**Incidence of Aeromonas spp. infection in fish and chicken meat and its related public health hazards: A review**

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**Abstract**

*Aeromonas* is recognized to cause a variety of diseases in man. In humans, they are associated with intestinal and extraintestinal infections. With the growing importance of *Aeromonas* as an emerging pathogen, it is important to combat this organism. It is indisputable that *Aeromonas* strains may produce many different putative virulence factors such as enterotoxins, hemolysins or cytotoxins, and antibiotic resistance against different antibiotics. The ability of these bacteria to grow competitively at 5°C may be indicative of their potential as a public health hazard. Comprehensive enteric disease surveillance strategies, prevention and education are essential for meeting the challenges in the years ahead. It is important for us to promote the value of enteric cultures when patients have a gastrointestinal illness or bloody diarrhea or when multiple cases of enteric disease occur after a common exposure. With the growing importance of *Aeromonas* as an emerging pathogen, it is important to combat this organism. It is indisputable that *Aeromonas* strains may produce many different putative virulence factors, such as enterotoxins, hemolysins or cytotoxins. It has been established that aerolysin is a virulence factor contributing to the pathogenesis of *Aeromonas hydrophila* infection. Fish and chicken play an important role in the transmission of this pathogen to humans. In the present study, the high prevalence of toxin-producing strains was found among the *Aeromonas* isolates. The ability of these bacteria to grow competitively at 5°C may be indicative of their potential as a public health hazard. The present review was constructed with a view to highlight the zoonotic importance of *Aeromonas* pathogen in fish and chicken meat.

**Keywords:** *Aeromonas*, antibiotic resistance, chicken, fish, public health.

**Introduction**

In the last two to three decades *Aeromonas* spp. have emerged as an important human pathogen. Praveen et al. [1] conducted a study on 179 samples from fish (Gills), and chicken (Raw meat) were processed for bacteriological examination. Ampicillin dextrin agar (ADA) media was used for isolation of aeromonads from fish and chicken. A total of 31 (17.32%) isolates were obtained from 179 samples of fish and chicken in the North Kolkata Region. In 31 isolates, the highest isolation were achieved from fish 24 (18.89%), followed by chicken 7 (13.46%) out of which 29 (93.54%), 1 (3.22%), 1 (3.22%) were recognized as three species of *Aeromonas* namely *Aeromonas hydrophila*, *Aeromonassobria*, and *Aeromonascaviae*, respectively, through biochemical characterization including aesculin hydrolysis, Voges–Proskauer (VP) and gas from glucose (triple sugar iron) tests. The organism of this genus is oxidase and catalase positive, facultatively anaerobic, Gram-negative, short rod-shaped bacteria. The highly valuable fish and chicken are not always safe to consume from the public health point of view. The newly identified etiological agents of diarrheal disease are mesophilic aeromonads which have emerged as an important public health hazard [2]. There is mounting evidence of their involvement in gastrointestinal and extraintestinal infection in human beings [3,4]. The genus *Aeromonas* comprises of two different groups of bacteria. One is non-motile psychrophilic *Aeromonas salmonicida* and the other group comprising of three mesophilic motile spp. *A. hydrophila*, *A. caviae*, and *A. sobria* [5]. *Aeromonas* is an environmental microorganism. They are cosmopolitan in distribution. Mesophilic motile aeromonads are ubiquitous and autochthonous aquatic microorganisms occurring in fresh water, sewage and brackish water [6] and in chlorinated and unchlorinated drinking water [7,8]. Besides these aeromonads occur as the normal microbial flora of many aquatic and terrestrial animals and are proven diseases...
in various cold blooded and warm blooded animals including fishes, amphibians, reptiles, birds and other domestic animals [9,10]. Not only the aquatic environment plays an important role in the dissemination of aeromonads, different foods, especially, fishes and other seafood, raw and cooked meat, chicken, vegetables, milk and milk products can be a potential vehicle for human infections as well as animals [11-16]. The present review discusses and elaborates on the zoonotic importance of Aeromonas pathogen in fish and chicken meat.

**Isolation and Identification of Aeromonas**

Fricker and Tompset [13] in a study examined 563 samples of fish, raw and cooked meats and of pre-prepared salads from retail outlets and reported the isolation of mesophilic Aeromonas spp. from 287 samples and the most frequent contaminated samples were chicken (79.3%) and offal (84.3%). A. salmonicida was isolated from paddlefish (Polyodon spathula) during an epizootic of furunculosis in river state Hatcheries, Arkansas [16]. The isolates were obtained from cultures of gills and kidney tissues [17]. Aeromonas spp. Were isolated from gills, eggs, stomach and ventral muscles of fresh water prawns available in the local fish market of Dhaka, Bangladesh [18]. A study on food samples including fish was carried out and reported that out of 382 food samples 40 (10.47%) were positive for aeromonads. Out of 99 fish samples 22 (22.22%) were found positive, in which A. hydrophila (66.6%), A. sobria (27.27%), A. caviae (9.09%) were found positive [19]. An examination was done on 68 food samples for the presence of mesophilic Aeromonas species both qualitatively and quantitatively. Aeromonads were isolated from 26% of the vegetable samples, 70% of the meat and chicken samples and 72% of the fish and shrimps [20]. One report of isolation of a total of 319 strains of A. hydrophila from 536 fish and 278 prawns for a 2-year period survey and the samples were collected from a major fish market of Coimbatore, Tamil Nadu, South India [18]. There was the detection of 82 strains of presumptive Aeromonas spp. out of a total of 250 frozen fish (Tilapia) samples purchased in local markets in Mexico City [21]. A study of 87 fish samples was done and reported that out of 87 fish samples 60 (69%) were found positive for Aeromonas species. Out of 60 isolates obtained, A. veronii biovar sobria 48, A. hydrophila 10 and A. caviae were found in 2 isolates [22]. In an examination of total of 78 raw and 123 processed and ready to eat retail food samples to assess the presence of motile Aeromonas spp. with the conventional cultivation method based on the use of ADA medium. He reported 65/201 (32.3%) samples showed presumptive Aeromonas colonies. The rate of contaminated samples and the presence of pathogenic Aeromonas reported by him were significantly lower for processed than in the case of raw samples [23]. A study was carried out on isolation and identification of motile Aeromonas spp. from 53 samples of raw chicken meat. They found 47.17% of the sample to be positive for motile Aeromonas spp. and of this 28.30% represented A. hydrophila and 9.43% of A. sobria, thus stating that the presence of these pathogenic organisms in the raw chicken samples possessed a serious potential risk for public health [24]. In an examination of 332 food samples of chicken, fish, pork and chevon, out of 332 food samples, 38 (11.44%) food samples were positive for Aeromonas species. In the case of fish out of 137 samples, 18 (13.13%) and in chicken out of 104 samples, 12 (11.53%) were found positive for Aeromonas species [25]. A study were carried out on 154 food samples (chicken, fish and ready-to-eat sprouts) from different retail outlets in Mumbai, India. They analyzed that out of 154 food samples tested, 22 (14.28%) isolates were Aeromonas species. The highest percentage of isolation were from chicken (28.6%), followed by fish (20%) and sprout (2.5%) [26]. In an examination 53 (57.6%) isolates of aeromonads from 92 chicken samples and 27 (17%) isolates of aeromonads from 158 minced meat samples. The isolation rate in chicken was significantly higher than minced meat. The highest contamination was found in chicken with A. caviae and minced meat contaminated with A. hydrophila [27-31].

**Antibiotic Resistance**

McNicol et al. [32] carried out a study on antibiotic-resistant strains of A. hydrophila from aquatic environments of Bangladesh. These strains carried resistance to chloramphenicol, streptomycin and tetracycline. A study was done on the activity of β-lactam antibiotics upon 20 strains of A. hydrophila [29]. Higher degrees of resistance to ampicillin and cephaloridine were observed along with the highest activity of clavulanic acid when assayed at sub-inhibitory concentrations in association with ampicillin [29]. One examination was performed on minimal inhibitory concentrations of 22 antimicrobial agents for 60 strains of three Aeromonas spp. by microdilution method. They found that newer cephalosporins such as moxalactam, cefotaxime, and cefoperazone, the aminoglycosides and chloramphenicol, tetracycline, nitrofurantoin and trimethoprim-sulfamethazole inhibited most of the strains within the genus and A. hydrophila was more resistant than either A. caviae or A. sobria to the antibiotics tested [30]. A study was carried out on the scope of antibacterial resistance among Aeromonas spp. from a variety of tropical fish species imported from Singapore [31]. There were 34 A. hydrophila strains from various fish and geographical locations isolated to study their antibiotic resistant pattern. It was observed that all the strains possessed multiple resistance, most commonly ampicillin and carbenicillin, whereas rifampicin was the most active antibiotic amongst these strains [32]. 80 isolates of A. salmonicida were isolated from separate outbreaks of furunculosis in farmed and wild salmon in Scotland during
1988-1989 and all these isolates subjected to suscepti-
bility to β-lactam antibiotic amoxycilline were found to
be resistant [33]. In a collection of 234 isolates of
Aeromonas primarily A. hydrophila the increasing
antibiotic resistances in Taiwan was studied. By agar
dilution method, they found that more than 90% of
the isolates were susceptible to moxalactam, ceftazi-
dine, cefepime, aztreonam, imipenem, amikacin and
fluoroquinolones, but more resistant to tetracycline,
trimethoprim-sulfamethoxazole, cephalosporins and
aminoglycosides [34]. In a report gentamicin, chlor-
amphenicol, ciprofloxacin and cotrimoxazole were
sensitive to Aeromonas isolates [19]. A study was car-
ried out on surveillance of bacterial susceptibility to
five antimicrobial agents during 1-year period demon-
strating high levels of individual and multiple anti-
microbial resistances among the aeromonads. Here-
forth indicating a substantial impact of fish farming
on several groups of bacteria associated with aqua-
culture environment [35]. In a report of antibiogram
studies, observation was found that chloramphenicol
were highly sensitive to Aeromonas species [22]. In
a study on antibiotic susceptibility of A. hydrophila and
A. sobria isolated from farmed carp (Cyprinus carpio)
and observed that of 21 isolates examined 100% were
resistant to ampicillin and penicillin and sensitive to
trimethoprim-sulphamides, oxolinic acid, flumequine,
chloramphenicol, norfloxacain, lincomycin, and per-
floxacin [36].

There were 132 Aeromonas isolated from the
fish market in Ankara, turkey; predominant being
A. cavate (66%) followed by A. hydrophila (22.6%) and
A. veronii biovars sobria (11.6%). All the aero-
monads were found to be resistant to ampicillin,
cephalothin and trimethoprim, but least resistant
to chloramphenicol (9.0%) and in contrast, all the
above strains were susceptible to ciprofloxacin and
ceftioxone [37]. An experiment was done on 51
strains of Aeromonas isolated from 20 rainbow trout
(Oncorhynchus mykiss) to determine the sensitivity
to different groups of β-lactam antibiotics (penicil-
in, cephalosporins, monolactams, and carbapenems)
through disc diffusion method and found that highest
rate of resistance was to ampicillin, carbenicillin and
ticarcillin [38]. A study was carried out on the occur-
cences of resistance to antimicrobials from a variety of
aquacultural species. It was observed that resistance to
ampicillin, amoxicillin, cephalaxin and erythromycin
was widespread, but all the strains were highly sus-
ceptible to ciprofloxacin [39]. A survey on fish rear-
ing in a prototype marine integrated a system where
oxolinic acid treatment was given and the level of
resistance to quinolone antibiotic monitored. In their
result, they observed that a resistance had occurred in
the intestines of fishes undergoing such treatment in
contrast to no evolution of resistance level either in
bivalves or in sediments of the integrated aquatic
system [40]. An antibiotic sensitivity test report was
shown on Aeromonas that Aeromonas were sensitive
toward ciprofloxacin, streptomycin, amikacin and
gentamicin [41]. A study was carried out on antibi-
otic sensitivity test on 22 isolates of Aeromonas. The
study reported that Aeromonas isolates were sensitive
to gentamicin, ceftrixone and chloramphenicol [42].
In an examination antibiotic resistance pattern shown
that more than 90%, 80%, 70% and 60% of the strains
were resistant to ampicillin, cephalothrin, tetracycline
and nalidixic acid, respectively [43].

Virulence

In a report, virulence study, the report sug-
gested that the spoilage potential and pathogenicity of
Aeromonas spp. in shellfish and food correlated well
with its ability to secrete several extracellular viru-
 lent factors such as hemolysin, enterotoxins, cytotox-
inus, lipase and protease [34]. There were 40 strains
of motile Aeromonas isolated from healthy fish and
identified them as A. hydrophila and A. sobria. They
observed that strains of A. hydrophila only produced
dermonecrotic factor and two zones of hemolysis on
blood agar and 72% of them were enterotoxigenic [35].
In a comparison of biochemical characteristics and vir-
ulence factors in 147 Aeromonas spp. isolated from
environmental sources. 91% of the isolates were
enterotoxogens and produced hemolysins, thus, sug-
gesting that such isolates may be a source of enteric
pathogens [44]. A study showed the significance of
Aeromonas spp. as potential water-borne enteric
pathogens by their biochemical characteristics and
virulence-associated properties that are hemolysin and
enterotoxin [45]. The majority of the enterotoxi-
genic strains isolated were A. sobria which exhibited
properties of VP positive, arabinose negative and lysin
decarboxylase positive [45]. An examination char-
acterized 73 Aeromonas strains to species level and
examined for their ability to produce virulence fac-
tors. They observed that strains identified as A. sobria
were the strongest producers of hemolysin and enter-
toxin, whereas A. caviae strains were consistently
 non-hemolytic and non-enterotoxigenic [46]. A study
characterized 58 Aeromonas strains from patients
with or without diarrhea in the Philippines. Out of 58
Aeromonas strains, 26% were enterotoxigenic, 41%
produced cytotoxin and 51% produced hemolysin. Of
the three spp. (A. hydrophila, A. caviae and A. sobria)
studied, A. sobria was the most toxigenic with 22 of
30 exhibiting at least one toxigenic property [47]. In
an examination A. hydrophila from food and drink-
ing water isolated and tested their pathogenicity by
studying the properties related to hemolysis, haemag-
glutination and cytoxicity [48]. They suggested that
human intestinal cell line HT-29 would be a useful
complement for studying the enteropathogenicity of
the species for humans [48]. A study was carried out
on 6 tests (4 in-vitro and 2 in-vivo) and reported that
77.5% of isolates were positive for β-hemolysis and
7.5% for α-hemolysis. Out of 77.5% A. hydrophila
(70.53%), A. sobria (92.30%) and A. caviae (66.66%)

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showed hemolytic activity [19]. In Norway, an examination was done on 31 isolates of Aeromonas spp. Isolated from food and water for the possible virulence factors. They recorded five different species, A. caviae (9/31), A. hydrophila (15/31), A. schubertii (3/31) and A. veronii biovar veronii (1/31), of which A. hydrophila were found to be responsible for small outbreaks of food poisoning caused by ingestion of raw fermented fish. All the strains produced and secreted cytotoxins at 37°C [49-52]. A result indicated that potentially enteropathogenic Aeromonas were commonly present in untreated drinking water and had been associated with intestinal and extraintestinal infections in humans [50]. A research was carried out to detect the incidence of motile Aeromonas in a variety of raw meat products consumed commonly in Ankara, Turkey. They found that A. hydrophila and A. sobria were the dominant species and strong producers of hemolysin and all the aeromonads were highly susceptible to ciprofloxacin (100%) but resistant to ampicillin and erythromycin (100%) [51]. In a study report the identification of A. sobria (67.3%) and A. hydrophila (21.2%) in meat and offals sold in Port Harcourt, Nigeria was reported. They found all the strains to be producers of hemolysin and these isolates were all susceptible to chloramphenicol and resistant to ampicillin. They also reported that aeromonads were unlikely to pose public health problems in Nigeria as meat undergoes prolonged cooking procedures [51]. In an examination result, it was concluded that all isolates were found to be associated with at least one virulent gene. Moreover, they were resistant to frequently used antibiotics for human infections. The study revealed that the pathogenic potential of Aeromonas, associated with ornamental fish culture systems suggesting the emerging threat to public health [52].

Earlier study [53] indicated hemolysin production in a lesser percentage of the isolates compared to the results obtained in this study [5]. A majority of hemolytic positive Aeromonas isolated in the present study were from the fish origin (83.33%) as compared to chicken (16.67%) which is supported by the findings of Sanyal et al. [54] and Sharma et al. [33].

Conclusion

Hemolysin which is considered to be a major virulence factor in Aeromonas infection was detected in 18 (58.06%) isolates. The activity was observed on sheep blood agar plates which confirmed that hemolysis was present. Aeromonas are recognized to cause variety of diseases in both animals and man. In humans, they are associated with intestinal and extra-intestinal infections. These have been isolated from a wide variety of fresh foods which get contaminated by infected water, animal feces and by infected symptomatic and asymptomatic food handlers. Ability of the Aeromonas spp. to grow at refrigerated temperatures and occurrence of food-borne strains with enterotoxigenic capabilities to strains from gastroenteritis is a cause for concern. The available information and data on its prevalence are scanty and it is in this context that, the present study was envisaged with a view to isolate and characterize the Aeromonas pathogen in fish and chicken. Comprehensive enteric disease surveillance strategies, prevention and education are essential for meeting the challenges in the years ahead. It is important for us to promote the value of enteric cultures when patients have gastrointestinal illness or bloody diarrhea or when multiple cases of enteric disease occur after a common exposure. The issue of surveillance must be among our highest priorities and understanding the role that of fish and chicken-borne disease plays as an emerging infectious disease problem.

Authors’ Contributions

Each and every author has contributed the relevant literature in preparation of this work of review. PKP and co-authors carried out their investigations and experimentations on the mentioned topic. All authors read and approved the final manuscript.

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Competing Interests

The authors declare that they have no competing interests.

References


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