Introduction

Like all organisms in nature, bacteria too have their own immune system and defense mechanisms. The antagonistic factors like antibiotics, bacteriocins, lysozymes, siderophores, proteases, and/or hydrogen peroxide and the alteration of pH values by organic acids produced either singly or in combination act as defense substances. Bacteriocins are potent antimicrobial peptides and proteins, found in almost every bacterial species examined till date, and within a species tens or even hundreds of different kinds of bacteriocins are produced [1].

The three types of cells in a microbial community are, bacteriocinogenic (produce bacteriocin), sensitive, or resistant to each bacteriocin. Thus in marine environments, all three cell types compete with each other for limited resources, with only a small percentage of bacteriocinogenic cells induced to produce and release bacteriocin. While some sensitive cells are killed immediately by the bacteriocin, others harbor mutations that impart resistance. These resistant cells rapidly displace the producing cells. In contrast to traditional antibiotics that are used in human health applications, bacteriocins mostly target members of the producer species and their closest relatives [2]. Hence they are classically considered to be narrow spectrum antibiotics. Halobacteria and archaea too produce their own version of bacteriocins, the halocins [3]. Some bacteriocins are capable of inhibiting archaea [4], but there is no confirmed inhibition of bacteria by a halocin, although there are reports that halophilic archaea are capable of inhibiting halophilic bacteria.

Bacteriocin was first discovered by Gratia in 1925 [5], during his search for ways to kill bacteria. He named it a colicine because it killed E. coli. The term bacteriocin was coined by Jacob and coworkers in 1953 [6], which paved the way for the development of microbial antibiotics and the discovery of bacteriophages, all within the span of a few years. High-throughput sequencing technologies reveal that bacterial diversity is larger than expected in marine microbial ecology and contains an extremely large number of microbial genes of unknown function [7]. Nevertheless, only a few bacteriocins and bacteriocin-like substances have been described from marine bacteria. In the limited knowledge of marine bacterial biodiversity and the urgent requirement for antibiotic alternatives, the marine bacteriocin research is an open alternative in the near future.

Discussion

Bacteriocin definition

Bacteriocins are ribosomally synthesized proteinaceous compounds, lethal to closely related species of producing bacteria, the latter being protected by self immunity. These toxins play a critical role in mediating microbial population or community interactions. Bacteriocins may serve as anti-competitors enabling the invasion of a strain into an established microbial community or act as communication molecules in bacterial consortia like biofilms. i.e., they play a defensive role and act to prohibit the invasion of other strains or species into an occupied niche or limit the advance of neighboring cells [8]. An additional role proposed by Miller & Bassler [9] for Gram-positive bacteriocins is in quorum sensing. Some bacterial species produce toxins which exhibit numerous bacteriocin-like features, but they are yet not fully characterized; such toxins are referred to as bacteriocin-like inhibitory substances, or BLIS. This review focuses on bacteriocins [10-14] and bacteriocin like substances [15-18] isolated from marine environment and marine food products [19,20].

A precise definition of the bacteriocins is obscure and futile. Conventional criteria for definition of bacteriocins were based on the characteristics of colicins. These criteria have been used in varying combinations and applied with different degrees of consistency and proof in defining other bacteriocins: (i) A narrow inhibitory spectrum of activity centered about the homologous species; (ii) a bactericidal mode of action; (iii) the presence of an essential, biologically active protein moiety; (iv) attachment to specific cell receptors; (v) plasmid-borne genetic determinants of bacteriocin production and of host cell bacteriocin immunity; (vi) production by lethal biosynthesis (i.e., commitment of the bacterium to produce a bacteriocin will ultimately lead to cell death) [21].
Marine Bacteriocins: A Review

Marine organisms as a potent source of bioactive compounds

The marine environment differs substantially from terrestrial and fresh water habitats because of its exigent, competitive and aggressive nature. The estimated density of bacteria in seawater and sediment ranges from $10^3$ to $10^7$/mL and $10^4$ - $10^9$/g respectively [22]. Little is known about the diversity of marine microorganisms. The number of species of microorganisms has been estimated from as low as $10^4$ - $10^5$ to as high as $10^6$ - $10^7$ [7]. Bacteriocins produced by marine bacteria are primarily of interest to researchers due to their potential as probiotics and antibiotics in the seafood industry and marine aquaculture [23-25].

The first marine bacteriocin was isolated from Vibrio harveyi (formerly Beneckea harveyi) by McCall & Sizemore [26] when they screened 795 strains of Vibrio spp. isolated from Galveston Island, Texas. The identification of harveyicin led to numerous bacteriocin-screening studies in marine bacteria, which focused on biochemical characterization of bacteriocins and BLIS.

A study by Wilson et al. [27] on surface-attached bacteria isolated from Sydney Harbor, Australia, revealed that approximately 10% of surface-attached marine bacteria possess antibacterial activity. Proteinase K treatment attributed this inhibitory activity to proteinaceous substances such as bacteriocins or BLIS. Antimicrobial screening of 258 bacterial strains from water and sediment in the Yucatan peninsula revealed 46 strains of genera Aeromonas, Burkholderia, Photobacterium, Bacillus, Pseudomonas, Serratia and Stenotrophomonas with antimicrobial activity. Around fifty percent of this antimicrobial activity was attributed to bacteriocins or BLIS [28]. A thermostable bacteriocin BL8 from Bacillus licheniformis from marine sediment [29] and halocin SH10 produced by an extreme haloarchaeon Natronimicrospora BTSH10 from salt pans of South India [30] were reported.

Some bacteria particularly those in the digestive tract, produce inhibitory compounds that control the colonization of potential pathogens in fish [31,32]. For instance a heat-labile and proteinaceous substance with a molecular mass of <5 kDa was recovered from Vibrio sp. obtained from the intestine of a spotted pony fish [33]. Similarly, bacteria capable of inhibiting growth of pathogenic Vibrio sp. were isolated from the digestive tract of halibut (Hippoglossus hippoglossus) larvae [34]. In another study, of the 1,055 intestinal bacteria derived from 7 coastal fish in Japan, 28 isolates (2.7% of the total) inhibited the human and eel pathogen V. vulnificus [35]. Marked inhibition was displayed by 15 isolates, consisting of 11 Vibrionaceae representatives, 3 coryneforms, and 1 Bacillus strain NM 12; the latter demonstrating the most pronounced antimicrobial activity. A heat labile siderophore of <5 kDa molecular weight inhibited the growth of 227 out of 363 (62.5% of the total) intestinal bacterial isolates from 7 fish [36]. Bacteriocin producer was also reported from the deep sea shark gut, where a Bacillus amyloliquefaciens BTSS3 was shown to produce thermostable, pH tolerant bacteriocin [37]. A detailed view is given in Table 1a & 1b.

### Table 1a: Some characterized marine bacteriocins and their sources.

| Bacteriocin   | Producer Strain | Molecular Weight | Killing Breadth              | Source of Isolation                  | Reference |
|---------------|-----------------|-----------------|-----------------------------|--------------------------------------|-----------|
| BLIS          | Lactobacillus pentosus 39 | -               | Aeromonas hydrophila, Listeria monocytyogenes | Salm onlets                         | [82]      |
| Carnocin U149 | Carnobacterium sp. | 4.5-5kDa        | Lactobacillus, Lactococcus, Pediococcus, Carnobacterium | Fish                                | [10]      |
| Divergicin M35 | Carnobacterium divergens M35 | ~4.5 kDa | Carnobacterium, Listeria | Frozen smoked mussel | [12]      |
| Divercin V41  | Carnobacterium divergens V41 | 4.5 kDa         | Carnobacterium, Listeria, Enterococcus | Fish vaccera                        | [11]      |
| Carnobacteriocin B2 | Carnobacterium piscicola A9b | ~4.5 kDa | Listeria | Cold smoked salmon | [19]      |
| Piscicocin CS526 | Carnobacterium piscicola CSS26 | ~4.4 kDa | Tetragenococcus, Leuconostoc, Listeria, Enterococcus, Pediococcus | Frozen surimi                        | [13,14]  |
| Piscicocin V1a | Carnobacterium piscicola V1 | 4.4 kDa | Lactobacillus, Listeria, Enterococcus, Pediococcus, Carnobacterium | Fish                                | [15]      |
| BLIS          | Enterococcus faecium CHG 2-1 and Ch 1-2 | -               | Enterococcus                  | Venus clams                         | [16]      |

Citation: Bindiya ES, Bhat SG (2016) Marine Bacteriocins: A Review. J Bacteriol Mycol Open Access 2(5): 00040. DOI: 10.15406/jbmoa.2016.02.00040
Table 1b: Some characterized marine bacteriocins and their sources.

| Bacteriocin | Bacteria                | Molecular Wt | Killing Breadth                        | Source                        | Reference |
|------------|-------------------------|--------------|---------------------------------------|-------------------------------|-----------|
| Bacteriocin BL8 | *Bacillus licheniformis* | <3kDa        | *Staphylococcus aureus, Bacillus sp.* | Sediment                      | [29]      |
| BLIS       | *Vibrio sp.*            | <5kDa        | *Bacillus sp., Vibrio sp.*           | *Pseudomonas sp.*             | [33]      |
| BLIS       | *Vibrio sp.*            |              |                                       | *Halibut larvae* (Hippoglossus hippoglossus) | [34]      |
| Bacteriocin | *Bacillus sp.* NM12     | Siderophile, <5kDa | Fish pathogens                      | Coastal fish                   | [35]      |
| Bacteriocin Bacf3 | *Bacillus amylobiquaciens BTSS3* | ~ 3kDa | *Bacillus sp., Staphylococcus aureus* | Deep sea shark (Centroscyllium fabricii) | [37]      |
| BLIS       | *Proteus sp.* CT1.1     | -            | *Vibrio*                             | *Gobia*                       | [90]      |
| BLIS       | *Proteus sp.* G1        | -            | *Vibrio*                             | Ornate spiny lobster           | [90]      |
| BLIS       | *Bacillus cereus* D9    | -            | *Vibrio*                             | Subnose pompano                | [90]      |

Fifteen isolates with confirmed consistent antimicrobial activity recovered from Irish seaweeds, as well as sand and seawater, were spore-forming *Bacillus* sp. While PCR screening was successful in identifying three of the marine bacteria as lichenicidin producers, the rest of the isolates did not harbor structural genes for any of the known Bacillus bacteriocins for which PCR primers could be designed. These negative PCR outcomes strongly suggest that these isolates produce novel bacteriocins [38].

**Bacteriocin classification**

The bacteriocin family includes diverse proteins in terms of size, modes of action, microbial targets and immunity mechanisms. In general, bacteriocins are studied based on the Gram designation of their producing species, Gram-negative Vs Gram-positive (Table 2). Additionally, a relatively small number of bacteriocins from *Archaeal species* have also been characterized.

**Bacteriocins of Gram-negative bacteria:** Bacteriocins of Gram-negative bacteria are categorized into four main classes: colicins, colicin-like bacteriocins, microcins, and phage-tail like bacteriocins [39]. Colicins are so well studied that they have been used as a model system to study bacteriocin structure, function and evolution [40-43]. In general, colicins are thermo-sensitive, protease sensitive proteins that vary in size from 25 to 90 kDa [44].

There are two major colicin types based on their mode of killing: nuclease and pore former colicins. Nuclease colicins (Colicins E2, E3, E4, E5, E6, E7, E8, E9) kill by acting as DNases, RNases, or tRNAses and pore former colicins (colicins A, B, E1, Ia, Ib, K) kill sensitive strains by forming pores in the cell membrane. Proteinaceous bacteriocins produced by other Gram-negative species are classified as colicin-like due to the presence of similar structural and functional characteristics. They can be nucleases (pyocins S1, S2) and pore-formers (pyocin S5) like colicins [45,46]. S-pyocins of *Pseudomonas aeruginosa*, Klebicins of *Klebsiella species*, and alveicins of *Hafnia alvei* are among the most studied colicin-like bacteriocins. Phage-tail like bacteriocins are larger structures that resemble the tails of bacteriophages which are even argued as defective phage particles [47]. R and F pyocins of *P. aeruginosa* are some examples of the most thoroughly studied phage-tail like bacteriocins [45,48,49].
Table 2: Classification of Bacteriocins with examples.

| Bacteriocins | Type/Class | Size  | Example                      | Reference |
|--------------|------------|-------|------------------------------|-----------|
| Colicins     | Pore Formers | 20-80 | Colicins A, B                | [46]      |
|              | Nuclease    |       | Colicins E2, E3              | [46]      |
| Colcin-like  | 20-80       |       | S-pyocins Klebicins          | [45]      |
| Phage-tail like | >80        |       | Maltocin P28                 | [49]      |
| Microcins    | Post translationally modified | <10  | Microcin C7, Microcin B17    | [45]      |
|              | Unmodified  |       | Colicin V                    | [50]      |
|              | Class IIc - non-ribosomal siderophore-type post-translation modification | | microcin E492 | [51] |

Gram negative Bacteria

| Bacteriocins | Type/Class | Size  | Example                      | Reference |
|--------------|------------|-------|------------------------------|-----------|
| Class I      | Type A- Linear peptides, positively charged | <5   | Nisin                        | [54]      |
|              | Type B - Rigid globular peptides, negatively or neutrally charged |       | Subtilosin A                 | [57]      |
| Class II     | IIIa contain YGNVxCxxxxCxV, Narrow spectrum of activity | <10  | Pediocin, Enterocin          | [60]      |
|              | IIb - require concerted activity of 2 peptides |       | Lactacin F, Lactococcin G    | [60]      |
|              | IIc - circular peptide bacteriocins |       | Carnocyclin A                | [61]      |
| Class III    | IIIa - bacteriolysin | >10  | Enterolysin A                | [63]      |
|              | IIIb - non-lytic bacteriocin |       | Helveticin A & J             | [64]      |

Gram positive Bacteria

| Bacteriocins | Type/Class | Size  | Example                      | Reference |
|--------------|------------|-------|------------------------------|-----------|
| Class IV     | Require lipid or carbohydrate moieties |       | Leuconocin S8, lactocin 27   | [65]      |
| Halocins     | Microhalocins | <10  | Halocin A4, C8, G1           | [67]      |
|              | Protein Halocins | >10  | Halocin H1, H4               | [67]      |
| Sulfolobicin | Membrane associated proteins | ~20  | Sulfolobicin                 | [71]      |

Pore-forming colicins range in size from 449 to 629 amino acids. Nuclease bacteriocins have an even broader size range, from 178 to 777 amino acids. In colicins, the central domain comprises about 50% of the protein and is involved in the recognition of specific cell surface receptors. The N-terminal domain (>25% of the protein) is responsible for translocation of the protein into the target cell. The remainder of the protein is a short sequence involved in immunity protein binding. The killing domain and the immunity region are present in this region. Although the pyocins share a similar domain structure, the order of the translocation and receptor recognition domains are exchanged [43].

Finally, Gram-negative bacteria produce much smaller (<10 kDa) peptide bacteriocins called microcins. They can be divided into three classes: post-translationally modified (microcins B17, C7, J25, and D93) [50] and unmodified microcins (microcins E492, V, L, H47, and 24). Class IIc bacteriocins are non-ribosomal siderophore-type post-translation modification at the serine-rich carboxy-terminal region, such as microcin E492 [51] (Table 2).
**Bacteriocins of Gram-positive bacteria:** Bacteriocins of gram-positive bacteria are more abundant and even more diverse than those in Gram-negative bacteria [52], but differing in two fundamental ways.

I. Bacteriocin production is not necessarily a lethal event as it is for Gram-negative bacteria.

II. This vital difference is due to the transport mechanisms encoded by Gram-positive bacteria to release bacteriocin toxin. Some have evolved a bacteriocin-specific transport system, whereas others employ the sec-dependent export pathway.

III. The Gram-positive bacteria have evolved bacteriocin-specific regulation, whereas bacteriocins of Gram-negative bacteria rely solely on host regulatory networks.

**Classification of bacteriocins of Gram-positive bacteria**

Based on size, morphology, physical, and chemical properties, bacteriocins of Gram-positive bacteria are generally divided into four classes [53].

**Class I bacteriocins:** Are post-translationally modified small peptides (<5 kDa) incorporating non-traditional amino acids such as dehydrobutyrine, dehydroalanine, lantionine and methyl-lanthione called lantibiotics [54]. This class is subdivided into Type A and B with the distinction being that members of Type A are linear peptides (nisin) [55] and positively charged, whereas those in Type B are rigid globular peptides (mersacidin), labyrinthopeptins, such as globular peptide labyrinthopeptin A2 [56], and sactibiotics, such as globular peptide subtilosin A [57] either negatively or neutrally charged.

**Class II bacteriocins:** Are small 30-60 amino acids (<10 kDa), heat-stable peptides that are not post-translationally modified and positively charged [58]. Class II is also subdivided into four subgroups. The class Ila Listeria-active or pediocin-like peptides containing a conserved N-terminal sequence (YGNGVxCxxxxCxV) or “pediocin box” with two cysteine residues forming disulphide bridge, are the most extensively studied group with a narrow spectrum of activity [59]. Lactocin F and lactococcin G are part of Class Iib bacteriocins that require the concerted activity of two peptides to be fully active [60]. Class Iic bacteriocins are circular peptide bacteriocins, such as carnocyclin A [61]. Class IId bacteriocins are linear, non-pediocin-like, single-peptide bacteriocins, including epidermicin N101 [62].

**Class III bacteriocins:** Are generally large (>10 kDa), heat-sensitive peptides, subdivided into two subtypes. Type IIIa are bacteriolytic, which are bacteriolytic enzymes such as Enterolisin, which kill sensitive strains by lysis of the cell wall [63]. Helveticin J (37 kDa) produced by *Lactobacillus helveticus* belongs to Type IIIb, which are non-lytic bacteriocins [64].

**Class IV bacteriocins:** Require lipid or carbohydrate moieties for activity. They are also known as complex bacteriocins, with unique structural characteristics. The first and last amino acids of these bacteriocins are covalently bound, thus having cyclic structures. Examples include leuconocin S 8 and lactocin 27 [65]. Enterocin AS-48 produced by *Enterococcus faecalis* subsp. *liquefaciens* S-48 was the first characterized bacteriocin of this class [66].

**Bacteriocins of archaea:** The Archaea also produce unique bacteriocin-like antimicrobial compounds called archaeococs [67], but are much less scrutinized than the bacteriocins. So far, two major types of archaeococs have been identified: halocins of halobacteria and sulfolobins of Sulfolobus genus. Halocins can be divided into two classes based on size: the smaller microhalocins (3.6 kDa) and larger halocins of 35 kDa [4]. The first halocin discovered was S8, which is a short hydrophobic peptide of 36 amino acids, processed from larger 34 kDa pro-protein. Halocin production is a universal feature of halobacteria [3]. Halocin genes are located on megaplasmids (or minichromosomes). Halocins H4 and S8 are located on ~300 kbp and ~200 kbp plasmids, respectively [68,69]. Their activity is usually detected at the late exponential to early stationary growth phase.

Sulfolobicins are not extensively studied, Prangishvili et al. [70] screened sulfolobin production from *Sulfolobus islandicus* isolated from volcanic vents throughout Iceland. This study predicted that sulfolobicin is a membrane associated protein. Sulfolobicins are also associated with membranous vesicles ranging in size from 90 to 180 nm in diameter. Like many bacteriocins, they are thermostable and sensitive to protease treatment. Their mode of action is still unknown [71].

**Bacteriocin mode of action**

The great variety of their chemical structures allow bacteriocins to affect different essential functions of the living cell (transcription, translation, replication and cell wall biosynthesis), but most act by forming membrane channels or pores destroying the energy potential of sensitive cells. Research on the mode of action of bacteriocins largely focused upon two distinct aspects of bacteriocin action on susceptible bacteria: the kinetics of the physical interaction between bacteriocin and susceptible cells, and the detection of specific biochemical lesions within the affected organisms. In a widely accepted hypothesis of the mode of action of bacteriocins, it was suggested that the interaction of a bacteriocin with a sensitive cell occurs in two stages [72]. The first stage, probably a reversible phase, corresponds to physical adsorption of bacteriocin to cell-envelope receptors. The removal of the bacteriocin during this stage apparently leaves the cell unscathed as there is no permanent physiological damage. The second stage develops later when irreversible pathological changes are effected via specific biochemical lesions after a measurable time.

Although in many cases the adsorption of bacteriocins are highly specific for susceptible bacteria, some others like the *staphylococci* 414 and 1580, lactocin LP27 and streptococcin B-74628 lack this adsorption specificity. Each of these bacteriocins adsorbed to bacteria resistant to its killing action. This nonlethal binding may be a reflection of the high surface activity of some bacteriocins. Polypeptide antibiotics such as polymyxin B show this capability of adsorbing nonspecifically to bacteria. Even though adsorption of bacteriocins exists in most cases, non-adsorption to susceptible or to resistant bacteria was also demonstrated by bacteriocin 28 of *C. perfringens* [73], staphylococcin 462 and viridin B.
The antibiotic activity of bacteriocins from Gram-positive bacteria is based on their interaction with the bacterial membrane. The mechanisms of action of peptide antibiotics are diverse, but the bacterial membrane is the target for most bacteriocins [74]. Most of the class II bacteriocins disturb the proton motive force (PMF) of the target cell by pore formation. The subclass IIc comprises miscellaneous peptides with various modes of action such as membrane permeabilisation, specific inhibition of septum formation and phenrome activity.

**Bacteriocin-induced cell damage**

The physiological state of the indicator culture has a strong influence on susceptibility to the lethal action of bacteriocins. Actively multiplying cells were most sensitive to streptococcin A-FF22, staphylococcin 1580, bacteriocin 28 of *C. perfringens*, and bacteriocin E-1 and bacteriocin X-14 (hemolysin) of *S. faecalis* subsp. *zymogenes*. This indicates a requirement for active cellular metabolism to affect killing of cells. A time-dependent morphological change to the sensitive strain was demonstrated by the action of pediocin from *P. acidilactici* on sensitive strain *L. monocytogenes*. Bacteriocin-treated *L. monocytogenes* V7 were almost completely destroyed after 6 h. The major morphological changes were apparently due to changes in the cell wall, which started to relax, and ruptured after just 0.5 h of treatment with bacteriocin (6,400 AU/mL). After 1 h and 3 h of treatment, ruptures in the cell wall and plasma membrane were more evident with more cell contents escaping. After 6 h of treatment, the cell wall was completely irregular and damaged [75].

**Applications in sea food industry**

Global production of fish, crustaceans, molluscs and other aquatic animals is ever increasing and reached 158 million tonnes in 2012. Aquaculture production continued to show strong growth, with an average annual growth rate of 6.1 percent from 36.8 million tonnes in 2002 to 66.6 million tonnes in 2012 according to Food and Agriculture Organization of United Nations (FAO) 2014 [76]. Consumer demand for fish continues to climb, according to Food and Agriculture Organization of United Nations. Aquaculture-raised juveniles of ornate spiny lobsters (*Panulirus ornatus*) challenged with bacteriocinogenic bacteria showed beneficial effects on the host [89]. Anacarso et al. [82] studied the ability of *Lactobacillus pentosus* 39, a BLIS producing strain to control the growth of *Aeromonas hydrophila* ATCC14715 and *Listeria monocytogenes*, under simulated cold chain break conditions. One area of active research in seafood aquaculture is the utilization of bacteriocins as antimicrobials.

**Probiotics in aquaculture**

Probiotics are defined as “live microorganisms, which when consumed in adequate amounts, confer a health benefit on the host” [83]. The majority of probiotics in use today include species of lactic acid bacteria (LAB), including lactobacilli, as well as bifidobacteria, nonpathogenic *Escherichia coli*, bacilli and yeasts such as *Saccharomyces boulardii* [84]. Antibiotic over use in aquaculture disease control results in the emergence of bacterial resistance and transfers the bacterial resistance genes to unexposed strains by alterations in the existing genome or horizontal gene transfer through plasmids or bacteriophages. This highlights the need for alternatives for antibiotics in aquatic disease management. Probiotics use in aquaculture for elimination of antimicrobial drug is increasing. Bacteria such as *Vibrio* sp., *Pseudomonas* sp., *Bacillus* sp. and several *Lactobacillus* sp. have been used successfully as probiotics in mollusk, crustacean, and finfish aquaculture, with most identified from aquatic animals, culture environment or from the intestine of different aquatic species [85]. Since probiotic research in aquaculture is still in its infancy and gaining acceptance in the industry, much research is needed to understand and resolve the controversies, such as real environmental demonstrations on successful usage of probiotics, their mode of action, and mechanism in vivo. The application of terrestrial bacteria in aquaculture has limited success because characteristics of bacteria depend upon their niche environment. Thus, identification of potential probiotics from marine environments where they grow optimally is a better approach.

*Aeromonas media* A199 controlled *Vibrio tubiashi* infection in Pacific oyster, *Crassostrea gigas* larvae by bacteriocin-like inhibitory substances, which antagonized several pathogenic bacteria in culture [86,87]. *Aeromonas macleodii* 0444 was studied as a probiotic for controlling *V. coralliilyticus* and *Vibrio pectenicida* in flat oyster, *Ostrea edulis*, larvae [88] and also against *Vibrio splendidus* infection in Green shell mussel *Perna canaliculus* larvae leading to increased survival [89].

Bacteriogenic bacteria were isolated from ornate spiny lobsters (*Panulirus ornatus*), black tiger shrimp (*Penaeus monodon*), cobia (*Rachycentron canadum*) and snubnose pompano (*Trachinotus blochii*). Two candidate probiotic formulations with bacteriogenic bacteria showed beneficial effects on aquaculture-raised juveniles of ornate spiny lobsters (*Panulirus ornatus*) challenged with *V. owensii* DY05 [90]. Thus in all aspects either the bacteriocin or the producer organism served as a food preservatives or immune enhancer in marine food industry.

**Conclusion**

Seafood industry is a growing part of the economy, but its economic value is diminished by infections which reduce the growth and survival of commercial species or decrease quality.
These impacts are most evident in the stressful and crowded conditions of aquaculture, which dominates seafood production. For instance, marine diseases of farmed oysters, shrimp, abalone, and various fishes, particularly Atlantic salmon, cost billions of dollars each year. Farmed species often receive infectious diseases from wild species and can return infectious agents to wild species. Disease control in marine aquaculture farms is the main concern in all the countries where seafood is a major source of income. The movement of exotic infectious agents to new areas continues to be the greatest concern.

Bacteriocins and bacteriocin producing bacteria isolated from marine environment can play a pivotal role in those places where we want to reduce the use of chemical antibiotics. Though the spectrum of action is small for bacteriocins, the probiotic bacteria can serve as an alternative. Thus a better understanding of bacteriocins, their classification and mechanism of action is worthwhile. The use of nisin and pediocin as food preservative is well studied and applied in many countries. The requirement of bacteriocin producing bacteria warfare: Inventory and potential applications as an alternative. Thus a better understanding of bacteriocins is still in the lime light.

Acknowledgement

The authors acknowledge project grants from Centre for Marine Living Resources & Ecology - Ministry of Earth Sciences, Government of India (MOES/10-MLR/2/2007and MOES/10-MLR-TD/03/2013) given to Dr. Sarita G Bhat, Dept. of Biotechnology, Cochini University of Science and Technology, Kochi, India.

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