Bioactive potential of some economically important marine gastropods along the Gulf of Mannar region, southeast coast of India

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ABSTRACT

Objective: To analyse the economically important gastropods for prospective antimicrobial, antioxidant and cytotoxic activities from the Gulf of Mannar region, southeast coast of India.

Methods: The bioactive potential of some gastropods i.e. Babylonia spirata (B. spirata), Phalium glaucum, Tonna dolium, Hemifusus pugilinus, Xancus pyrum, Chicoreus ramosus (C. ramosus), Harpa articularis, Ficus ficus and Babyonila zeylanica were analysed. Antimicrobial activity was carried out against 8 human pathogenic bacteria and 3 fungal strains by well diffusion method. Antioxidant and cytotoxic activities were analyzed by standard methods.

Results: In antibacterial and antifungal activities, methanolic extract of B. spirata significantly showed the highest inhibition zone against Aeromonas hydrophila and Fusarium spp. (P > 0.05). In the total antioxidant activity, the maximum activity was observed in B. spirata (510 µg/mg) and in the 1,1-diphenyl-2-picrylhydrazyl scavenging activity, B. spirata showed the highest percentage of inhibition (76.7%). In the case of cytotoxicity i.e. brine shrimp lethality tests the methanolic extract of C. ramosus showed the lowest percentage of mortality and the LC50 values were found to be 523.9 µg/mL.

Conclusions: The results revealed that all the gastropods in the present study possessed antimicrobial, antioxidant and cytotoxic effects. However, species like B. spirata and C. ramosus exhibited potent activity and can be used for further clinical studies.

1. Introduction

Marine organisms have important compounds in necessities of pharmaceuticals especially invertebrates which are used in the biomedical area[1,2]. Molluscs are potential organisms for the extract of pharmacologically active drugs and are distributed throughout the world. Molluscs are the largest phylum comprising about 23% of the marine organisms and account for 80% from this gastropod. The Gulf of Mannar is one of the most important beds for gastropods which are associated with seaweed and algae. Numerous bioactive compounds have been studied for their bioactive potential i.e. antimicrobial, cytotoxic and anti-tumor[3,4]. In general very less studies have been done on the antimicrobial protein of molluscs while some molluscs have been studied for their bioactive potential i.e. antimicrobial, cytotoxic and anti-tumor[3,4]. In general very less studies have been done on the antimicrobial protein of molluscs while some molluscs have been estimated as whole body homogenate which possesses a range of antimicrobial compounds. The gastropod egg and tissue consists of active secondary metabolites that have more antimicrobial activities because of the protecting embryos inside the capsule[5]. The antioxidant compounds are essential to trap free radicles and reduce the risk of cancer and heart disorders[6,7,8,9]. The large number of works has been done in other organisms, but only a few researches were done on molluscs[9]. The resources of gastropods are not well utilized in the areas around the Gulf of Mannar region. The objective of the present study was to investigate the antimicrobial activity, cytotoxicity and antioxidant potential of the body tissues of some economically important gastropods around the Gulf of Mannar region, southeast coast of India.

2. Materials and methods

2.1. Sample collection and extraction

Live specimens of Babylonia spirata (B. spirata), Phalium glaucum (P. glaucum), Tonna dolium (T. dolium), Hemifusus pugilinus (H. pugilinus), Xancus pyrum (X. pyrum), Chicoreus ramosus (C. ramosus), Harpa articularis (H. articularis), Ficus ficus (F. ficus) and Babyonila zeylanica (B. zeylanica) were collected from the Mandapam coast, southeast coast of India. They were directly brought to the laboratory and identified from marine gastropod hatchery research laboratory, Kamaraj College, Tuticorin, Tamilnadu, India. The 50 g of whole body muscle was taken out from the shell, used for extraction by methanol and stored for 4 days. The crude extracts were filtered through Whatman No.1
filter paper and the solvents were concentrated by rotary evaporator (VC100A Lark Rotavapor® at 30 °C) with reduced pressure to give aqueous suspension and freeze dried. The final residues were stored at 4 °C for more analysis[10].

2.2. Bacterial strains and fungal strains

The dried methanolic crude extracts were used for antimicrobial assay against human pathogens viz., *Escherichia coli*, *Salmonella typhi* (S. typhi), *Salmonella paratyphi A*, *Aeromonas hydrophila* (A. hydrophila), *Vibrio cholera*, *Vibrio parahaemolyticus*, *Klebsiella pneumonia*, *Staphylococcus aureus*, *Aspergillus niger* (A. niger), *Penicillium* spp. and *Fusarium* spp. All the pathogenic microbial strains were obtained from Department of Microbiology, Kamaraj College, Tuticorin, Tamil Nadu, India.

2.3. Antibacterial and antifungal assay

Antibacterial activity was determined by well diffusion method[11]. Methanol was used as negative control and streptomycin was used as positive control. All the plates were incubated at 37 °C for 24 h. Results were calculated by measuring the zone of inhibition in millimetres. Antifungal activity was carried out by using the standard well diffusion method according to National Committee for Clinical Laboratory Standards[12]. The tetracycline discs (30 mg disc) were used as a positive control and methanol were used as negative control. All the extracts were tested in triplicate at attention of accurate results.

2.4. Total antioxidant activity

The total antioxidant activities of methanolic extract acquired from gastropods were determined[13]. The sample volume of 0.3 mL was taken and mixed with the reaction mixture consisting 63.0 mL reagent solution (0.6 mol/L sulfuric acid, 28 mol/L sodium phosphate and 4 mol/L ammonium molybdate). By using the water bath it was incubated at 95 °C for 90 min. At 695 nm the absorbance was measured and total antioxidant activity was expressed as the number of equivalents of ascorbic acid in milligram per gram of extract.

2.5. 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical scavenging assay

The free radical scavenging capacity of the methanolic extracts of gastropods was determined[14]. DPPH solution was prepared freshly, added into all test tubes followed by the extract in a serial dilution method (15–250 µg/mL) and made the final volume up to 5 mL. The absorbance was examined at 517 nm in spectrophotometer after 30 min. Gallic acid and methanol were used as the standard and blank controls respectively. This blank was used as control samples.

2.6. Cytotoxicity-brine shrimp lethality assay

Brine shrimp eggs were collected from Kolathur aquaculture industry. The glass chamber was used for hatching shrimp eggs which were filled with filtered seawater. The chamber was partitioned by both dark and light areas. After two days of hatching, 10 brine shrimps were introduced into the tube containing 4 mL of seawater. Test tubes were made in triplicate and 30 brine shrimps were totally used. The volumes of test tubes were made up to 5 mL by adding the methanolic extract of marine gastropods and left uncovered under the lamp. Totally five concentrations were used to assess the LC₉₀, i.e., 0.1, 1.0, 10.0, 100.0 and 1 000.0 mg/mL. Every 24 h the number of surviving shrimp were counted and noted. Probit analysis was done to calculate LC₉₀ and 95% confidence intervals. The percentage of mortality was calculated to know the activity of the bioactive compounds presenting in the gastropod extracts.

2.7. Statistical analysis

All experiments were done in triplicate (antimicrobial activity) and One-way ANOVA was calculated using SPSS statistical software. Means of three observations were compared with Duncan’s multiple range test at P > 0.05 for determining the statistical significance. Probit software version 1.5 (US-EPA) was used to calculate LC₉₀ and 95% confidence limit.

3. Results

3.1. Antimicrobial activity

The crude extracts from the gastropod species against eight human pathogenic bacteria and three fungal strains were tested for the antimicrobial activity. The inhibition zones of methanolic extracts against the treated organisms were shown in Tables 1 and 2. From the antimicrobial result, *B. spirata* significantly showed the highest inhibition zone (P > 0.05) ([12.40 ± 0.16] mm) against *A. hydrophila* and *H. articularis* significantly showed the lowest inhibition zone (P > 0.05) ([2.20 ± 0.11] mm) against *Vibrio parahaemolyticus*. In fungal assay, *Fusarium* spp. significantly showed high susceptibility (P > 0.05) ([18.00 ± 0.13] mm) against methanolic extract of *B. spirata* and *B. zeylanica* significantly showed the lowest inhibition zone (P > 0.05) ([1.90 ± 0.04] mm) against *A. niger*.

3.2. Total antioxidant activity

The methanolic extracts of the gastropods were analysed for total antioxidant activity (Figure 1) and the result showed that the
maximum antioxidant activity was observed in B. spirata (510 µg/ mg) and the minimum activity was observed in T. dolium (56 µg/ mg).

3.3. DPPH scavenging activity

The DPPH radical scavenging activity at different concentration of 20–100 µg were showed in Figure 2. The B. spirata extract showed the highest percentage inhibition of 76.7% and the lowest percentage inhibition was observed in T. dolium of 13.4%.

3.4. Cytotoxicity-brine shrimp lethality assay

From the result, C. ramosus showed the lowest percentage of mortality and the LC₅₀ of 523.9 µg/mL was obtained. And the highest percentage of mortality was observed in T. dolium and LC₅₀ of 93.5 µg/mL was obtained. The values were represented in Tables 3 and 4.

4. Discussion

Marine natural products gain importance in the pharmaceutical industries. The identification of new compounds is extremely important. From the present study the diverse antimicrobial activities were observed against eight human pathogenic bacteria and three fungal strains. Methanolic extracts of B. spirata, P. glaucum, T. dolium, H. pugilinus, X. pyrum, C. ramosus, H. articularis, F. ficus and B. zeylanica were used. The maximum inhibition zone was found in B. spirata and the lowest inhibition zone was found in H. articularis and all the nine gastropod showed antimicrobial activities. Previous report revealed that the marine snail Tibia insulaechorab possesses potent antimicrobial activity[15]. Mollusc like Meretrix casta and Tridacna maxima exhibited higher antibacterial activity against twelve human pathogens and they were used in six solvents out of those ethanol and methanol extracts showed higher antimicrobial activity[16]. The antimicrobial activity of green mussel Perna viridis (P. viridis) and edible oyster Crassostrea madrasensis extract of marine bivalves was previously reported[17]. According to Periyasamy et al.[18] the mollusk P. viridis showed the highest activity against Pseudomonas aeruginosa. The mollusk B. spirata showed the maximum activity (12 mm) against Pseudomonas aeruginosa[19]. Sugesh and Mayavan[20] reported maximum antibacterial activity

Table 2

| Species                        | Inhibition of zone (mm) | % Antioxidant activity |
|-------------------------------|-------------------------|-----------------------|
| P. glaucum                    | 14.00 ± 0.52            | 32.9                 |
| T. dolium                     | 8.00 ± 0.51             | 17.2                 |
| H. pugilinus                  | 2.30 ± 0.03             | 3.71                |
| B. spirata                    | 2.40 ± 0.23             | 4.73                |
| X. pyrum                      | 1.00 ± 0.47             | 1.18                |
| C. ramosus                    | 1.00 ± 0.47             | 1.21                |
| H. articularis                | 2.00 ± 0.89             | 2.08                |
| F. ficus                      | 7.00 ± 0.21             | 16.00 ± 0.47         |
| B. zeylanica                  | 22.00 ± 0.03            | 22.00 ± 0.03         |

PC: Positive control (tetracycline 30 µg); NC: Negative control.

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with the solvents like ethanol and methanol extracts of *H. pyluginus* against human pathogens. According to Tilaga et al.[21] *P. glaucom* showed wide spectrum activity against *S. typhi* (12 mm). From the reports it was evident that molluscs possess diverse antibacterial activities against eight human pathogenic bacteria and three fungal strains in the present study.

DPPH radical (oil-soluble free radical) scavenging activity assay has been widely used for screening antioxidant activity. Earlier report evidenced that the antioxidant peptide isolated from *Conus betulinus* (body and viscera) shows 20%–25% of scavenging effect[22]. According to methanolic extract from *B. spinosa*, the scavenging activity was found to be 39.43% at 10 mg/mL[23]. In the present study, the scavenging activity was higher in *C. ramosus* and lower in *T. doliolum*. Brine shrimp assay was the initial estimation of toxicity test and can be correlated with cytotoxic and anti-tumour properties. The cytotoxic assays revealed the strong cytotoxic nature to *P. viridis*[24]. According to Subhapradha et al.[25] cytotoxic activity was observed in three molluscs, namely, *Anadara granosa*, *Placenta placenta* and *Pinctada fucata* and mortality was increased with increasing concentration. It was similar to the present study that cytotoxicity was observed in all the nine molluscs and the mortality was increased with increasing concentration. And the maximum activity was found in *C. ramosus* and the minimum activity found in *T. doliolum*.

There are only few studies conducted in the commercial important gastropods. The information on the antimicrobial, antioxidant and cytotoxicity were only limited. Therefore, the present study was focused on it. Brine shrimp lethality test is the initial test to analyse the toxicity profile of the extract against brine shrimp nauplii. However, all the nine gastropods showed antibacterial, antioxidant and cytotoxic activities. By analysing the toxicity they will be further used in cell lines in drug industry.

**Conflict of interest statement**

We declare that we have no conflict of interest.

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**References**

[1] Janaki M, Santhi V, Kannagi A. Bioactive potential of *Fusinus nicobericus* from Gulf of Mannar. *Int J Pharm Res Biosci* 2015; 4(5): 262-70.

[2] Pachaiyappan A, Muthuvel A, Sadhasivam G, Sankar VJV, Sridhar N, Kumar M. *In vitro* antioxidant activity of different gastropods, bivalves and echinoderm by solvent extraction method. *Int J Pharm Sci Res* 2014; 5(6): 2539-45.

[3] Prem Anand T, Patterson Edward JK. Screening for antibacterial activity in the opercula of gastropods. *Palermo: NATURAMA*; 2001, p. 215-7.

[4] Kamiya H, Muramoto K, Goto R, Sakai M, Endo Y, Yamazaki M. *In vitro* antioxidant activity of different gastropods, bivalves and echinoderm by solvent extraction method. *Int J Pharm Sci Res* 2014; 5(6): 2539-45.

[5] Kaviarasalan T, Sankar RS, Yogamoorthi A. Studies in ultra structure of egg capsule wall of snails using scanning electron microscope. *J Coast Environ* 2011; 2(2): 143-50.

[6] Kamala K, Karuppiah V, Sivakumar K. Comparative evaluation of *in vitro* antioxidant potential of the marine actinobacteria from Gulf of Mannar biosphere reserve. *Int J Pharm Sci* 2013; 4(3): 207-16.

[7] Sivaperumal P, Kamala K, Natarajan E, Dilipan E. Antimicrobial peptide from crab haemolymph of *Ocypoda macrocera* (Milne Edwards 1852) with reference to antioxidant: a case study. *Int J Pharm Pharm Sci* 2013; 5(Suppl 2): S719-27.

[8] Sivaperumal P, Kamala K, Rajaram R. Bioactive DOPA melanin isolated and characterized from a marine actinobacterium *Streptomyces* sp. Mvcs6 from Versova coast. *Nat Prod Res* 2015; 29(22): 2117-21.

[9] Mariappan R, Balasubramanian U. Antibacterial activity of bivalves *Meretrix casta* and *Tridacna maxima* from south east coast of India. *Int J Pharm Sci Res* 2012; 13(2): 137-40.

[10] Suresh M, Anurasan S, Kumaran NS. Screening on antimicrobial activity of marine gastropods *Babylonia zeylanica* (Bruguiere, 1789) and *Harpa conooidalis* (Lamarck, 1822) from Mudasalodai, southeast coast of India. *Int J Pharm Sci Res* 2012; 4(4): 552-6.

[11] Ramasamy P, Thampi DPK, Chelladurai G, Gautham N, Mohanraj S, Mohanraj J. Screening of antibacterial drugs from marine gastropod *Chicoreus ramosus* (Linnaeus, 1758). *J Coast Life Med* 2013; 1(3): 181-5.

[12] Amini R, Abdulamir AS, Chung C, Jahanshiri F, Wong CB, Poyling B, et al. Circulation and transmission of methicillin-resistant *Staphylococcus aureus* among college students in Malaysia (cell phones as reservoir). *Asian Biomed* 2012; 6(5): 659-73.

[13] Prieto P, Pineda M, Aguilar M. Spectrophotometric quantitation of antioxidant capacity through the formation of a Photosphorbolbendun complex: specific application to the determination of vitamin E. *Anal Biochem* 1999; 260(2): 337-41.

[14] Braça A, De Tommasi N, Di Bari L, Pizza C, Politi M, Morelli I. Antioxidant principles from *Bauhinia tarapotensis*. *J Nat Prod* 2001; 64(7): 892-5.

[15] Degiam ZD, Abas AT. Antimicrobial activity of some crude marine Mollusca extracts against some human pathogenic bacteria. *Thi-Qar Med J* 2010; 4(3): 142-7.

[16] Mariappan R, Sukumaran V, Ayyavoo M. Potential antibacterial activity of marine bivalves *Meretrix casta* and *Tridacna maxima* from south east coast of India. *Adv Biore* 2010; 1(1): 92-6.

[17] Annamalai N, Anburaj R, Jayalakshmi S, Thavasi TR. Antibacterial activities of green mussel (*Perna viridis*) and edible oyster (*Crassostrea madrasensis*). *Res J Microbiol* 2007; 2(12): 978-82.

[18] Periyasamy N, Srinivasan M, Balakrishnan S. Antimicrobial activities of the tissue extracts of *Babylonia spirata* Linnaeus, 1758 (*Mollusca: Gastropoda*) from Thazhanguda, southeast coast of India. *Asian Pac J Trop Biomed* 2012; 2(1): 36-40.

[19] Kiran N, Siddiqui G, Khan AN, Ibrar K, Tushar P. Extraction and screening of bioactive compounds with antimicrobial properties from selected species of mollusk and crustacean. *J Clin Cell Immunol* 2014; 5: 1-5.

[20] Sugesh S, Mayavu P. Antimicrobial activities of two edible bivalves *M. meretrix* and *M. casta*. *Pak J Biol Sci* 2013; 16(1): 38-43.

[21] Thiylaga RD, Vimala S, Subavathi P. Isolation and characterization of bioactive compounds and antibacterial activity of marine gastropod *Phalium glaucum* (L.). *Int J Pure Appl Zool* 2014; 2(3): 218-23.

[22] Pachaiyappan A, Muthuvel A, Sadhasivam G, Vidhya Sankar VJ, Sridhar N, Kumar M. *In vitro* antioxidant activity of different gastropods, bivalves and echinoderm by solvent extraction method. *Int J Pharm Sci Res* 2014; 5(6): 2539-45.

[23] Sreejameole KL, Radhakrishnan CK. Antioxidant and cytotoxic activities of ethyl acetate extract of the Indian green mussel *Perna viridis*. *Asian J Pharm Clin Res* 2013; 6(3): 197-201.

[24] Esswar A, Ramamoorthy K, Mohanraj M, Gokulakrishnan S, Sankar G. *In vitro* antibacterial activity and brine shrimp lethality test on selected three marine mollusks from vellar estuary, Parangipetipet. *Int J Curr Res* 2014; 6(10): 9075-8.

[25] Subhapradha N, Ramasamy P, Sadhasivam S, Seedevi P, Moovendhan M, Dharmadurai D, et al. Antioxidant potential of crude methanolic extract from whole body tissue of *Bursa spinosa* (Schumacher, 1817). Proceedings National conference-USSE-2013; 2013 Apr 16-17; Tamil Nadu, South India.