ILEA:77, ASNA:63	TRPA:84
C-07	-7.0	ASNB:134, GLUB;138, ASPB 324	ARGB:135, SERB:131, LYSB194	-6.1	ARGA:78, GLPA:80, ILEA:77	ARGA:73
C-08	-6.9	TYRB:217, TRPB:203	LYSB:114, ARGA:296	-6.3	ASNA:63, GLUA:76, TRPA:84	ILEA:77
C-09	-7.1	SERD:131, ASND:134	ARGD:127, ALAD:267, ASPD::268	-7.0	ARGA:78, GLYA:80	ILEA:77
C-10	-6.9	GLUD: 123. ALAD:195	ASPC:296	-6.9	GLUA:76, TRPA:84	ARGA:73
Reference drug: Ciprofloxacin				**Reference drug: Celecoxib**		
	-8.7	GLUA:300, ASNS:297, ARGB:26, TYRB:302	TYRA:302	-7.8	ASPA:41.PRDA:60	ASPS:10, THRA:59, TYRA:58

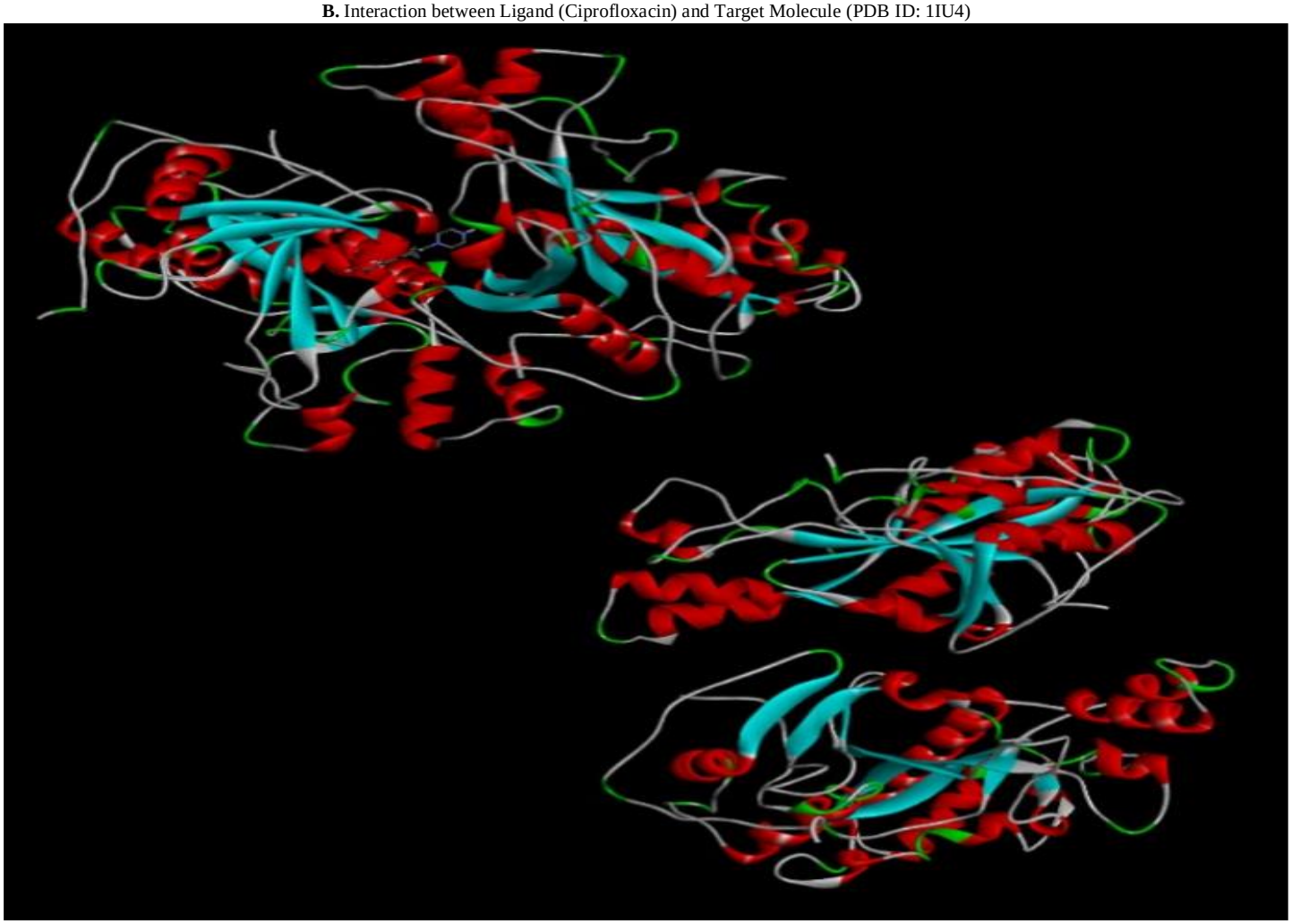
To determine how a proposed medication could inhibit the 1IU4 binding site for antibacterial action and the 4LHF for anti-inflammatory activity, respectively, this work used molecular docking. The synthesized compounds C-04, C-01, C-02, and C-06 all demonstrated a significant binding affinity to PDB ID 1IU4 at -8.9 kcal/mol, -8.6 kcal/mol, -8.1 kcal/mol, and -7.9 kcal/mol, respectively. Compound C-04 also formed typical hydrogen bonds with SERD: 303 and TYRC: 24 (Figure 2). Similarly, chemical C-05 established normal hydrogen bonds with LEUA: 66 and exhibited the maximum binding affinity (-8.3 kcal/mol) with PDB ID: 4LHF (figure 3). Additionally, compound C-06, compound C-01, compound C-02, and compound C-04 demonstrated considerable binding to 4LHF at -7.9 kcal/mol, -7.8 kcal/mol, -7.6 kcal/mol, and -7.1 kcal/mol, in that order. Compounds C-01, C-02, C-04, C-05, and C-06 are therefore taken into consideration for derivatization based on the docking result, as they may exhibit strong antibacterial and Anti-inflammatory activity.

Figure 2: A. Interaction between Ligand (Compound C-04) and Target Molecule (PDB ID: 1IU4)





B. Interaction between Ligand (Ciprofloxacin) and Target Molecule (PDB ID: 1IU4)



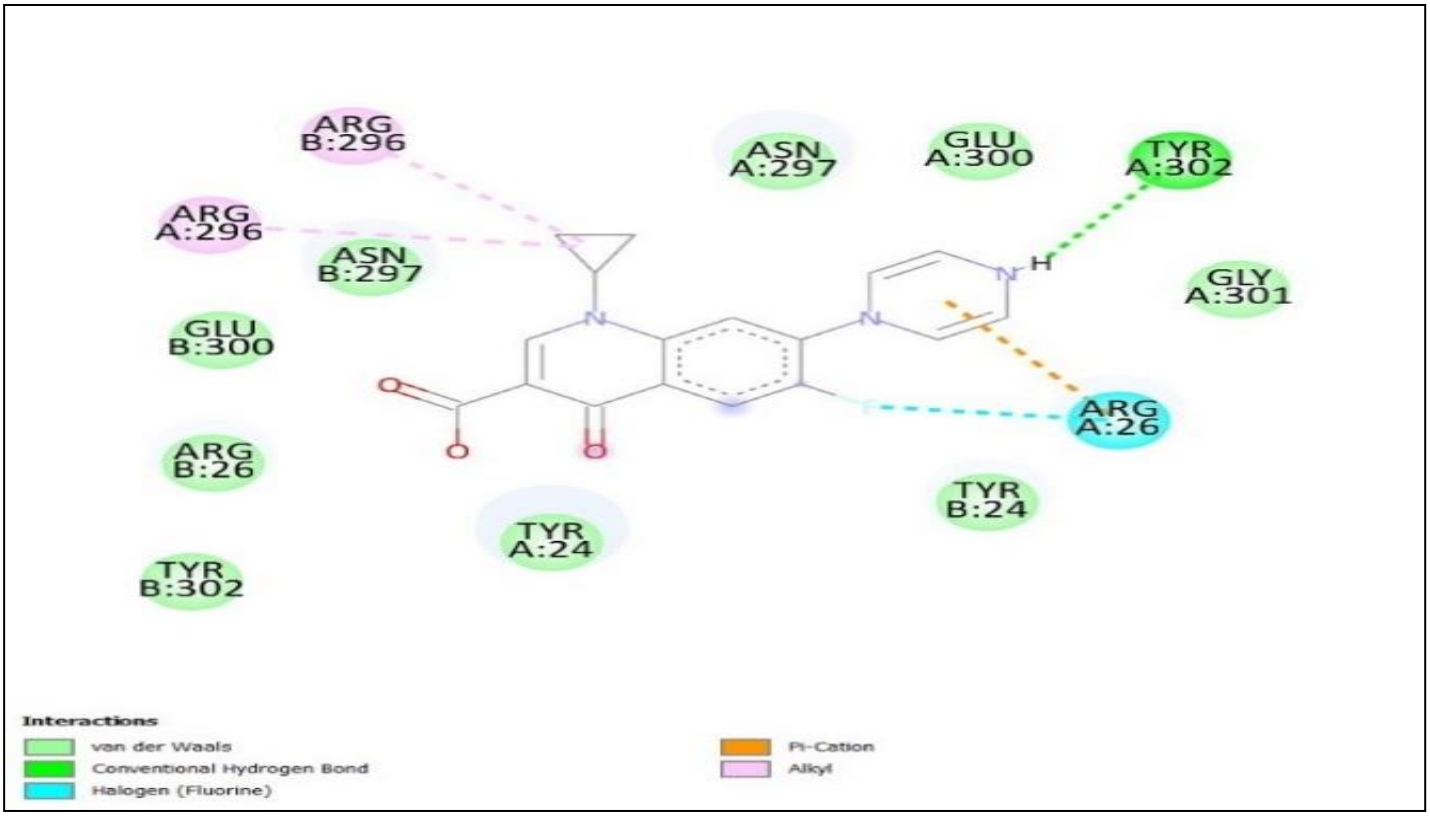
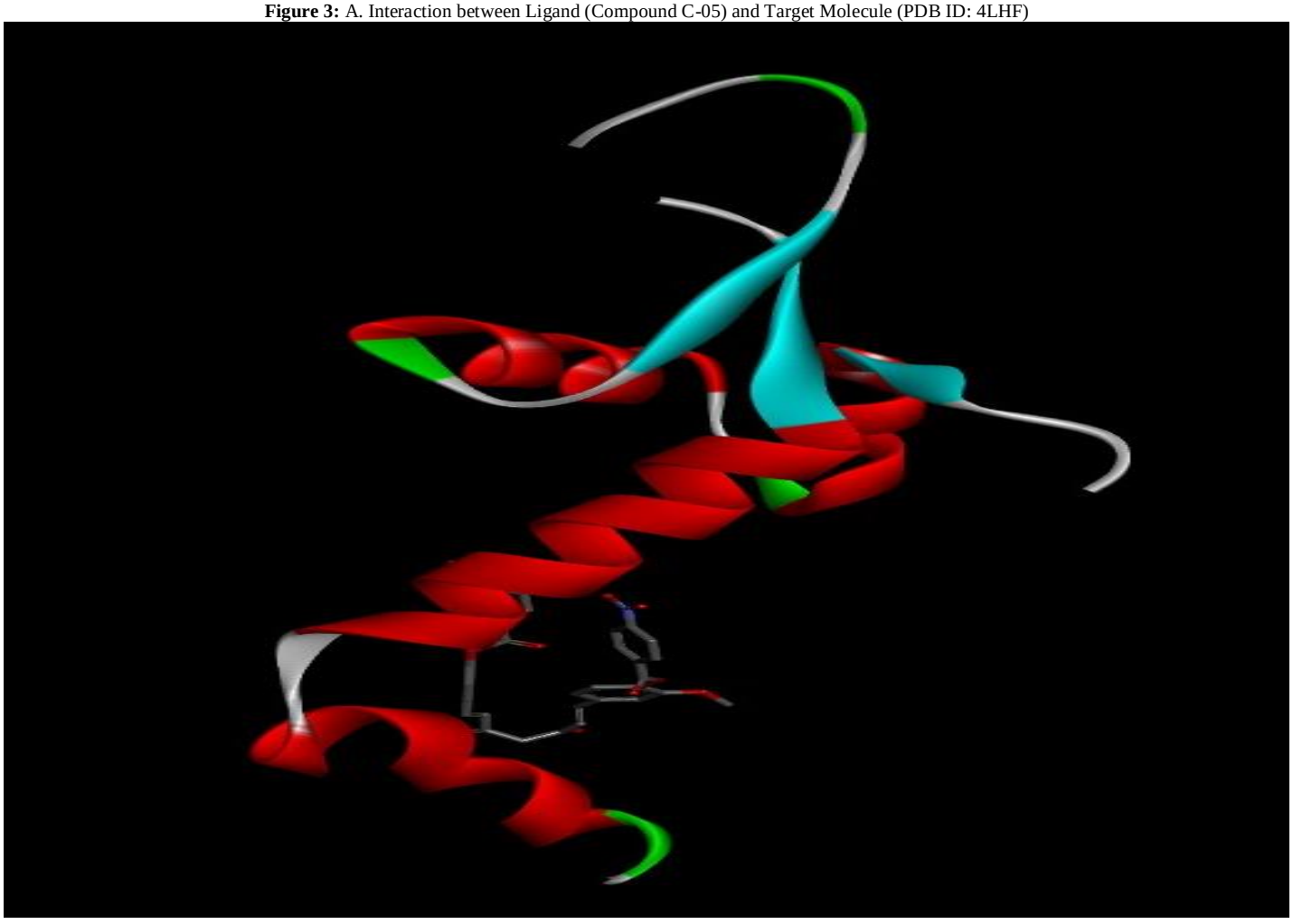
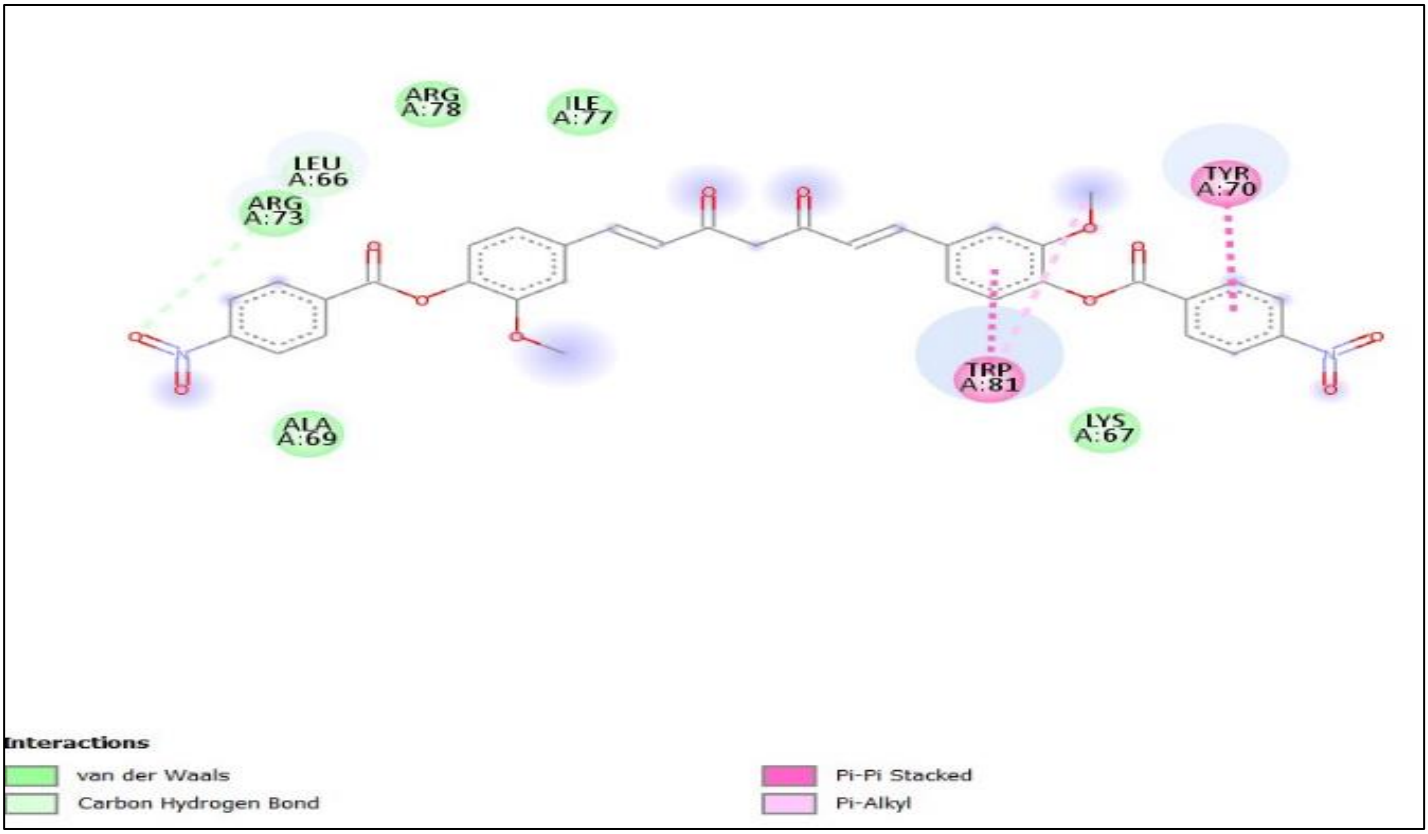
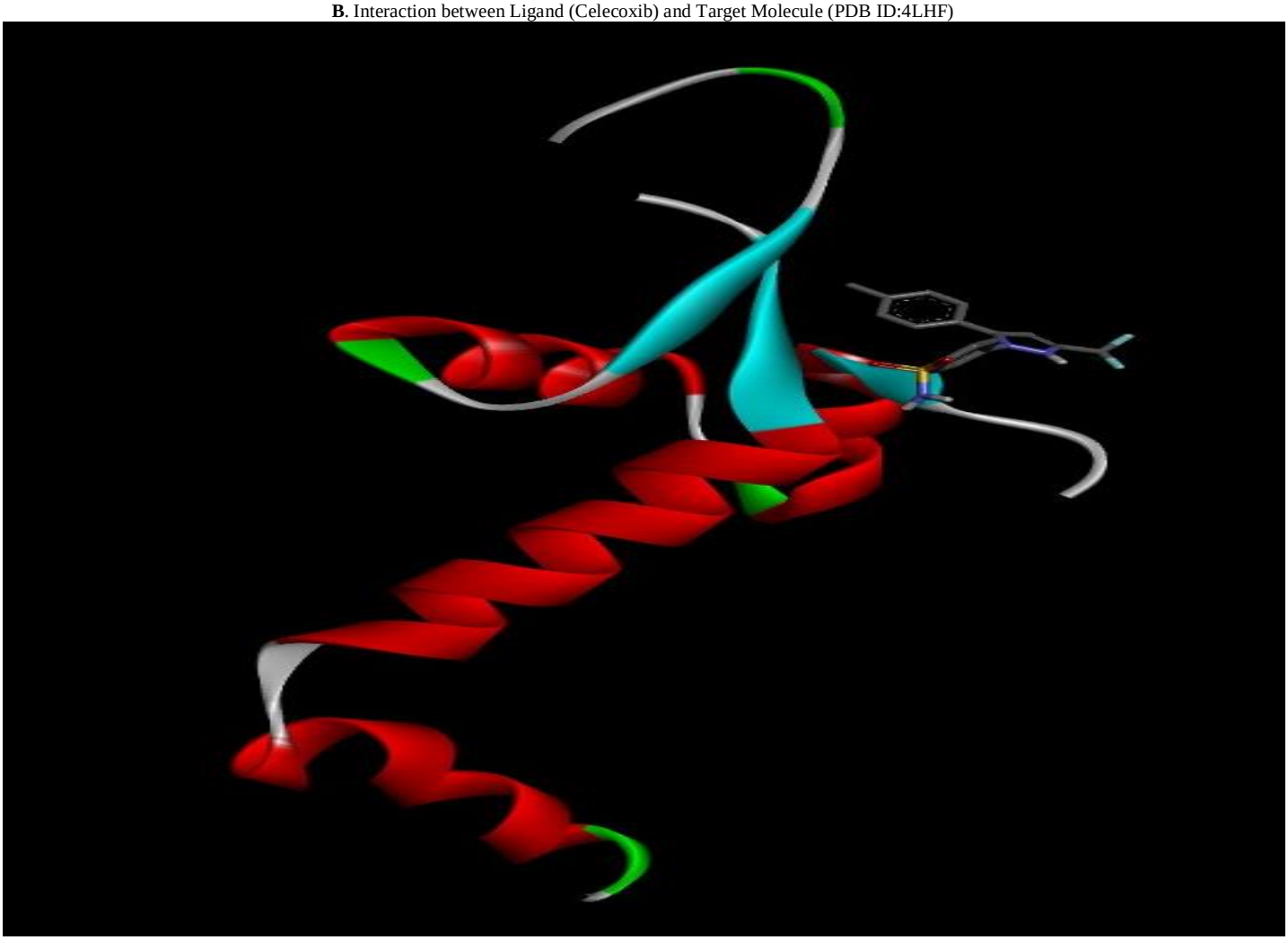


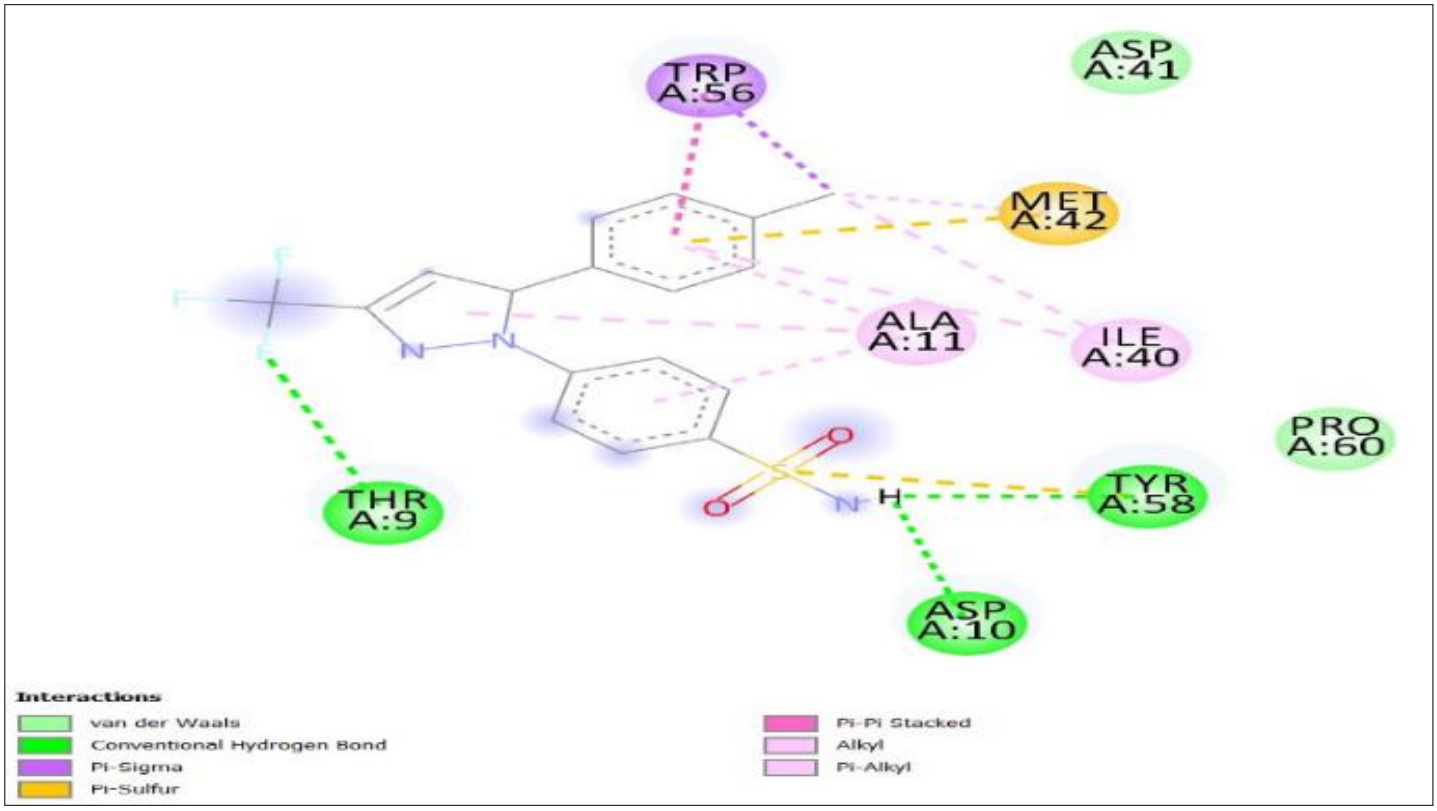
Figure 3: A. Interaction between Ligand (Compound C-05) and Target Molecule (PDB ID: 4LHF)





B. Interaction between Ligand (Celecoxib) and Target Molecule (PDB ID:4LHF)

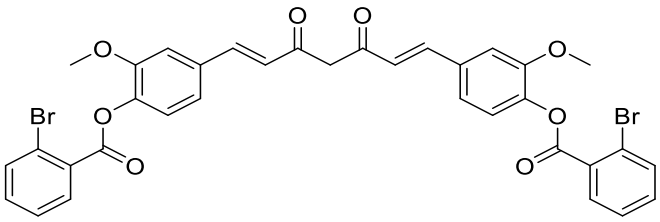




Derivatization of Curcumin

7-Bis (4-(2-bromo) benzoyloxy-3-methoxyphenyl) hepta-1, 6-diene-3, 5-dione (C-06)

Curcumin (100mg) was dissolved in dry pyridine (4ml) and then followed by the addition of 2-bromo benzoyl chloride (3ml) and DMAP (100mg). The reaction mixture was placed in a Microwave Synthesizer at 510 watts for 15 mins. After completion of the reaction, place in chilled water for 10 min. Crystals are obtained after some time and then this crystal is recrystallized from ethanol.

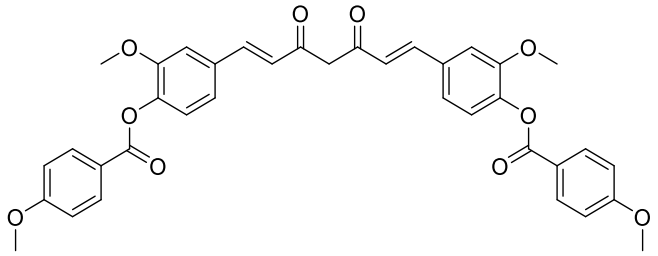


%Yield: 65.13%, MP (°c): 186-188°C, RF: 0.58, λmax (nm):246nm

IR: 3050 (C-H stretch aromatic), 2884 (C-H stretch), 1697 (C=O ester), 1600& 1450 (C=C aromatic ring), 1234 (C-O ether stretch) &1045 cm^{-1} (C-Br stretch)

1, 7-Bis (4-(4-methoxy) benzoyloxyphenyl) hepta-1, 6-diene-3, 5-dione (C-03)

Curcumin (100mg) was dissolved in dry pyridine (4ml) and then followed by the addition of 4methoxybenzoylchloride (3ml) and DMAP (100mg). The reaction mixture was placed in Microwave Synthesizer at 510watts for 15 min and after completion of the reaction, placed for 10 min in chilled water. Crystals were obtained after some time and then this crystal was recrystallized from ethanol.

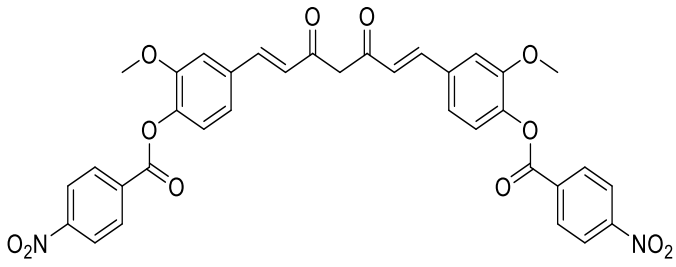


%Yield: 71.20%MP (°c):196-198°C, RF: 0.59, λmax (nm):241nm

IR: 3377.67cm^{-1}(OH group), 2793.46cm^{-1}(O-CH_3group), 1577.49cm^{-1} (C=O group), 1485.12cm^{-1} (C=C aromatic group) and 1267.49 cm^{-1} (C-Group)

1, 7-Bis (4-(4-nitro) benzoyloxy-3-methoxyphenyl) hepta-1, 6-diene-3, 5-dione (C-05)

Curcumin (100mg) was dissolved in dry pyridine (4ml) and then followed by the addition of 4-nitro benzoyl chloride (3ml) and DMAP (100mg). The reaction mixture was placed in Microwave Synthesizer at 510 watts for 15 min. After completion of the reaction, place for 10 minutes in chilled water. Crystals were obtained after some time and then this crystal was recrystallized from ethanol.

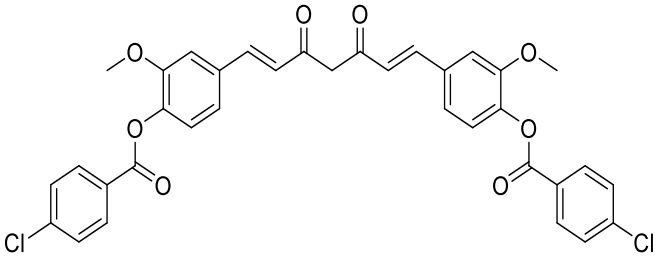


% Yield: 81.23%, MP (°c): 122-124°C, RF: 0.72, λ max (nm): 239nm

IR: 1512.02cm^{-1} (N-O stretch), 1330.58cm^{-1}(N-O stretch), 1203.05cm^{-1}(C-O group), 1480.90cm^{-1}(C=C aromatic group), 1767.17cm^{-1}(C=O group)

1, 7-Bis (4-(4-chloro) benzoyloxy-3-methoxyphenyl) hepta-1, 6-diene-3, 5-dione (C-01)

Curcumin (100mg) was dissolved in dry pyridine (4ml) and then followed by the addition of 4-chloro benzoyl chloride (3ml) and DMAP (100mg). The reaction mixture was placed in a Microwave Synthesizer at 510 watts for 15 mins and after completion of the reaction, placed for 10min in chilled water. Crystals were obtained after some time and then this crystal was recrystallized from ethanol.

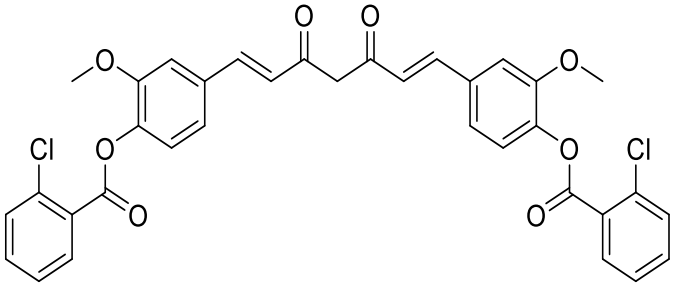


%Yield : 100%, MP (°c): 124-128°cRf: 0.88, λmax (nm):238nm

IR: 1776.27cm^{-1}(C=O group), 1479.82cm^{-1}(C=Caromatic group), 1206.62cm^{-1}(C-O group), 734.35cm^{-1}(-Cl group)

1, 7-Bis (4-(2-chloro) benzoyloxy-3-methoxyphenyl) hepta-1, 6-diene-3, 5-dione (C-02)

Curcumin (100mg) was dissolved in dry pyridine (4ml) and then followed by the addition of 2-chloro benzoyl chloride (3ml) and DMAP (100mg). The action mixture was placed in a microwave synthesizer (Catalyst- CATA-R) at 510 watts for 15 minutes. After the reaction is complete, place for 10 mins in chilled water. Crystals were obtained after some time and then this crystal was recrystallized from ethanol.



%Yield: 98.28% MP (°C): 132-136°C RF: 0.85λmax (nm):239nm

IR: 1591.60cm^{-1}(C=O group), 1419.27cm^{-1}(C=C aromatic group), 1251.49cm^{-1}(C-O group) and 760.99 cm^{-1}(-Cl group)

Evaluation of antibacterial potential

Using the disc diffusion method, the antimicrobial efficacy of curcumin derivatives against S. aureus and E. coli was assessed. The antimicrobial test revealed that C-04 had the largest zone of inhibition at 500 µg of dosage when conducted with varying concentrations of Curcumin derivatives, i.e., 100µg, 300µg, and 500µg. At 500 µg dosage, derivatized chemicals significantly decreased the overall antimicrobial activity. (Shown in Table 2). The reference chemical was ciprofloxacin. It is presently thought that curcumin mostly affects bacterial cells by breaking down their membranes or cell walls, preventing them from replicating their DNA and altering the expression of specific genes. Furthermore, because curcumin suppresses the bacterial quorum sensing process, which regulates bacterial cell density and behavior, its antibacterial effect may also be mediated through oxidative stress. Since curcumin targets several places within the bacterial cell, it has a significant advantage over most antibiotics. Curcumin is present in turmeric extract. This makes curcumin a potentially effective treatment for antibiotic-resistant microorganisms [23 - 24].

Table 2: Inhibition measurements (diameter in mm) for the various compounds

Compound	S.aureus	E. coli
C-01	11mm	10mm
C-02	13mm	13 mm
C-04	14mm	14 mm
C-05	13mm	12 mm
C-06	10 mm	12 mm
Ciprofloxacin 500 µg/ml	15 mm	15 mm

Evaluation of Anti-inflammatory activity

Carrageenan-Induced Paw Edema Method

Edema was not seen in any of the curcumin derivative dosages after three hours. At dose levels of 1000 mg/kg, the chemical C-05 demonstrated a statistically significant anti-inflammatory effect that was comparable to that of the widely used medication aspirin. At 500 mg/kg and 250 mg/kg, there was no discernible difference in response, and the levels were comparable to the control. At doses of 250, 500, and 1000 mg/kg b/w, the test medication caused 11.77%, 67.73%, and 88.80% suppression of edema, respectively, while aspirin produced 94.83% inhibition of edema (Table 3). Curcumin exhibits an inclination to inhibit both acute and chronic inflammation. The method of effect may involve lowering histamine levels and maybe boosting the adrenal glands' regular production of cortisone [25].

Table 3: Effect of curcumin derivatives on carrageenan-induced rat paw edema.

Concentration in mg/kg	% inhibition of edema				
	C-01	C-02	C-04	C-05	C-06
Control	-	-	-	-	-
200	9.65	9.19	10.23	11.77	10.14
500	53.26	60.39	60.98	67.73	65.24
1000	76.88	74.31	80.65	88.80	73.65
Asprin 1000 mg/kg	94.83%				

Human red blood cell (HRBC) membrane stabilization assay

Using HRBC membrane stabilization, the anti-inflammatory efficacy of derived curcumin compounds was investigated. To measure the anti-inflammatory activity, curcumin-derived compounds were compared to ibuprofen, a common medication. Out of all the generated compounds, C-05 and C-06 showed considerable inhibition of 79.56% and 73.65%, respectively, when compared to Ibuprofen 1000 µg/ml (83.33%).

Table 4: HRBC Membrane stabilization of derived compounds

Concentration in µg/ml	% inhibition of Derived Compound				
	C-01	C-02	C-04	C-05	C-06
100	09.46	7.13	8.86	9.54	7.28
200	18.53	19.26	12.23	19.56	13.39
400	31.71	39.78	29.99	36.17	27.20
800	58.39	56.22	45.31	59.37	51.32
1000	69.91	71.34	68.42	79.56	78.17
Ibuprofen 1000 µg/ml	83.33%				

CONCLUSION

Some of the therapeutic characteristics of curcumin were identified with the help of the current study using its derivatives. It has a wide spectrum of antibacterial and anti-inflammatory properties, according to the study. The results of this study corroborate those of earlier research demonstrating curcumin's antibacterial and anti-inflammatory qualities. To determine the precise mechanism of action and active components, more investigation is needed. It is a promising anti-inflammatory drug because many pharmaceuticals that are currently on the market, such as NSAIDs and corticosteroids, have numerous side effects, even when taken at recommended dosages.

ACKNOWLEDGMENT

The authors are thankful to the Head, of the University Department of Pharmaceutical Sciences, R.T. M. N. U. Nagpur for providing the necessary facilities to carry out work. No financial support is provided to all authors.

Conflict of interest

All authors of the above manuscript have not declared any conflict of interest.

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