ABSTRACT

Bacterial diseases in fishes create one of the alarming situations that render significant loss to the fishing industries and aquacultural farm units worldwide. Various drugs have been formulated, standardized, and used in the industry to combat bacterial infections. However, non-judicious drugs can lead to pharmacological problems and induction of toxicity in fishes, leaving them less suitable for human consumption. These drugs can be supplemented with the natural herb plants having antibacterial activities, although they cannot be used solely to curb the menace. Therefore, the review put forth an idea, which plant herbs can be used as antibacterial drugs in fishes.

Keywords: Medicinal plants; bacterial diseases; fishes; anti bacterial activity.

1. INTRODUCTION

The recent goal in aquaculture is to achieve maximum possible fish production from an area, within the shortest possible time period. In order to proceed towards this goal, the emphasis being laid on intensive fish culturing practices, and cage cultures results in overcrowding of
specimens in such culturing units. Thus, chances of disease occurrence increases. In other words, disease outbreak acts as a limiting factor in aquaculture.

The bacterial infections are considered the major cause of mortality in aquaculture [1]. Among the common fish pathogens, A. hydrophila, Y. ruckeri, S. agalactiae, L. garvieae, and E. faecalis cause infectious diseases. A. hydrophila is widespread in freshwater fish culture, causing skin infections, septicemia, and gastroenteritis in human, besides the fish [2]. Y. ruckeri causes enteric red mouth disease especially in Salmonids, characterized by reddening of mouth and throat [3]. S. agalactiae is a dangerous pathogen to both freshwater and marine fish, causing brain invasion, nervous signs and septicemia [4]. S. agalactiae, L. garvieae, and E. faecalis are closely related groups of bacteria that cause streptococcosis, lactococcosis, haemorrhagic septicemia, and ulcers in fins [5].

Frequently antibiotics are used to control bacterial diseases but these result in the development of antibiotic-resistant strains [6]. On the contrary, plant extracts can be used as disease inhibitors without causing any negative effect [7,8,9]. Additionally, phytomedicines provide a cheaper source for treatment and have greater accuracy than chemotherapeutic agents in fish [10,11]. Extracts of plants besides treating diseases are also used as stress resistance boosters, infection preventatives, and growth promoters. A wide variety of chemicals, especially secondary metabolites, that have antimicrobial effects in vitro are produced by plants [12]. Plant produced antimicrobials belong to two categories:

1) Phytoalexins

Antimicrobials produced in response to microbes, environmental stimuli [8], require activation of specific genes and enzymes for their synthesis and include simple phenyl propanoid derivates, flavonoids, isoflavonoids, terpenes, and polyketides [13,14].

2) Phytoanticipins

Antimicrobials which are present in plants before the challenge by microorganisms [12]. These include phenolic and iridoid glycosides, glucosinolates, and saponins.

2. MEDICINAL PLANTS ACTING AGAINST FISH DISEASES

Medicinal plants are known to improve digestibility and feed conversion [15], enhance fish weight [16], enhance immune response (higher levels of erythrocytes, lymphocytes, monocytes and haemoglobin) [17] in fishes. Medicinal plants have been reported to act against wide range of bacterial, viral and fungal pathogens. Medicinal plants prevent mortality rates in aquaculture.

Fish ectoparasites, especially Tricodina infections in O. niloticus fingerlings are easily treated by garlic (Allium sativum) and Indian almond (Terminalia catappa). Indian almond is claimed to act as a wound-healingsubstance for Siamese fighting fish hurt after matches in Thailand. According to Chitmanat et al. [18] neem (Azadirachta indica) leaves contain nimbin, azadirachtin, and meliantroil that possess a variety of properties, including insecticidal and antiviral from ancient times. Immunostimulatory effect of aqueous extract (AqE) of Bhangra (Eclipta alba) leaf in tilapia fish, Oreochromis mossambicus was studied, and it was observed that this extract enhances non-specific immune responses and disease resistance of O. mossambicus against A. hydrophila infection [19]. Methanolic extract of 46 Brazilian plants were screened against fish pathogenic bacteria; Streptococcus agalactiae, Flavobacterium columnare, and A. hydrophila, out of which only 31 were found effective [1]. Several studies and reported increase in the phagocytic capability of cells in rainbow trout (fish) when orally administered with ginger (Z. officinale) extract [7]. He further observed that the extracts of 4 Chinese herbs (Rheum officinale, Andrographispaniculata, Isatisindigotica, and Lonicera japonica) increases white sphaugocytic property blood cells of carp. Antibacterial activity of the alcoholic and aqueous extracts of Nuphar lutea, Nymphaea alba, Stachys annua, Genista lydia, Vinca minor, Fragariasvesca, Filipendulaulmaria, and Helichrysum plicatum herbs of Bold (Turkey) against A. hydrophila, Yersinia ruckeri, Lactococcus garvieae, Str. Agalactiae, and Enterococcus faecalis bacteria isolated from fish has been reported [11]. Nya and Austin [20] observed that after feeding rainbow trout, O. mykiss (Walbaum) with A. sativum @ 0.5 and 1 g/100 g of feed for 14 days, A. hydrophila infection can be controlled. The addition of Phyllanthus niruriand Aloe vera (Aloe) as herbal additives enhances the growth of...
goldfish, *Carassius auratus*, and its resistance to *A. Hydrophila* [21]. Mixed herbal extracted supplemented diets were reported to enhance the innate immune response of goldfish (*C. auratus*) against *A. hydrophila* infection [22]. Chloroform extract of *Datura metal* plant can be used against several fish pathogens [23]. While studying the effect of dietary doses of *Withania somnifera* (Ashwagandha) root, it was reported that it enhances the immunity and disease resistance of Indian major carp, *L. rohita* fingerlings against *A. hydrophila* infection [20]. Aqueous extract of *A. indica* leaf can be used to control the *A. hydrophila* infection in common carp (*Cyprinus carpio*) [24]. They further studied that the antimicrobial effect of aqueous extract of *A. indica* (leaf), *Solaniumtorvum* Sundakai (fruit coat), and *C. longa* (rhizome) against *A. hydrophila*, isolated from infected fresh-water fish, *Channa striatus*. Some herbal extracts such as *Benedenia seriola* are highly effective against flukes (gill and skin) [25]. The dietary intake of *A. sativum* and *Vitex negundo* extracts has an immunostimulant effect on fingerlings of *L. rohita* fish [26]. Certain parts of *A. indica*, *Cinnamomum verum*, and *Eupatorium odoratum* have excellent antibacterial activity against bacterial pathogens of fish [23].

The disease-resistant *Catla* catla fish was produced through immersion treatment of 3 herbs, viz., *A. sativum*, *A. indica*, and *Curcuma longa* (Haldi rhizome, turmeric) in spawn.

The antibacterial properties of medicinal plant extracts are being exploited nowadays. Different concentrations of extracts obtained from various parts of plants are tested against that specific pathogen. Kumar *et al.* assessed the ethanol extract of medicinal plants towards selected bacteria [27]. The extracts having concentrations between 8 and 250 µg/ml revealed significant antibacterial effect and expressed minimum inhibition concentration (MIC) against both Gram-negative and Gram-positive bacteria. The antibacterial property of *Beta vulgaris* was assessed against various pathogens [28]. Extract obtained exhibited highest activity against *Staphylococcus aureus* and *Bacillus* species.

### Table 1. Locally found medicinal plants in Kashmir

<table>
<thead>
<tr>
<th>Taxon Name/Plant</th>
<th>Local Name</th>
<th>Family</th>
<th>Part used</th>
<th>Can be used against</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Datura stramonium</em></td>
<td>Dhatur</td>
<td>Solanaceae</td>
<td>Leaves</td>
<td><em>Streptococcus aureus</em>, <em>Escherichia coli</em></td>
<td>[29]</td>
</tr>
<tr>
<td><em>Punica granatum</em></td>
<td>Danh</td>
<td>Punicaceae</td>
<td>Leaves, fruit, flower</td>
<td><em>Streptococcus aureus</em>, <em>Escherichia coli</em>, <em>Shigella dysenteriae</em>, <em>Salmonella typhi</em>, <em>Vibrio cholera</em>.</td>
<td>[30]</td>
</tr>
<tr>
<td>* Celasia argentea</td>
<td>Moval</td>
<td>Amaranthaceae</td>
<td>Leaves, stem, root</td>
<td><em>Aspergillus niger</em>, <em>Escherichia coli</em>.</td>
<td>[31]</td>
</tr>
<tr>
<td><em>Trigonella foenum-graecum</em></td>
<td>Meeth</td>
<td>Fabaceae</td>
<td>Leaf</td>
<td><em>Bacillus cereus</em>.</td>
<td>[32]</td>
</tr>
<tr>
<td><em>Podophyllum hexandrum</em></td>
<td>Wanwan-gun</td>
<td>Berberidaceae</td>
<td>Rhizome</td>
<td><em>Bacillus sp.</em>, <em>Pseudomonas sp.</em></td>
<td>[27]</td>
</tr>
<tr>
<td><em>Mentha arvensis</em></td>
<td>Pudhna</td>
<td>Lamiaceae</td>
<td>Leaves</td>
<td><em>Escherichia coli</em>, <em>Streptococcus aureus</em>, <em>Pseudomonas aeruginosa</em>, <em>Pseudomonas mirabilis</em>.</td>
<td>[33]</td>
</tr>
<tr>
<td><em>Rubus niveus</em></td>
<td>Chanch</td>
<td>Rosaceae</td>
<td>Leaf</td>
<td><em>Streptococcus aureus</em>.</td>
<td>[34]</td>
</tr>
<tr>
<td><em>Viscum album</em></td>
<td>Aal</td>
<td>Loranthaceae</td>
<td>Whole plant</td>
<td><em>Streptococcus aureus</em>, <em>Bacillus subtilis</em>, <em>Escherichia coli</em>.</td>
<td>[35]</td>
</tr>
<tr>
<td><em>Viola odorata</em></td>
<td>Banafsha</td>
<td>Violaceae</td>
<td>Aerial parts</td>
<td><em>Pseudomonas aeruginosa</em>, <em>Streptococcus aureus</em>, <em>Streptococcus pyogenes</em></td>
<td>[36]</td>
</tr>
</tbody>
</table>
**Dipsacus inermis** Wopalhak Caprifoliaceae Roots *E. faecali*, *Escherichia coli*, *P. vulgaris* \[37\]

**Coriandrum sativum** Dhanwal Apiaceae Seeds *Klebsiella pneumoniae*, *Pseudomonas aeruginosa*, *Streptococcus aureus*, *Escherichia coli*, *Enterococcus faecalis* \[38\]

**Arnebiabenthalii** KahZaban Boraginaceae Rhizome *Streptococcus aureus and E. coli* \[39\]

**Artemesia absinthium** Tethwan Asteraceae Whole plant *Staphylococcus aureus*, *Bacillus subtilis*, *Escherichia coli* \[40\]

**Berberis lyceum** Kawdach Berberidaceae Roots *Pseudomonas sp.*, *Escherichia coli*, *Streptococci sp. and Staphylococcus sp* \[41\]

**Malva sylvestris** Sotal Malvaceae Flower *Staphylococcus aureus*, *Streptococcus agalactiae*, *Enterococcus faecalis* \[42\]

**Ficus carica** Anjeer Moraceae Leaf, latex *Staphylococcus aureus*, *Salmonella typhi* \[43\]

**Sambucus wigstronia** Hapatfal Caprifoliaceae Floral parts *Staphylococcus aureus*, *Escherichia coli* \[44\]

**Gallium aparine** Loothar Rubiaceae Leaves *Pseudomonas aeruginosa*, *Bacillus subtilis* \[45\]

**Papaver somniferum** Khush-Khash. Papaveraceae Pollens *Staphylococcus sp. And family Enterobacteriaceae* \[46\]

**Rumex nepalensis** Aabuj Polygonaceae Root *Staphylococcus aureus*, *E. coli*, *Pseudomonas aeruginosa* \[47\]

**Solanum nigrum** Kambae Solanaceae Whole Plant *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *E. coli* \[48\]

**Beta vulgaris** Beetroot Amaranthaceae Root *Staphylococcus aureus and Bacillus cereus* \[28\]

**Cichorium intybus** Kazal-Handh Asteraceae Seeds *Bacillus subtilis*, *Staphylococcus aureus*, *Micrococcus luteus*, *Escherichia coli*, *Salmonella typhi*, *Pseudomonas aeruginosa* \[49\]

**Allium sativum** Rohun Amaryllidaceae Bulb *B. subtilis*, *Escherichia coli* and *Saccharomyces cerevisiae*. \[50\]

### 3. CONCLUSION

With the continuous usage of antimicrobials in aquaculture, the apprehension of antibiotic resistance has occurred in most water bodies. Medicinal plants can be used as an essential alternate for controlling aquacultural infestations. Besides acting as antibacterial agents, the medicinal plants also diminish the side effects associated with antibiotics, are more economic and have accurate usage. Present study provides an overview of the local medical plants of Kashmir valley that can be used as be used as an alternative to antibiotics, chemicals or drugs in aquaculture.

### COMPETING INTERESTS

Authors have declared that no competing interests exist.
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