

Chemical and Microbiological Hazards of Dried Fishes in Bangladesh: A Food Safety Concern

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How to cite this paper: Rasul, Md.G., Yuan, C.H. and Shah, A.K.M.A. (2020) Chemical and Microbiological Hazards of Dried Fishes in Bangladesh: A Food Safety Concern. *Food and Nutrition Sciences*, 11, 523-539. <https://doi.org/10.4236/fns.2020.116037>

Received: April 24, 2020

Accepted: June 10, 2020

Published: June 17, 2020

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Abstract

Food safety along with nutrition is an important issue in the present world. Only nutritionally safe food can ensure a healthy balanced diet to consumers. Dried fish is a popular processed fishery product not only in our country, but also in many countries of the world. It is a very good source of dietary protein, lipid and minerals necessary for a healthy body. The consumers of dried fish in national and international level are losing their interest to buy dried fish due to poor quality and safety of the products. Therefore, we reviewed the state of knowledge regarding the contamination level of dried fish by heavy metals, harmful pesticides, amount of lipid oxidation, and microbial quantity and quality from several districts in Bangladesh. The data reviewed in this article revealed that several dried fishes contaminated with excess amount of heavy metals (Pb, Cd, Cr etc.), pesticide residue (dichlorodiphenyltrichloroethane, heptachlor, endrin, aldrin, dieldrin), higher degree of lipid oxidation, excess amount of total plate count and presence of highly pathogenic *E. coli*, *Salmonella* sp. *Vibrio* sp. were found in few dried fish that may cause substantial human health hazard after consumption. The possible factors of these hazards are traditional drying, use of illegal pesticides with higher dose, lack of maintaining proper hygiene, sanitation, packaging, storage, distribution as well as water pollution. These findings will be helpful to develop an effective quality control and assurance program for producing safe dried fishery products for domestic consumption as well as earning foreign currency.

Keywords

Organochlorine Chemicals, Heavy Metals, Lipid Oxidation, Microorganisms, Dried Fish

1. Introduction

Fish and fisheries are the intrinsic part of life of Bangladeshi people from ancient time and play a vital role in generating employment, nutrition, earning foreign currency and many aspects of the economy [1]. Drying is an effective and low-cost processing method of fish preservation by lowering the moisture level of fish body [2]. It has been practiced to preserve fish for longer periods in various parts of the world especially in Asian and African countries and it is very popular due to its simplicity and low-cost method and the dried fish develops characteristic texture and flavor [3]. It is estimated that about 20% of the local artisanal fish catch are sun-dried and consumed in the local market in Bangladesh [4]. Moreover, dried fish (commonly called as *Shutki*) acts as a protein source and plays a vital role in providing nutrition for the poor people of Bangladesh [5]. Generally, in developing country like Bangladesh drying of fish is practiced on the sand of the beach, on elevated bamboo rack and on the bamboo covering. The drying process of fish under the sun takes about 1 week depending on temperature, humidity and air velocity etc. [6].

In Bangladesh, proper hygiene and sanitation are not maintained during drying of fish; therefore, insect infestation, presence of dirt, filth and pesticide residue are very common problems with the dried fish products of Bangladesh [5] [7] [8]. The fish processors who are involved in drying, packaging and distribution of fish to the market are not well trained and also do not have proper knowledge of public health and sanitation [9] [10]. Generally, the dried fish are stored in a warehouse nearby the coastal town. Longer duration for drying can cause several spoilage and quality loss due to blowfly infestation, broken pieces, dirt and filth on the product. Some reports indicate 30% - 40% weight loss of dried fish due to insect infestation and dull weather [10] [11]. During monsoon season, the weather becomes humid that delays the drying process and dried fish also reabsorb moisture from the environment, which makes a suitable condition for beetle and mite infestation on the fish body [10] [12]. Another problem is most of the fishermen who are involved in fish drying process and do not dry fish properly for weight loss because they want to make more profit by selling dried fish in wet condition; thus, it reduces the quality of the final product and also accelerates the insect infestation [13] [14]. Moreover, fish processors usually use a mixture of organochlorine (dichlorodiphenyltrichloroethane (DDT) and heptachlor) insecticides to protect the dried fish from insect infestation [15] [16] [17]. Some studies also showed the presence of alarming pollutants like DDT and heptachlor in dried fish of Bangladesh [18]. Some fish processors from Kuakata of Patuakhali district have also used higher doses of DDT powder in the dried fish, though it is a banned chemical [19]. Insecticides are a great hazard for public health. The major problem of using insecticides in many Asian countries like Bangladesh is that they have no information about recommended dose and most of the cases; processors do not follow the instructions that are written on the insecticide label and sometimes labeling gives false information [10] [20].

Besides these things, the quality of dried fish is deteriorated due to the accumulation of heavy metal from the aquatic environment [21]. Moreover, improper processing and storage also enhanced lipid rancidity that produces off flavor, off odor and harmful hydro peroxide compounds [22] [23] that ultimately increase the microorganism growth in dried fish [24] [25]. All these problems make dried fish unsafe for human consumption which is associated with human health hazard. We know hazard means a substance of food that may cause adverse effects on human health. This review article focuses on chemical and microbiological hazards of dried fish in Bangladesh. This kind of information will be helpful for the protection of consumers' health.

2. Chemical Hazards

2.1. Heavy Metals in Dried Fish

Heavy metals are non-biodegradable materials which cause serious carcinogenic effects on animals and human body [26]. Fish and fishery products may be contaminated by heavy metals as fishes live in the aquatic environment. Reference [21] studied the level of heavy metal contamination in the dried fish found in Cox's Bazar local market. Comparatively higher amount of heavy metals was accumulated in Mola (*Amblopharyngodon mola*), Rupchanda (*Stromateus chinensis*) and Chhuri (*Trichiurus lepturus*) than other fish species (Loitta, Shundori, Fatra, Phasa). Iron (Fe) was found in greater concentrations compared to other heavy metals [21]. Also, reference [27] found more or less similar amount of cadmium, chromium and lead in the sun dried Loitta (*Harpodon nehereus*) and Churi (*Trichiurus haumela*), which is higher than the Maximum Allowable Limit of reference [26] [28] [29]. Besides, the excess amount of these three heavy metals (Cd, Cr and Pb) were also found in dried taki, tengra, shol and punti collected from the local market of Natore district of Bangladesh [30] (Table 1). Similarly, Cd, Cr and Pb concentration in Silver pomfret (*Stromateus cinereus*) and Perch (*Lates calcarifer*) purchased from the local fish markets of Cox's Bazar exceeded the maximum allowable limit [31] (Table 1). Moreover, reference [32] investigated the heavy metal concentration in dried boal (*Wallago attu*) collected from Mymensingh local market. They observed that the Chromium (Cr) concentration was 0.068 ppm, which exceeds the acceptable limit for human consumption, according to reference [28].

These heavy metals are accumulated in fish and other aquatic organisms from aquatic environmental pollution due to enhanced urbanization, industrialization, population number and over exploitation of mother nature [33] [34] [35]. Most of the heavy metal elements are cumulative poisons, that is, those that cause injury to health through progressive and irreversible accumulation in the body as a result of ingestion of small amounts repeatedly [36]. Cadmium affects kidneys and causes symptoms of chronic toxicity, including impairment of kidney function, poor reproductive capacity, hypertension, tumors and hepatic dysfunction [37]. Excess exposure to Pb may cause nervous system damage,

Table 1. Concentration of different heavy metals in dried fish of Bangladesh.

Fish species	Location	Concentrations (ppm)					Reference
		Cd	Cr	Pb	Fe	Cu	
Loitta (<i>Harporodon neherus</i>)	Cox's Bazar	0.029	0.323	-	9.384	0.1031	[21]
	Saint Martin	0.0226	0.311	-	12.967	0.057	
	Cox's Bazar	0.824	8.38	8.281	-	2.210	[27]
Mola (<i>Amblopharyngodon mola</i>)	Cox's Bazar	0.0179	0.3072	-	52.773	0.0473	[21]
	Saint Martin	0.0232	0.314	-	9.7269	0.0454	
Gonia (<i>Labeo gonius</i>)	Cox's Bazar	0.0545	0.3657	-	10.004	0.2632	[21]
	Saint Martin	0.0256	0.746	-	21.008	0.2092	
Shundori (<i>Nemipterus vigatus</i>)	Cox's Bazar	0.0209	0.3702	0.2571	18.926	0.185	[21]
	Saint Martin	0.0592	0.4872	0.2692	19.1961	0.229	
Churi (<i>Trichiurus lepturus</i>)	Cox's Bazar	0.0156	0.5502	BDL	65.938	0.1925	[21]
	Saint Martin	0.0191	0.539	0.1243	20.526	0.3172	
	Cox's Bazar	0.485	6.969	5.465	-	1.401	[27]
Rupchanda (<i>Stromateus chinensis</i>)	Cox's Bazar	0.0191	8.5352	0.0277	19.685	0.1571	[21]
	Saint Martin	0.0221	0.1743	0.4625	30.314	0.2278	
Fatra	Cox's Bazar	0.1428	0.163	0.0277	15.555	0.1664	[21]
	Saint Martin	0.1339	0.1968	0.397	16.477	0.5108	
Phasa (<i>Septipinna phasa</i>)	Cox's Bazar	0.0633	0.1788	0.0277	13.056	0.1981	[21]
	Saint Martin	0.1386	0.8445	0.4021	16.077	0.116	
Silver pomfret (<i>Stromateus cinereus</i>)	Cox's Bazar	0.68	5.85	8.43	-	1.15	[31]
Perch (<i>Lates calcarifer</i>)	Cox's Bazar	0.65	5.60	6.28	-	1.04	[31]
Boal (<i>Wallago attu</i>)	Mymensingh	0.097	0.068	-	-	-	[32]
Taki (<i>Channa punctatus</i>)	Natore	0.0192	0.91	1.288	-	3.03	[30]
Tengra (<i>Mystus vitatus</i>)	Natore	0.0163	0.72	0.6088	-	23.6	[30]
Shol (<i>Channa striatus</i>)	Natore	0.0179	0.99	0.9968	-	6.60	[30]
Punti (<i>Puntius sophore</i>)	Natore	0.0149	1.47	1.60	-	6.12	[30]
Standard Source		0.1 ppm [26]	0.05 ppm [28]	0.1 ppm [29]	15 ppm [21]	30 ppm [29]	

paralysis, and pain in the legs [38]. Moreover, Cr is also injurious to health. If eaten regularly with contaminated fish and fishery products, Cr cause irreversible problem in stomach, renal disease and overall health risk [31]. Many countries in the world are taking various types of mandatory and voluntary actions to prevent aquatic pollution by hazardous chemicals to ensure food safety, especially for aquatic food products. The food regulatory and health authority of some developed countries have taken serious measures and adopted a maximum allowable limit for hazardous substances by considering their effect on human health [32].

2.2. Harmful Pesticide and Insecticides in Dried Fish

Insect infestation is a major problem during fish drying [39]. Fish processors have usually taken various preventive measures to protect the dried fish from insect infestation [16]. Among them the most popular preventive measure is the use of hazardous chemical pesticides without considering the lethal effects of these pesticides on consumer body. DDT and Nogos are most commonly used in dried fish as pesticides to prevent insect infestation [5]. In another study, reference [15] found that DDT and Heptachlor are used in dried fish of Bangladesh as a mixture of organochlorine (Table 2). DDT is locally known as white powder. These chemical pesticides are effective to protect fish from insect infestation, but they are associated with human health hazard and also hazardous for the environment [12] [20].

In the last few years, application of a number of health hazard pesticides (e.g. dichloro-diphenyl-trichloroethane, heptachlor) has been exposed nakedly in the dried fish industries [16]. However, the maximum recommended limit (MRL) of DDT is 50 ppb and the MRL of heptachlor, endrin, aldrin and dieldrin (Dirty Dozen) in food is 10 ppb [40]. Exceeding this limit of these chemicals causes a long-term health effects and a variety of diseases to the consumers. Also, reference [15] screened DDT concentration ranges from 3.038 to 874.966 ppb and heptachlor residue ranges from 0.682 to 5.464 ppb in the dried Bombay duck (*Harpodon nehereus*), Ribbon fish (*Trichiurus haumela*) from 4 different places of Dhaka and Chattogram. It can be assumed from this study that a mixture of insecticides is still used in the dried fish of Bangladesh. In another study, the DDT and heptachlor concentration in dried Anhovy (*Septipinna phasa*) and Croaker (*Johnius dussumieri*) were 19.416 ppb and 18.306 ppb, and 16.404 ppb and 14.856 ppb, respectively [41], which exceeded the MRL (Table 2). Similarly, the excess amount of heptachlor was found in dried Chinese pomfret (*Pampus chinensis*) and Indian salmon (*Polynemus indicas*) [42] [43]. It was observed that heptachlor is a carcinogenic to human (B2) and it can pass to unborn baby from pregnant mother's through the placenta [44].

In another study, the mean concentration of DDT in dried Bombay Duck (*Harpodon nehereus*) collected from Borobazar and Reajuddin Bazar stations, Chinese Pomfret (*Pampus chinensis*) from Kalishpur and Reajuddin Bazar, Shrimp (*Penaeus* spp.) from Borobazar and Moilapara were ranged from 261.89 ppb and 874.35 ppb; 250.47 ppb and 877.82 ppb; 161.67 ppb and 589.97 ppb, respectively [18]. For ribbon fish (*Lepturacanthus savala*), the DDT residues were 141.43 and 253.68 ppb that detected from Reajuddin Bazar, Borobazar and Moilapara station, respectively, which were higher than the acceptable limit recommended by WHO. DDT concentration in the Ribbon fish (*Trichiurus haumela*), Bombay duck (*Harpodon nehereus*) and croaker (*Johnius dussumieri*) were ranged from 130.85 to 153.47 ppb, 125.21 to 181.4 ppb and 119.86 to 208.65 ppb, respectively. The mean concentrations of DDT were found at a lower amount in *Penaeus* sp. than the other, which indicates that the concentrations of DDT in

Table 2. Concentration of DDT and heptachlor in marine dried fish in different regions of Bangladesh.

Fish species	Location	DDT residue (ppb)	Heptachlor residue (ppb)	Reference
Ribbon fish (<i>Trichiurus haumela</i>)	New Market, Dhaka	149.430	1.710	[15]
	Karwan Bazaar, Dhaka	131.611	1.937	[15]
	Asadgonj Bazaar, Chattogram	140.398	2.306	[15]
	Asadgonj Bazaar, Chattogram	137.535	ND	[15]
	New Market Bazar	132.11	ND	[45]
	Asadgonj Bazar	139.34	ND	[45]
	Teknaf Bazar	134.28	ND	[45]
Ribbon fish (<i>Lepturacanthus savala</i>)	Sayedpur	755.032	ND	[47]
	Cox's Bazar	209.185	ND	[47]
	Reajuddin Bazar	141.43	ND	[18]
Bombay duck (<i>Harpodon nehereus</i>)	Karwan Bazaar, Dhaka	182.333	1.762	[15]
	Asadgonj Bazaar, Chattogram	874.966	5.464	[15]
	Asadgonj Bazaar, Chattogram	61.918	2.283	[15]
	Sayedpur	485.809	ND	[47]
	Cox's Bazar	262.185	ND	[47]
	Reajuddin Bazar	874.35	ND	[18]
	Borobazar	261.89	ND	[18]
	Teknaf	145.75	ND	[45]
	Asadgonj Bazar	181.14	ND	[45]
	New market Bazar	168.36	ND	[45]
Chinese pomfret (<i>Pampus chinensis</i>)	Karwan Bazar	ND	54.753	[42]
	Khalispur	250.47	ND	[18]
	Reajuddin Bazar	877.82	ND	[18]
Indian Salmon (<i>Polynemus indicas</i>)	Asadgonj Bazar	233.70	37.8	[43]
Anchovy (<i>Septipinna phasa</i>)	Karwan Bazar	19.416	18.306	[41]
Shrimp (<i>Penaeus</i> spp.)	Cox's Bazar	146.37	ND	[45]
	Moilapata	585.97	ND	[18]
	Borobazar	161.67	ND	[18]
Perch (<i>Lates calcarifer</i>)	Sayedpur	298.165	ND	[47]
	Cox's Bazar	242.166	ND	[47]
Croaker (<i>Johnius dussumieri</i>)	Karwan Bazar	16.404	14.856	[41]
	Cox's Bazar	184.22	ND	[45]
	Teknaf	119.86	ND	[45]
	Moheskhali	133.52	ND	[45]
	New Market	208.65	ND	[45]
	Asadgonj Bazar	180.63	ND	[45]
	Reajuddin Bazar	167.52	ND	[45]

ND: Not determined; MRL of DDT is 50 ppb, MRL of heptachlor is 10 ppb.

dried fish from Bangladesh were higher and may cause chronic disease and potential long-term risk to human health [45].

A significant amount of multiple pesticides (DDT, endrin, aldrin, dieldrin) have been found in various dried fishes such as tengra, taki, shol, chingri, prawn, kaski, chapila, gonia, mola and puti [20] [46] [47] [48] (Table 3 and Table 4). The presence of multiple pesticides in dried fish could be explained as a single pesticide used by dried fish producers and another might be used by the dried fish value chain vendors for long-term preservation [16] [20]. Besides, reference [49] reported that more than 60.19% fish and fisheries products contain pesticide residue. Moreover, contaminations of pesticide in fish and fisheries products varied geographically. DDT, Heptachlor, Diazinon, Chlorpyrifos, Acephate, Qunalphos, Carbaryl, etc. were abundant in Dhaka, Chattogram and Rajshahi divisions [49]. Also, reference [16] screened 92 dried fish samples obtained from eight districts of Bangladesh and found that 42 samples were contaminated with DDT, Dimethoate, Fenitrothion, Chlorpyrifos, Acephate and Diazinon residues, which are extremely hazardous for humans and the environment.

Dried fish contaminated with DDT is responsible for chronic health hazards as DDT is a slow poisoning substance and shows vertical transmission from generation to generation through breast milk [50]. It is the most concerning issue. Processors, exposed to DDT occupationally have an increased incidence of non-allergic

Table 3. Concentration of DDT in fresh water dried fish in different regions of Bangladesh.

Fish species	Location	DDT residue (ppb)	Reference
Tengra (<i>Mystus vitatus</i>)	Sayedpur	370.461	[47]
Punti (<i>Puntius sophore</i>)	Sayedpur	204.403	[47]
	Dhaka	187.41	[46]
Taki (<i>Channa punctatus</i>)	Sayedpur	420.191	[47]
	Cox's Bazar	111.495	[47]
Shol (<i>Channa striatus</i>)	Sayedpur	1249.68	[47]
	Cox's Bazar	587.146	[47]
	Dhaka	177.23	[46]
Boro Chingri (<i>Macrobrachium rosenbergii</i>)	Dhaka	183.48	[46]
Prawn (<i>Leander styliferus</i>)	Sayedpur	515.185	[47]
	Cox's Bazar	161.739	[47]
	Dhaka	332.38	[46]
Gonia (<i>Labeo gonius</i>)	Dhaka	7968.26	[46]
Kaski (<i>Corica soborna</i>)	Dhaka	808.68	[46]
Chapila (<i>Gudusia chapra</i>)	Dhaka	665.72	[46]
Chanda (<i>Chanda ranga</i>)	Dhaka	554.78	[46]

MRL of DDT is 50 ppb.

Table 4. Concentration of endrin, aldrin and dieldrin in fresh water dried fish in different regions of Bangladesh.

Fish species	Location	Detected pesticide	Pesticide residue (ppb)	Reference
Kaski (<i>Corica soborna</i>)	Rajshahi		120	[48]
	Dhaka		105	[48]
	Dinajpur		90	[48]
	Mymensingh		120	[48]
	Bogra		70	[48]
	Chattogram	Endrin	60	[48]
	Paysha	Mymensingh		80
Bogura			90	[48]
Dinajpur			50	[48]
Mola (<i>Amblopharyngodon mola</i>)	Bogura		120	[48]
Puti (<i>Puntius sophore</i>)	Sylhet		828	[20]
	Sylhet	Aldrin	332 - 812	[20]
	Sylhet	Dieldrin	762	[20]

MRL of Endrin, aldrin and dieldrin is 10 ppb.

asthma [51] and have direct links with diabetes [52], cancer [53]. A number of studies have argued that the accumulation of DDT in human body before puberty increases the risk of breast cancer for the women [54]. At present, importing as well as producing the “Dirty Dozen” pesticides is prohibited in Bangladesh. Now a day, there is no legal use of any persistent organochlorine pesticides in Bangladesh, however, some old stocks may be available and some may be available through other unknown sources [20] [55].

2.3. Lipid Oxidation in Dried Fish

Fish lipids containing polyunsaturated fatty acids are highly unstable and susceptible to reaction with atmospheric oxygen and produce hydroperoxide compounds and free radicals cause off flavor and off odor in dried fish. The higher amount of hydroperoxide compounds and free radicals indicate the poor quality of a food product [56] [57]. **Table 5** shows rate of lipid oxidation in dried fishes available in Bangladesh. The peroxide values of the traditionally dried 8 marine fish samples ranged between 46.80 and 82.70 meq/Kg oil [58]. Almost all values are above the acceptable limit indicating whole marine dried fish can be considered to be spoiled for most uses. More or less similar findings have been reported in the cases of dried tengra [22] and kholisa [23] and sun dried puti, chapila, taki [59]. Moreover, the excess amount of acid value was also found in dried kholisa, punti, chapila and taki [23] [59]. In general, the rate of oxidation increases with the increasing temperature. Other factors may be relative humidity of environment and absorbing moisture from atmosphere. The increased peroxide

Table 5. Peroxide value and acid values of some dried fish in Bangladesh.

Dried fish	Location & Storage condition	Peroxide value (meq/Kg of lipid)	Acid value (mg KOH/g of lipid)	Reference
Tengra (<i>Mystus vitatus</i>)	Gazipur and stored in room temperature at 90 days	25.35	19.59	[22]
Kholisa (<i>Trichogaster fasciata</i>)	Gazipur and stored in room temperature at 90 days	27.87	22.25	[23]
Punti (<i>Puntius sophore</i>)	Dhaka city	36	20.83	[59]
Chapila (<i>Gudusia chapra</i>)	Dhaka city	32.6	22.25	[59]
Taki (<i>Channa punctatus</i>)	Dhaka city	33.09	25.13	[59]
Chinese pomfret (<i>Stromateus chinensis</i>)	Cox's Bazar and packed in pyrogen-free polyethylene bag	48.67	-	[58]
Silver pomfret (<i>Stromateus cinereus</i>)		72.50	-	[58]
Riksha fish (<i>Ricksha</i> sp.)		54.40	-	[58]
Silver jew fish (<i>Johinus argentatus</i>)		72.50	-	[58]
Ribbon fish (<i>Trichiurus haumela</i>)		74.60	-	[58]
Bombay duck (<i>Harpodon neherus</i>)		72.70	-	[58]
Red snapper (<i>Lutjanus johnii</i>)		46.80	-	[58]
Shrimp (<i>Penaeus</i> sp.)		82.70	-	[58]
Standard		20	20	[36]

and acid value in the dried products are susceptible to rapid oxidation during processing, drying and storage under abused influencing conditions. The abused influencing conditions include inappropriate packaging causing off flavor and off odor [22] [23] [60] [61] [62] which reduce the product value to the consumers. Oxidized dried fish products are not safe for human consumption [63]. The lipid oxidation primary products in fish reduce its protein digestibility [64] and formation of secondary oxidation products can cause aging, membrane injury, cardiovascular diseases, atherosclerosis and tumor growth [65] [66].

3. Microbiological Hazards

Now a day, consumers are very much concerned about the quality of dried fish products. They consider not only chemical contaminants, spoilage but also infestation by flies and microorganisms while buying dried fish. Various microorganisms adversely affect the quality of dried fishery products due to traditional drying, storage and distribution [23] [67]. The presence of the pathogenic microbial loads in dried fishes is getting importance in the safety and quality aspects of the dried fishes [68]. Particularly, besides pathogenic bacteria, some pathogenic molds have been found as a significant amount in dried food [69]. The incidence of *Salmonella* sp. in various dried fishes directly indicated the maintenance of poor hygienic condition during drying [67].

The total viable count of bacteria, 7 log CFU/g is the upper acceptable limit for fresh and frozen fish and cold-smoked fish species [70] and beyond this lim-

it, the product is not safe for the consumer. The amount of total plate count in ten indigenous dried fish varied between 7.50 to 8.56 log CFU/g [25] (Table 6). More or less similar findings were observed in the cases of dried kholisa [23], dried tengra [22] and dried taki [71]. Besides, the bacterial load of traditionally dried small indigenous species products ranged from 8.156 log CFU/g to 8.460 log CFU/g [72]. During improper packaging, storage and exposed condition in the retail market, dried products absorb a considerable amount of moisture because humidity enhances the microbial load [22] [71]. Moreover, spores of bacteria may not be destroyed at the time of drying because of an inappropriate or low drying temperature.

In Table 7, *E. coli*, *Salmonella* sp. were found in sun dried *Mastacembelus armatus* [24], in dried *Puntius sophore* [20] [73] and in *Puntius chola*, *Brama brama*, *Penaeus monodon* [74]. Besides, *Vibrio* sp. were identified in dried *Puntius sophore* [20] [73] and dried *Brama brama* [74]. *E. coli*, *Salmonella*, *Shigella*, *S. aureus* are highly pathogenic bacteria which indicates the fecal contamination of water from where fish were harvested and their presence in food can cause food poisoning, food infection to consumer [75]. Seafood products harvested from contaminated waters, which have been improperly preserved after harvesting, are known to play an important role in infections by *Vibrio* sp. [76]. It can cause diarrhea, headache, vomiting, nausea, abdominal cramps, and low fever to consumers [77]. Besides, total staphylococcal count (TSC) in dried churi, chingri, punti, mola, challa and chapila collected from Chattogram and My-mensingh district were 86.33, 31.67, 32.33, 61.00, 53.00 and 53.67 respectively [67]. It has been reported that *Staphylococcus* sp. was found in sun dried *Brama*

Table 6. Total plate count (log CFU/g) of various dried fish in Bangladesh.

Fish species	Location	Total plate count (log CFU/g)	Reference
Mola (<i>Amblypharyngodon mola</i>)	Dhaka city	8.26	[25]
Puti (<i>Puntius sophore</i>)	Dhaka city	7.50	[25]
	Sylhet	5.2	[20]
Batasi (<i>Pseudeutropius atherinoides</i>)	Dhaka city	8.49	[25]
Tengra (<i>Mystus vitatus</i>)	Dhaka city	8.24	[25]
	Gazipur	8.88	[22]
Chapila (<i>Gudusia chapra</i>)	Dhaka city	8.56	[25]
Katchki (<i>Corica soborna</i>)	Dhaka city	8.56	[25]
Churi (<i>Trichiurus lepturus</i>)	Dhaka city	7.61	[25]
Taki (<i>Channa punctatus</i>)	Dhaka city	8.29	[25]
	Natore	7.56	[71]
Loita (<i>Harpadon nehereus</i>)	Dhaka city	8.39	[25]
Chanda (<i>Chanda ranga</i>)	Dhaka city	7.52	[25]
Kholisa (<i>Trichogaster fasiata</i>)	Gazipur	8.37	[23]

Table 7. Pathogenic bacteria in some dried fish

Fish species	Sample source	Total sample tested	<i>E. coli</i> (%)	<i>Salmonella</i> (%)	<i>Vibrio</i> (%)	Reference
<i>Mastacembelus armatus</i>	Bondor Bazar, Sylhet	25	100	80	-	[24]
	Lamagaji, Sylhet	25	100	60	-	[24]
<i>Puntius sophore</i>	Mahtabpur, Sylhet	25	100	32	28	[73]
	Tuker Bazar, Sylhet	25	100	36	24	[73]
	Local Market, Sylhet	25	100	44	40	[73]
	Producer	15	100	13.3	0	[20]
	Retailer	15	100	20	13.3	[20]
<i>Puntius chola</i>	Kawran Bazar, Dhaka	5	100	100	-	[74]
<i>Amblypharyngodon mola</i>		5	100	-	-	[74]
<i>Brama brama</i>		5	100	100	100	[74]
<i>Harpodon neherreus</i>		5	100	-	-	[74]
<i>Penaeus monodon</i>		5	100	100	-	[74]

brama and *Penaeus monodon*, and *Pseudomonas* sp. was also isolated from dried *Brama brama*, *Puntius chola* and *Amblypharyngodon mola* collected from retail market of Kawran Bazar, Dhaka [74]. Monitoring of these microorganisms has been suggested as a measure of fish quality.

4. Conclusions and Recommendations

This review provides important information on heavy metal, organochlorine chemicals and pesticides, rate of lipid oxidation and microbial contamination of some dried fish samples collected from local markets, retail market and producer of Cox's Bazar, Chattogram, Dhaka, Gazipur, Sylhet, Khulna, Mymensingh, Bogura, Natore, Rajshahi, Dinajpur and Nilphamari district. The amount of contaminants and hazards detected by different researchers is alarming for Bangladesh and can be used as basic information to risk assessment of these dried fish to consumers and will help to make fruitful policy. Considering the above facts, several recommendations can be made to eradicate these hazards from dried fishery products in Bangladesh:

- 1) Develop safe and economical methods of drying, processing, packaging, storage, distribution and heavy metal decontamination strategies of dried fish products;
- 2) Provide awareness of fish processors and retailers about public health and sanitation practice and about the harmful role of various insecticides;
- 3) Provide necessary training to ensure good quality dried fish through improved, cost-effective and safe drying, packaging and storage method;
- 4) The processor should dry the fishes appropriately and pack properly so that the fish cannot reabsorb moisture in monsoon;

5) Since organochlorine synthetic chemicals could cause danger to human health, these insecticides have been strictly banned in various countries (1970 in Sweden; 1971 in Japan; 1972 in USA). Therefore, the government of Bangladesh should implement and strictly enforce updated pesticide legislation and policies in fishery products;

6) Presence of heavy metal in aquatic environment and water pollution affects the aquatic ecosystem; it should be brought under continuous monitoring;

7) Enforce mandatory and voluntary actions to prevent aquatic pollution by hazardous chemicals etc.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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