applied sciences

MDPI

Review

Foodborne Illnesses and Microbiological Safety of Fish and Fish Products: A Brief Overview in Regard to Mexico

Alejandro De Jesús Cortés-Sánchez [1,2,*], Mayra Díaz-Ramírez [2], Ma. De la Paz Salgado-Cruz [3], Erika Berenice León-Espinosa [4], Hypatia Arano-Varela [2], Izlia J. Arroyo-Maya [5] and María De Jesús Perea-Flores [6]

1 Secretaría de Ciencia, Humanidades, Tecnología e Innovación (SECIHTI), Av. Insurgentes Sur 1582, Col. Crédito Constructor, Alcaldía Benito Juárez, Ciudad de México CP. 03940, Mexico
2 División de Ciencias Biológicas y de la Salud, Universidad Autónoma Metropolitana, Unidad Lerma (UAML), Av. de las Garzas 10, Col. El Panteón, Lerma de Villada CP. 52005, Estado de México, Mexico; m.diaz@correo.ler.uam.mx (M.D.-R.); h.arano@correo.ler.uam.mx (H.A.-V.)
3 Departamento de Ingeniería Bioquímica, Unidad Profesional Adolfo López Mateos, Instituto Politécnico Nacional, Av. Luis Enrique Erro s/n, Ciudad de México CP. 07738, Mexico; msalgadoc@ipn.mx
4 Tecnologico Nacional de México/Instituto Tecnológico Superior de San Felipe del Progreso, San Felipe del Progreso CP. 50640, Estado de México, Mexico; erikab.le@sfelipeprogreso.tecnm.mx
5 División de Ciencias Naturales e Ingeniería, Universidad Autónoma Metropolitana, Unidad Cuajimalpa (UAMC), Av. Vasco de Quiroga 4871, Col. Santa Fe Cuajimalpa, Alcaldía Cuajimalpa de Morelos, Ciudad de México CP. 05348, Mexico; iarroyo@cua.uam.mx
6 Centro de Nanociencias y Micro y Nanotecnologías, Instituto Politécnico Nacional, Av. Luis Enrique Erro s/n, Unidad Profesional Adolfo López Mateos, Zacatenco, Gustavo A. Madero, Ciudad de México CP. 07738, Mexico; mpereaf@ipn.mx
* Correspondence: alecortes_1@hotmail.com or aj_cortes@correo.ler.uam.mx

Abstract

The presence of microorganisms in fish and fish products is a relevant factor in spoilage and food safety. Fish is considered a nutritious staple of the human diet and is produced, processed, and marketed worldwide. To describe the role of microorganisms in regard to the safety of fish and fish products, we conducted this narrative review to present information on fish production; various pollution hazards; and the causes, control, and prevention of diseases caused by food consumption. It also explores documented cases of foodborne illnesses in Mexico associated with microorganisms. Furthermore, microbiological evaluations of products that are offered for consumption in different areas and cities of Mexico are reviewed, as is the regulatory framework that has been developed regarding the safety of produced and marketed products. This was achieved through the searching for, compilation of, and analysis of information in various databases (Redalyc, Scielo, Scopus, Web of Science, ScienceDirect, Google Scholar, among others). The knowledge obtained indicates that bacteria and parasites are frequently associated with illnesses caused by the consumption of raw products or products subjected to inadequate cooking and hygiene practices. Meanwhile, a microbiological evaluation of fish and marketed products reveals contamination that compromises food safety. Therefore, it is necessary to strengthen microbiological surveillance of products and hygiene education throughout the food chain by government, industry, researchers, and end consumers to promote the availability of safe, nutritious foods for the population.

Keywords: food safety; fish; food microbiology; pathogens; hazards; contamination; microbiological assessment; public health

check for updates

Academic Editor: Claudio Medana

Received: 17 September 2025
Revised: 15 October 2025
Accepted: 22 October 2025
Published: 27 October 2025

Citation: Cortés-Sánchez, A.D.J.; Díaz-Ramírez, M.; Salgado-Cruz, M.D.l.P.; León-Espinosa, E.B.; Arano-Varela, H.; Arroyo-Maya, I.J.; Perea-Flores, M.D.J. Foodborne Illnesses and Microbiological Safety of Fish and Fish Products: A Brief Overview in Regard to Mexico. *Appl. Sci.* **2025**, *15*, 11447. https://doi.org/10.3390/app152111447

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Access to healthy and safe food is a fundamental right for all people worldwide, enabling them to grow, develop, and maintain their health throughout their lives [1]. Food is considered safe when it is free of substances that can cause harm to the consumer's health at any level of exposure [2]. The overall quality of food is defined by four attributes that influence its value and acceptability: nutritional, sensory, safety, and commercial qualities [3,4]. There is an important relationship between food safety and consumer health, making food safety essential [4].

In the food production industry, food safety must be a basic, non-negotiable, high-priority concept, unlike other food attributes. Consumers demand and trust that all types of food are safe, regardless of the production process, and producers must be legally and morally responsible for ensuring that this requirement is met in their products [3].

Throughout the food production chain—from the farm through processing, storage, and preparation, and before consumption in restaurants or at home—contamination by various agents or hazards can occur, and its subsequent consumption can lead to foodborne illnesses [5]. Meat products are a staple of human nutrition in several countries and contribute substantially to nutrients such as fats, vitamins, minerals, and proteins, the latter being of high nutritional quality due to their high biological value and bioavailability [6].

Fish is one of the most produced and marketed meat products worldwide, primarily intended for human consumption. It is relatively affordable and accessible, leading to an increase in consumption [6,7]. In 2022, global fishing and aquaculture activities represented a source of employment for 61.8 million people and a significant contribution to the food supply, reaching a production from both activities of 185.4 million tons of live weight, of which approximately 88.7% was intended for human consumption; this amounted to a per capita consumption of 20.7 kg, while the remaining 11.2% was for non-food use [7]. Fish is considered part of the human diet due to its nutritional value which, along with the degree of freshness and safety at which it reaches our tables, depends on various factors, such as the capture or cultivation conditions, processing, handling, storage, transportation, and marketing, making it highly susceptible to spoilage and contamination by a variety of hazards that increase the risk of foodborne illnesses in consumers [8–10]. This food can also generate economic losses due to confiscations of products in good or poor condition being associated with these illnesses, as well as the closure of establishments that prepare and market these foods [11].

Therefore, the objective of this narrative review is to present a general and concise perspective on foodborne illnesses, with an emphasis on fish and fish products. This information includes sources of production and consumption, the main hazards of contamination associated with these diseases, and methods for their control and prevention. Emphasis is also placed on the case of fish production in Mexico, including reported cases of foodborne illnesses, the presence of biological contaminating hazards in fish products, and reported cases associated with consumption. This information is presented through searches, compilation, and analysis using various databases (Redalyc, Scielo, Scopus, Web of Science, ScienceDirect, Google Scholar, among others). Our inclusion criteria focused on microbial pathogens, food types, information availability, regulations, and location. Published articles and gray literature in English and Spanish were considered, with no specific search and selection period being defined. The Boolean search method was included using search blocks such as foodborne diseases, microbiological terms, geographic focus, control systems, and public health, as well as the combination of keywords and general or specific phrases such as "Foodborne outbreak Mexico" OR "Microbiological hazards fish" OR "Foodborne disease" OR "Foodborne illness" OR "Microbiological evaluation seafood Mexico" OR "Food safety fish Mexico" OR "Food safety" OR "Hygiene" OR "Surveillance"

OR "Food safety fish" OR "Regulation food safety Mexico" OR "Evaluation microbiological fish Mexico". In the selection and evaluation of information, the titles and abstracts were reviewed, and, if necessary, the entire document was evaluated.

Studies on foodborne illnesses, fish- and shellfish-borne illnesses, microbial causative agents, surveillance, risk practices, and disease prevention were included; information regarding fish-borne diseases in Mexico and causative agents of non-microbial origin was excluded.

2. Foodborne Illnesses

Foodborne illnesses are a group of conditions caused by the ingestion of food or water that has been contaminated by physical, biological, or chemical agents, affecting the health of consumers individually and collectively [5,12,13].

These diseases are a priority challenge in global public health due to their incidence, sequelae, and mortality; new forms of transmission; vulnerable population groups; the increase in international trade; the preference for ready-to-eat foods and consumption of these in public places; the increased resistance of causal agents to antimicrobial compounds; and negative effects on the economy due to costs in hospital services, productivity, demands, and consumer confidence [12–16].

Foodborne illnesses have a variety of primarily gastrointestinal symptoms, such as nausea, vomiting, diarrhea, abdominal pain, and fever. In some cases, there are severe complications, including sepsis, meningitis, miscarriage, Reiter's syndrome, Guillain–Barré syndrome, or death [5,12,17]. An individual's health status, age, and other characteristics influence their predisposition to foodborne illnesses. The most susceptible populations are pregnant women, elderly populations, children, malnourished people, immunocompromised people, as well as those living in high levels of poverty and unsanitary conditions [1,14,17].

More than 250 causal agents of foodborne illnesses have been described due to the diversity of contaminants that can have a chemical (antimicrobials, growth promoters, toxic food additives, lubricants, inks, disinfectants, heavy metals, and pesticides, among others), physical (fragments of glass, metal, wood, or others), or biological (bacteria, fungi, parasites, viruses, and prions) origin, with the latter being involved in most of these diseases [12,14,15,17].

Foodborne illnesses caused by biological agents are classified into two types: firstly, foodborne infections occur when food is contaminated by the pathogen, which establishes and multiplies in the consumer. There are two variants: (1) Invasive infections, characterized by the microorganism colonizing tissues and organs of the affected person. Examples of these are salmonellosis, listeriosis, trichinosis, hepatitis A, and toxoplasmosis. (2) Toxiinfections caused by non-invasive microorganisms, which are capable of developing in the host's intestinal tract and producing toxins. Some examples are *Bacillus cereus*, *Vibrio cholerae*, *Vibrio parahaemolyticus*, and *Yersinia enterocolitica.* Secondly, food poisoning due to toxins being present in the food, produced by microbial growth in the food prior to consumption. A few examples are botulism, staphylococcal poisoning, histamine poisoning, fungi-produced toxins (aflatoxins), or marine species (ciguatoxin and saxitoxin, among others) [1,8,14].

According to the World Health Organization (WHO), every year, 600 million people around the world become ill after consuming contaminated food, of which 420,000 are fatal cases [5,13]. Likewise, it is estimated that 1.5 billion cases of diarrhea are reported annually, of which 70% are a consequence of the ingestion of food contaminated by various microorganisms or derived toxins [13].

The most common causative agents of foodborne and diarrheal diseases globally are those of a biological origin, such as *Campylobacter* spp., *Salmonella* spp., *Taenia solium*, *Anisakis* sp., *Trichinella* spp., *Staphylococcus aureus*, *Clostridium* spp., *Escherichia coli*, *Vibrio* spp., *Shigella* sp., *Listeria monocytogenes*, *B. cereus*, *Yersinia* sp., norovirus, and hepatitis A virus [16–21].

In most Latin American and Caribbean countries, foodborne illnesses are among the top five causes of death [13]. Food safety is a critical factor in countries such as Costa Rica, El Salvador, Guatemala, Honduras, and Nicaragua. It has been reported that a lack of food safety increases the risk of gastrointestinal diseases due to bacterial and parasitic infections and poisonings, manifesting as episodes of diarrhea, headache, vomiting, and fever. The main identified pathogens are Staphylococcus aureus, *Bacillus cereus*, *fecal coliforms*, *Clostridium botulinum*, *C. perfringens*, *Vibrio cholerae*, *V. parahaemolyticus*, *Yersinia enterocolitica*, *Listeria monocytogenes*, *Shigella* sp., and *Salmonella* sp. [1].

In Mexico, gastrointestinal diseases are among the leading causes of medical consultations and deaths, affecting individuals of all ages and social backgrounds, and are frequently reported in children and the elderly population [22–24]. These diseases are primarily caused by bacteria (including *E. coli*, *Vibrio* sp., *Salmonella* ssp., and *Shigella* sp.), parasites (*Ascaris*, *Enterobius*, *Giardia*, *Amoeba*, and *Taenia*), and viruses (Rotavirus, norovirus, and hepatitis A virus), either by consuming contaminated food and water or through direct contact due to poor hygiene [22,23,25].

By 2020, intestinal infections were the 20th leading cause of death in Mexico, with 3,513 deaths, primarily affecting children and older adults [26]. In 2024, 4,348,944 cases of infectious intestinal diseases (IIDs) were reported, as were 24,751 cases of bacterial food poisoning (BFP). Women were most affected by IIDs, with the highest proportion of cases occurring in the states of Chiapas, Mexico City, Jalisco, State of Mexico, Nuevo León, Puebla, Tamaulipas, and Veracruz. For BFP, women were also the most affected group, with the highest number of cases occurring in the states of Baja California, Jalisco, San Luis Potosí, Nuevo León, and Chihuahua [25].

3. Fish and Fish Products

The category of fish is defined as fish, crustaceans, mollusks, and other forms of aquatic organisms (such as algae) that come from fresh or salt water and are intended for human consumption [27,28]. Fishery products are intended for human consumption and contain fish as a primary ingredient [27]. Fish is considered a basic element in the human diet and recommended to be consumed twice a week, for a number of reasons: it is an important source of proteins (15% to 25%); exhibits high digestibility (above 80%); has biological value (close to 100%); is a source of essential amino acids (mainly lysine, leucine, and histidine), omega-3 and 6 fatty acids, vitamins (A, D, and E), and minerals (I, Na, Ca, Fe, Mg, and P, among others); varies from one species to another; and has low caloric contents. Therefore, the consumption of fish promotes health and prevents various cardiovascular diseases, improves cognitive function, reduces the risk of dementia and Alzheimer's, contributes to glycemic control, and improves insulin sensitivity, among other positive effects [28–31]. However, despite their nutritional value, the safety of these products can be compromised throughout the food chain by multiple contamination hazards (microorganisms, metabolites, chemicals, and toxins) that can represent a significant risk of consumption-related diseases [31].

4. Aquaculture and Fishing

Aquatic systems are a source of food and nutrition and support socioeconomic development and sustainability, as they have a low ecological footprint. Through fishing

and aquaculture activities, humans obtain fish. The global production from both activities in 2022 was 185.4 million tons, with Asian countries such as China, Indonesia, Vietnam, and India being the main producers; 88.7% of total production was used for food, while the remainder was used for fishmeal and oil production. Per capita consumption reached 20.7 kg, with this food being used, processed, or distributed in live, fresh, refrigerated, frozen, prepared, canned, or cured form; the last of these procedures promote the safety of fish products, reduce spoilage, and increase their availability for consumption [7]. In Mexico, fishing and aquaculture activities represent an important source of food and economic value, with production in 2023 from both activities amounting to 2,455,025 tons, and with the states of Sonora, Sinaloa, Baja California, Baja California Sur, and Veracruz being the main producers; direct human consumption was the main destination, with a per capita consumption of 13.88 kg, while the main industrial processes to which it is subjected are freezing, canning, production of fishmeal and oils, dehydration, smoking, dry-salting, and cooking [32]. In Mexico, the period with greatest consumption of fish is the "Lent/Easter season", with a wide variety of species such as sardines, tuna, squid, octopus, catfish, shrimp, tilapia, trout, oyster, sawfish, grouper, and sea bass being eaten [33].

5. Foodborne Illnesses: Fish Consumption

Fish, having high nutritional value, is also susceptible to contamination and spoilage through autolysis, oxidation, and microbial activities, which reduce its nutritional and sensory quality and pose a health risk to consumers [8,10,34]. Thus, the high nutritional value, freshness, and safety of fish are related to factors such as species, age, environment and conditions of capture or harvesting, type of feed, handling, storage, transportation, and distribution conditions [10,29].

There are a variety of physical, chemical, or biological agents that can impact quality aspects relating to fish safety and spoilage (Table 1). Around the world, a correlation between the consumption of fish and outbreaks or cases of diseases has been reported, with the main causal agents being those of a biological origin such as bacteria and toxins [17,35–38]. Among the fish products that have been reported as vehicles of causal agents of foodborne illnesses are the following presentations: 1. raw (sushi, sashimi); 2. cooked (fried, roasted, or grilled); 3. smoked; 4. retorted; 5. acidified; 6. acidified raw (ceviche); 7. salads; 8. liquid mixtures (soups or stews); 9. salted; and 10. fermented [39].

Fish is considered a safe food, since the edible part (muscle) of healthy fish is sterile; microorganisms are commonly present in the skin, gills, digestive tract, and other internal organs of live and freshly caught fish; their qualitative and quantitative proportions depend on the aquatic environment in which they live, which can be affected by human activities, climate change, or natural disasters [27,34,40,41]; their species; feed; the fishing gear used; the season of the year; initial processing and storage conditions of the fish; and other factors [27,34,41,42].

The microbiota of fish from temperate waters is primarily composed of psychrotrophic Gram-negative bacteria of the genus *Moraxella*, *Acinetobacter*, *Flavobacterium*, *Aeromonas*, *Vibrio*, *Shewanella*, and *Pseudomonas* [34,42]. Gram-positive organisms such as *Bacillus*, *Micrococcus*, *Clostridium*, *Lactobacillus*, and *Coryneformes* can also be found in varying proportions, but Gram-negative organisms generally remain dominant. It has been reported that the Gram-positive bacteria *Micrococcus* and *Bacillus* are abundant in the microbiota of fish from tropical waters. However, various studies have reported that the microbiota of fish from temperate and tropical waters are very similar [34].

Fish have also been identified as reservoirs of various bacterial pathogens that are linked to human diseases such as *Erysipelothrix rhusiopathiae*, *Aeromonas* sp., *Salmonella* spp., *Staphylococcus aureus*, *Mycobacterium* spp., *Streptococcus iniae*, *Photobacterium damselae*,

Vibrio sp., *Listeria monocytogenes*, *Clostridium* sp., *Plesiomonas shigelloides*, and *Edwardsiella tarda* [27,42].

Pathogenic bacteria can be part of the natural microbiota, while others are a product of contamination of the waters where they live or during their processing and handling; they can therefore be classified into 1. native bacteria that are widely distributed in aquatic environments around the world, where the water temperature has a selective effect (such as *C. botulinum*, *Listeria* spp., *Pseudomonas* spp., *Vibrio* spp., *Aeromonas* sp., and *Plesiomonas* sp.) and 2. non-native bacteria that are present in fish and derived from fecal contamination from the animal/human reservoir of aquatic environments or through contamination of products during handling and processing (some examples are *Salmonella* spp., *Shigella* spp., *Yersinia* spp., *Campylobacter jejuni*, *E. coli*, *Bacillus cereus*, *Clostridium perfringens*, *L. monocytogenes*, and *S. aureus*) [8,42–46].

Table 1. Main hazards or causative agents of foodborne illnesses due to consumption of fish, shellfish, and seafood products.

Hazard	Type of Hazard/Causal Agent	Category	Clinical Signs	Source
Physical				
	Glass, plastic packaging, metal (tools, fishhooks, knives), stones, shells/sand, wood, thorns (bones).	Foreign particles.	Injuries to organs of the gastrointestinal tract, broken teeth, asphyxiation.	[46,47]
Biological				
	Ciguatera.	Biotoxin.	Vomiting, itching, nausea, dizziness, chills, myalgia, temporary blindness, hallucinations, and hypertension may occur. Severe and extreme cases can lead to paralysis, coma, and/or death.	[47–50]
	Scombroid toxin (histamine).	Biogenic amines.	Hot flashes, sweating, burning sensation in the mouth, dizziness, diarrhea, nausea, and headache.	[8,30,48,49]
	Paralytic shellfish poisoning (PSP) (saxitoxin).	Biotoxin.	Numbness of face, neck, and hands; nausea; vomiting; and death due to respiratory arrest.	[47,51]
	Diarrheic Shellfish Poisoning (DSP).	Biotoxin.	Diarrhea, nausea, vomiting, and chronic exposure promote the formation of gastrointestinal tumors.	[47,51]
	Neurotoxic Shellfish Poisoning (NSP) (Brevotoxins).	Biotoxin.	Nausea; vomiting; diarrhea; numbness and tingling of the lips, mouth, face, and extremities; paralysis; respiratory distress; and death.	[47,52]
	Amnesic Shellfish Poisoning (ASP) (Domoic acid).	Biotoxin.	Diarrhea, vomiting, and abdominal cramps.	[47,53]
	Tetrodotoxin.	Biotoxin.	Tingling sensation in the face and extremities, paralysis, respiratory symptoms, cardiovascular collapse, and death.	[8,48]
	Mycotoxin.	Toxins/fungi (*Aspergillus*, *Penicillium*, *Fusarium*, and *Mucor*).	Lesions and symptoms in various organs: fibrosis and liver cancer, intestinal bleeding, central nervous system involvement, bone marrow atrophy, myocardial degeneration, immunosuppressive effect, increased vascular fragility with hemorrhage, and nephrotoxicity.	[54,55]
	Cryptosporidium spp.	Parasite.	Watery diarrhea, constipation, fever, anorexia, nausea, vomiting, and weight loss.	[56–58]
	Toxoplasma gondii.	Parasite.	Asymptomatic or with nonspecific symptoms, flu-like symptoms, or lymphadenopathy. Ocular involvement.	[57,59]
	Giardia duodenalis.	Parasite.	Diarrhea, abdominal pain, nausea, anorexia, and weight loss.	[57,60]
	Anisakis sp.	Parasite.	Allergies, sore throat, vomiting, stomach pain, cramps, fever, and nausea.	[6,8,49,61]
	Eustrongylides spp.	Parasite.	Gastritis and intestinal perforation.	[62]

Table 1. *Cont.*

Hazard	Type of Hazard/Causal Agent	Category	Clinical Signs	Source
Biological				
	Diphyllobothrium sp.	Parasite.	Abdominal pain and discomfort, flatulence, diarrhea, vomiting, weight loss, anemia, and intestinal or bile duct obstruction.	[16,61,63]
	Gnathostoma sp.	Parasite.	Serpiginous eruptions and/or erythema (reddening of the skin—alteration of the superficial circulation of the skin).	[61,64]
	Clonorchis sp.	Parasite.	Asthenia, nausea, indigestion, headache, dizziness, vertigo, abdominal discomfort, diarrhea, or abdominal pain. Jaundice, hepatomegaly, and liver tenderness.	[8,16,65,66]
	Opisthorchis spp.	Parasite.	Chronic inflammation of the bile duct, cholangitis and liver cirrhosis, and may promote colangiocarcinoma.	[8,16,66,67]
	Heterophyes sp.	Parasite.	Diarrhea, anorexia, abdominal pain, and weight loss, varying according to individual patient susceptibility.	[16,61,66,68]
	Paragonimus sp.	Parasite.	Diarrhea, abdominal pain, fever, cough, hives, hepatosplenomegaly (enlargement of the liver and spleen), and eosinophilia.	[16,61,64]
	Edwardsiella tarda.	Bacteria.	Gastroenteritis, meningitis, cholecystitis, endocarditis, liver abscess, and osteomyelitis.	[69]
	Listeria spp.	Bacteria.	Nausea, vomiting, diarrhea, fever, headache, abdominal distension, bacteremia, meningitis, miscarriage, and others.	[64,70,71]
	Bacillus cereus.	Bacteria.	Diarrhea and vomiting.	[42]
	Campylobacter sp.	Bacteria.	Diarrhea (sometimes bloody), stomach cramps, fever, muscle aches, headache, and nausea.	[71]
	Salmonella spp.	Bacteria.	Fever, headache, abdominal pain, and diarrhea that may be bloody.	[8,64,72]
	Clostridium spp.	Bacteria.	Watery diarrhea, severe abdominal pain, and cramps. Botulism: abdominal pain, nausea, vomiting, and possible diarrhea, progressive neurological symptoms (diplopia, blurred vision, ptosis, difficulty swallowing, muscle weakness), and, eventually, respiratory failure due secondary to paralysis of the respiratory muscles.	[8,64,72]
	Vibrio sp.	Bacteria.	Watery diarrhea, abdominal cramps, nausea, vomiting, headache, fever, and chills.	[8,64,73]
	S. aureus.	Bacteria.	Nausea, vomiting, abdominal cramps, and diarrhea.	[8,73]
	Shigella sp.	Bacteria.	Gastroenteritis associated with fever, abdominal pain, and diarrhea, possibly bloody or with mucus.	[8,71,72]
	Aeromonas sp.	Bacteria.	Intestinal disorders: vomiting, abdominal pain, fever, nausea, and malaise. Extraintestinal infections (wound, soft tissue, lung infections, or sepsis).	[8,74,75]
	P. shigelloides.	Bacteria.	Gastroenteritis, spontaneous diarrhea, septicemia, and meningitis.	[76]
	E. coli (pathogenic).	Bacteria.	Acute stomach cramps, bloody diarrhea, and nausea. May also present as non-bloody diarrhea or be asymptomatic. Kidney damage.	[8,71]
	Yersinia spp.	Bacteria.	Enterocolitis—abdominal pain. Prolonged diarrhea—complications such as reactive arthritis, Reiter's syndrome, myocarditis, and glomerulonephritis.	[44,77]
	Norovirus.	Virus.	Diarrhea, nausea, vomiting, stomach cramps, headache, and fever.	[8,64,71,78]
	Hepatitis A virus.	Virus.	Fever, anorexia, nausea, vomiting, diarrhea, myalgia, jaundice, abdominal tenderness, hepatomegaly, or splenomegaly.	[8,64,78,79]
	Hepatitis E virus.	Virus.	Fatigue, nausea and vomiting, loss of appetite, abdominal pain, darker urine, and yellowing of eyes and skin.	[80–82]

Table 1. *Cont.*

Hazard	Type of Hazard/Causal Agent	Category	Clinical Signs	Source
Chemical				
	Antimicrobials.	Environmental pollutants. Waste from veterinary and aquaculture activities.	Antimicrobial resistance, metabolic disorders, poisoning, genotoxicity, carcinogenesis, anemia. and allergies.	[2,8,47,83,84]
	Hormones.		Endocrine disruptors. Precocious puberty, increased bone age, negative effects on growth, modification of sexual characteristics, and carcinogenicity.	[47,85,86]
	Antimony, strontium, aluminum, nickel, arsenic, cadmium, lead, mercury, and selenium.	Heavy metals. Environmental pollutants. Produced by natural phenomena and anthropogenic and industrial activities.	Effects depend on the metal accumulated in the body, the degree of exposure (quantity, frequency, and duration), gender, and age. Neurotoxicity, immunotoxicity, cytotoxicity, hormonal disruption, renal and cardiovascular effects, and carcinogenic effects.	[8,30,47,80,87,88]
	Plastics.	Environmental pollutants. Product of anthropogenic and industrial activities.	Risk of oxidative stress, modification of gene expression, endocrine disruption, immunological responses, genotoxicity, transgenerational effects, neurotoxicity, reproductive abnormalities and behavioral abnormalities, and carcinogens.	[30,81,89–92]
	PCB, PAHs, and dioxins.	Environmental pollutants. Product of anthropogenic and industrial activities. PAH for smoked fish.	Carcinogenic. Damage to liver and reproductive, immune, cardiovascular, and endocrine systems.	[8,30,47,80,81,93–96]

PCBs: polychlorinated biphenyls. PAHs: polycyclic aromatic hydrocarbons.

6. Cases of Foodborne Illnesses in Mexico Due to Consumption of Fish and Fish Products

Fish has several nutritional benefits, and Mexico's government encourages the consumption of fish and seafood, because the per capita consumption is less than 13 kg/year, while the recommended intake to maintain a healthy lifestyle is at least 16.5 kg/year. However, to take advantage of the nutritional benefits of fish, it is necessary to consider the potential risks of illnesses associated with the presence of various hazards [97].

In several Latin American countries, outbreaks of foodborne illnesses are subject to mandatory reporting to generate an information system that provides prevention and control measures for these diseases [98]. Nevertheless, information regarding foodborne illnesses and contaminants may be insufficient and difficult to analyze. Passive surveillance systems are often inadequate or deficient due to various factors, such as (a) patients avoiding or not seeking medical attention in a population that does not like to go to the doctor for health incidents with gastrointestinal clinical manifestations (diarrhea), because they are considered transient in nature, meaning that patients wait for the process to end spontaneously, which does not occur in severe cases in infants or older adults [1,98,99]; (b) adequate samples not being collected and sent for culture; or (c) treating physicians not reporting cases or deaths to public health reference centers for cultural reasons. Alternatively, information on outbreaks is often insubstantial, either because health authorities lack the capacity or resources for detection, or because diarrheal diseases are endemic and outbreaks may be less common or obvious than in industrialized countries [99].

Information on foodborne illness outbreaks associated with the consumption of fish and shellfish and causative agents such as different pathogenic microorganisms is limited in Mexico [100]. Several cases of foodborne illnesses have been reported and documented, the causative agents of which are mainly bacteria or parasites (Table 2). It should be noted that in Mexico, as in other Latin American countries, the consumption of fish and shellfish frequently involves raw or undercooked preparations such as ceviche or sushi; this, along with poor hygiene practices and conditions in processing and handling, increases the risk of foodborne illness [100–102].

Table 2. Cases or outbreaks of foodborne illnesses in Mexico due to consumption of fish contaminated by various biological hazards.

Place/Time Period	Cases	Causative Agent	Food Implicated	Source
Cozumel/1981.	98	*Vibrio*, *Salmonella*, and toxigenic *Escherichia coli.*	Unrefrigerated seafood dishes served at outdoor buffets.	[103]
Federal District (now Mexico City) and other 16 states/1980 to 1989.	26 outbreaks	*Staphylococcus aureus.*	Fish and shellfish implicated in 7% of outbreaks.	[104]
Durango/1990 to 1999.	8	*V. vulnificus.*	Raw shellfish.	[73]
Southern state of Sinaloa in northwestern Mexico/2003 and the end of September 2004.	1230	*Vibrio parahaemolyticus.*	Raw or undercooked shrimp.	[105]
From the southern to the northern part of Sinaloa/2011–2013.	249	*V. parahaemolyticus.*	Seafood.	[106]

Table 2. *Cont.*

Place/Time Period	Cases	Causative Agent	Food Implicated	Source
Culiacan, Sinaloa/1991 to 1996.	>300	*Gnathostoma* sp.	Raw or undercooked fish.	[107]
Tepic, Nayarit/1988 to 1996.	>500	*Gnathostoma* sp.		[107]
Acapulco, Guerrero/1990 to 1996.	>80	*Gnathostoma* sp.		[107]
Temascal Tuxtepec, Oaxaca/1980 to 1996.	>300	*Gnathostoma* sp.		[107]
Tierra Blanca, Veracruz/1980 to 1996.	>100	*Gnathostoma* sp.		[107]
Tampico, Tamaulipas/1990 to 1993.	>100	*Gnathostoma* sp.		[107]
Sinaloa, Nayarit and Oaxaca/1997 to 2001	8367	*Gnathostoma* sp.		[108]
Aguascalientes/1998, 2000.	2	*Gnathostoma* sp.		[109]
Acapulco, Guerrero/1993 to 1997.	98	*Gnathostoma* sp.	Raw or poorly cooked freshwater fish, especially in the form of sashimi or ceviche.	[110]
Tecualilla, Sinaloa/no time period specified in the study.	5	*Gnathostoma* sp.	Raw fish.	[111]
Morelia, Michoacán/2010.	150	*S. enterica* serotype *Oranienburg*.	Shrimp or cantaloupe melon drink.	[112]
Mazatlán, Sinaloa/2014–2018.	39	*Entamoeba histolytica*, *Salmonella typhi*, *Clostridium*, *Endolimax nana*, and *Entamoeba coli.*	Seafood.	[100]

In Mexico, information on qualitative and/or quantitative analyses of pathogenic microorganisms in fish and fish products marketed for human consumption is limited or not very accessible, but some studies on the microbiological safety of these products are available to the population (Table 3 and Figure 1). The "Central de Abastos of Mexico City" is an important wholesale food market in Mexico, receiving products from every state of the Mexican Republic and other countries around the world. Located within the Central de Abastos is the "La Nueva Viga" Market, which sells fish products (65% of the country's fish production and a significant amount of seafood). It is the largest fish and seafood market in Latin America and the second largest internationally, serving as a national commercial benchmark; various products offered here have been analyzed for microbiological safety, revealing hazards that compromise product safety and consumer health (Table 3) [113].

Table 3. Studies on the microbiological safety of various fishery products offered to the Mexican population for consumption in different locations in Mexico.

Place of Production or Marketing/Year	Product	Microbiological Assessment	Microbiological Specification/Mexican Standard Applicable to Products	Risk/Recommendation	Source
Mazatlán in the state of Sinaloa (market and pier)/10 consecutive weeks; the period is not specified.	Fish filet (*Mugil cephalus*, *Scomberomorus sierra*, *Coryphaena hippurus*).	100% of samples showed contamination by aerobic mesophiles, with a range of 5.2 to 5.9 Log CFU g^{-1}.	Maximum permissible limit: 7 log CFU g^{-1} / NOM-027-SSA1-1993.	It does not pose a risk to consumer health. Implement good hygiene and sanitation practices to ensure food safety.	[114]
Obregon city, Sonora (street stalls)/June–July 1998. September–January 2001.	Raw and fresh fish filet (*Mugil cephalus*, *Anadara* sp.).	*V. parahaemolyticus* was isolated in 40% of *Mugil cephalus* samples, and *V. vulnificus* was isolated in 25% of *Anadara* sp. samples.	Specification only for *Vibrio cholerae* O1 toxigenic absent in 50 g/NOM-027-SSA1-1993.	Foods are considered high-risk for gastrointestinal illnesses. Improve health education on food handling and implement quality assurance procedures.	[73]
Contoy Island, Mujeres Island, Cancun, Puerto Morelos, Playa del Carmen, Cozumel Island, Tulum, Ascension Bay, and Quintana Roo (market and cooperatives)/July to October 2008.	Fresh and processed fish (*Calamos pennatula*, *Caranx crysos*, *Epinephelus morio*, *Haemulon plumieri*, *Larimus argenteus*, *Lutjanus campechanus*, *Lutjanus synagris*, *Mycteroperca bonaci*, *Scomberomorus maculatus*, *Mugil curema*, *Seriola dumerili*).	The average presence of *S. faecalis* was 2×10^8 CFU mL^{-1} in fresh fish and 8×10^6 CFU mL^{-1} in processed fish samples; for *S. faecium*, it was 1×10^6 CFU mL^{-1} in fresh fish and 7×10^4 CFU mL^{-1} in processed fish.	Maximum permissible limit fecal coliforms: 400 $MPNg^{-1}$ /NOM-027-SSA1-1993.	Contamination by pathogenic bacteria and health risks from consumption. Implement good hygiene practices during handling and processing.	[9]
Old town lagoon, Veracruz (Gulf of Mexico)/June, August, September, and November 2001, as well as in February, March, April, May, and June 2002.	Oysters and fish.	Isolation and detection of *V. parahaemolyticus* in 15% of the samples.	Specification for *Vibrio cholerae* O1 toxigenic absent in 50 g/NOM-027-SSA1-1993. The standard does not have a microbiological specification for *V. parahaemolyticus*/NOM-027-SSA1-1993.	Incidence and distribution in aquatic environments are affected by water temperature, salt and oxygen concentrations, interactions with plankton, and the presence of sediments, among others. Health risks from eating fish and shellfish.	[115]
Mexico City, north zone (street-vended seafood)/May 2004.	Raw oysters, fish ceviche (raw fish marinated in lemon juice), shrimp cocktails.	*E. coli* was present in 25% of samples. The highest value was 1.1×10^7 CFU g^{-1}. *Vibrio cholerae* non-O1/non-O139 was present in 18.7% of samples, *Aeromonas hydrophila* in 10.4% of samples, and *Vibrio parahaemolyticus* in 2% of samples.	Specification for *Vibrio cholerae* O1 toxigenic absent in 50 g and fecal coliforms MPN g^{-1} / NOM-027-SSA1-1993. Maximum permissible limit for *V. parahaemolyticus*: MPN g^{-1} /NOM-242-SSA1-2009. The standard does not have a microbiological specification for *Aeromonas* sp./NOM-027-SSA1-1993 and NOM-242-SSA1-2009.	Contamination by pathogenic bacteria and health risks from consumption. Implement good hygiene practices during handling and storage.	[116]
Market of the Tepic City, Nayarit/between February and March 2022.	*Centropomus robalito* (filet).	100% of samples were contaminated with aerobic mesophiles in the range of 7.25×10^3 and 1.41×10^6 CFU g^{-1}, and total coliforms of 1×10^3 and 1.05×10^6 CFU g^{-1}. *Salmonella* was present in 16.6% of samples.	Maximum permissible limit for aerobic mesophiles: 7 log CFU g^{-1}; absence of *Salmonella* spp., in 25g/NOM-027-SSA1-1993.	Microbiological contamination and health risks from consumption. Implement good hygiene practices for handling and storage.	[117]
Campeche, Champoton, Seybaplaya, Villa Madero, Isla Arena, and Sabancuy state of Campeche (fishing ports)/October to December 2013.	Red octopus.	Presence of *V. cholerae*, *V. parahaemolyticus*, and *V. vulnificus* in 82% of samples and *Salmonella* sp. in 11% of samples. Fecal coliforms in 4.4% of samples.	Specification for *Vibrio cholerae* O1 toxigenic absent in 50 g, absence of *Salmonella* spp., in 25 g, fecal coliforms 400 MPN g^{-1} / NOM-029-SSA1-1993.	Regular microbiological quality contributes to the implementation of strategies to meet sanitary specifications during the handling and processing of fishery products in order to reduce the risk of epidemiological outbreaks in the region.	[118]

Table 3. *Cont.*

Place of Production or Marketing/Year	Product	Microbiological Assessment	Microbiological Specification/Mexican Standard Applicable to Products	Risk/Recommendation	Source
Hotels located in the golden zone on the beachfront in Acapulco City, Guerrero/April to August 2014.	Raw fish. Raw fish filet.	*Vibrio cholerae* non- O1 present in food supplied in 2 of 14 hotels evaluated.	Specification for *Vibrio cholerae* non- O1 absent in 50 g/NOM-242-SSA1-2009.	Health risk. Implement basic requirements for a food quality and safety system for hotel restaurants.	[119]
Distribution centers, street vendors, and small restaurants in Guadalajara City, Jalisco/1997.	*Lutjanus purpureous* and *Scomberomorus sierra*. Fresh fish and ceviche (marinated raw fish).	11% of ceviche from street vendors and 6% from restaurants tested positive for *V. cholerae* O1. Plate aerobic counts were 6.6 log CFU g^{-1}, and coliform counts were 4.8 log CFU g^{-1} of fish.	Maximum permissible limit for aerobic mesophiles: 7 log CFU g^{-1}. Specification for *Vibrio cholerae* O1 toxigenic absent in 50 g and fecal coliforms 400 MPN g^{-1}/NOM-027-SSA1-1993.	Food constitutes a health risk, where temperature abuse and unsanitary conditions during handling and sale contribute to microbial load.	[120]
Supermarkets in Mexico City/the period is not specified.	Fresh raw oyster (*Crassostrea virginica*).	12.9% of samples were positive for hepatitis A virus and 5.5% for Norovirus.	The standard does not present microbiological specifications for viruses/NOM-242-SSA1-2009.	Health risks, especially when consumed raw or undercooked.	[121]
Retail seafood markets in Culiacan, Sinaloa/October 2010 to January 2011, March to April 2011, and May 2011.	Fresh and raw (*C. corteziensis*).	All samples were contaminated with at least one species of *Vibrio* (*V. cholerae*, *V. parahaemolyticus and V. vulnificus*).	Specification for *Vibrio cholerae* and *V. vulnificus* absent in 50 g, *V. parahaemolyticus*: 10^4 MPN g^{-1}/ NOM-242-SSA1-2009.	Health risks from raw or undercooked food consumption. Establish and enforce food monitoring and inspection programs.	[122]
10 different municipalities in the state of Sinaloa/January 2008 to December 2009.	Raw products, seasoned shrimp, clams, squid, mixed seafood, shrimp, rays, oysters, octopus, and fish.	17% of the samples showed fecal coliforms above permissive levels for human consumption; diarrheagenic *E. coli* detected in 10.8% of the samples.	Fecal coliforms 400 MPN g^{-1}/ NOM-242-SSA1-2009.	Low risk of foodborne illness for the general population or tourists.	[123]
Street vendors, supermarkets, and retail markets in Reynosa, Tamaulipas/September to November 2017.	Raw shrimp.	Presence of *Vibrio* spp. 59.1%, *V. cholerae* 17.8%, *V. mimicus* 6.7%, and *V. parahaemolyticus* in 4.6% of samples.	Specification for *Vibrio cholerae* and *V. vulnificus* absent in 50 g, *V. parahaemolyticus*: 10^4 MPN g^{-1}/ NOM-242-SSA1-2009.	Potential risk to consumer health, as Mexican cuisine sometimes serves it raw or semi-cooked. It is necessary to review the microbiological food surveillance programs of government health agencies.	[124]
Local markets in Mexico City/2002.	Frozen tilapia (*Oreochromis niloticus*).	Isolation of *Aeromonas* spp., strains.	The standard does not have a microbiological specification for *Aeromonas* sp./NOM-027-SSA1-1993.	Incidence of *Aeromonas* spp. in frozen fish intended for human consumption, which can be a vehicle for disease.	[125]
Main cities of 14 municipalities in the state of Sonora/April to October 2011.	Crustaceans, mollusks, and raw and ready-to-eat fish.	Detection of *Vibrio mimicus* in 12.2% of total simples.	The standard does not have a microbiological specification for *V. mimicus*/NOM-242-SSA1-2009.	The presence is multifactorial (environmental conditions, handling, cross-contamination, and others) and poses a risk to the health of consumers.	[126]
29 aquaculture farms in the state of Sinaloa/November 2011 to May 2014.	Tilapia.	Total coliforms and fecal coliforms were detected in 64% and 48% of the samples, with average values ranging from 6.9×10^2 to 8.3×10^4, and from 8.5×10^1 to 8.4×10^2 CFU g^{-1}, respectively; aerobic mesophilic bacteria were detected in 90% of the samples, with average values ranging from 3×10^5 to 3.9×10^6 CFU g^{-1}.	Maximum permissible limit for aerobic mesophilic bacteria: 7 log CFU g^{-1}. Fecal coliforms 400 MPN g^{-1}/NOM-027-SSA1-1993.	Various samples were out of compliance with regulations. Attention should be paid to fish handling on farms to ensure product safety.	[127]
Freshwater fish used in subsistence fisheries in the state of Jalisco/February–April and July, September, and October in 2015.	Fresh meat of *Oreochromis* sp., *Lepomis macrochirus*, *Cyprinus carpio*, and *Carassius auratus*.	Isolation of *Pseudomonas* sp., *Shigella sonnei*, *Escherichia coli*, and *Bacillus subtilis* from most fish, as well as *Citrobacter freundii* and *E. coli*.	Fecal coliforms 400 MPN g^{-1}/ NOM-242-SSA1-2009. The standard does not have a microbiological specification for *Pseudomonas* sp., *Shigella sonnei*, *Bacillus subtilis*, and *Citrobacter freundii*	Health risks from products for human populations that depend on rivers for their food.	[128]

Table 3. *Cont.*

Place of Production or Marketing/Year	Product	Microbiological Assessment	Microbiological Specification/Mexican Standard Applicable to Products	Risk/Recommendation	Source
"La Nueva Viga" Market in Mexico City/August 2017 to February 2018.	Fish and seafood, fresh and raw.	High presence of *V. parahaemolyticus* (28%), *V. alginolyticus* (27%), *V. mimicus* (23%), and *V. vulnificus* (21% of samples).	Specification for *Vibrio cholerae* and *V. vulnificus* absent in 50 g, *V. parahaemolyticus*: 10^4 MPN g^{-1}. The standard does not have a microbiological specification for *V. mimicus* and *V. alginolyticus*/NOM-242-SSA1-2009.	Surveillance programs by health regulatory agencies should be improved to reduce the risk of illness from consuming raw or undercooked seafood, given that the market is a national commercial hub and supplies convenience stores, retailers, and restaurants.	[113]
Public markets of San Francisco de Campeche City, Campeche/ six months.	Raw shrimp and octopus.	Presence of *Salmonella* sp. in 45% of octopus samples and 55% of shrimp samples.	Absence of *Salmonella* sp., in 25 g/ NOM-242-SSA1-2009.	Health risks to the population. Implementation and monitoring of good hygiene practices in the processing and handling of products.	[129]
Veracruz Reef System/dry seasons (April to June), rainy seasons (July to September), and windy seasons (October to March).	Fresh octopus, octopus packed in ice (*Octopus insulares*).	High levels of total coliforms around 853 MPN/ 100 g and fecal coliforms of 818 MPN/100 g in marketing stages.	Fecal coliforms 230 MPN/100 g/ NOM-242-SSA1-2009.	Strengthening good hygiene and handling practices and conditions throughout the production chain to improve food safety.	[130]
Popular area of San Luis Mextepec, state of Mexico/June and July 2023.	Fresh filet (*Cyprinus carpio*) and frozen shrimp.	Aerobic mesophilic bacteria were found in 100% of samples ranging from 11,050 to 26,400 CFU g^{-1}, while 100% of samples had total coliforms ranging from 275 to 18,450 CFU/g, and 50% of fish and shrimp samples were positive for *Salmonella* sp.	Maximum permissible limit for aerobic mesophilic bacteria: 7 log CFU g^{-1}/ NOM-027-SSA1-1993. Absence of *Salmonella* spp., in 25 g/NOM-242-SSA1-2009.	Health risks to the population. Consumption of raw or improperly cooked food is not recommended. Improve hygiene practices in product handling and preservation.	[131]
Restaurants and street vendors at Reynosa, Tamaulipas/product analysis period not specified.	Ceviche (raw fish meat, marinated).	Presence of *Aeromonas* sp., *Prevotella* sp., and *Pseudomonas* sp.	The standard does not have a microbiological specification for *Aeromonas* sp. and *Pseudomonas* sp./NOM-242-SSA1-2009.	The microbial diversity of raw fish ceviche for human consumption contains bacteria associated with health risks due to improper handling practices.	[132]
Establishments in the city of Telchac Puerto, Yucatan/July to December 2019.	Raw seafood, marinated without heat, partially cooked with heat, and completely cooked with heat.	*Vibrio vulnificus* was isolated in 28.03% of samples.	Specification for *V. vulnificus* absent in 50 g/NOM-242-SSA1-2009. Cooked meat foods (fish): total aerobic mesophiles 150,000 CFU g^{-1} and total coliforms < 10 CFUg-1/NOM-093-SSA1-1994.	Raw shellfish, seafood marinated without heat, and seafood partially cooked with heat are all potential sources of illness from *Vibrio vulnificus*.	[133]
Establishments in the port of Chabihau, Yucatan/June 2019 to May, 2020.	Raw seafood, marinated without heat, partially cooked with heat, and completely cooked with heat.	Presence of *Vibrio alginolyticus* in 7.72% of raw seafood samples, 0.0% in ones marinated without heat, 7.79% in ones partially cooked with heat, and 0.0% in ones fully cooked with heat.	The standard does not have a microbiological specification for *V. alginolyticus*/NOM-242-SSA1-2009. Cooked meat foods (fish): total aerobic mesophiles 150,000 CFU g^{-1} and total coliforms < 10 CFU g^{-1}/NOM-093-SSA1-1994.	Raw and partially cooked seafood poses a health risk.	[134]
Pueblo Viejo lagoon, Veracruz/June 2001 to May 2002.	Raw fish.	*Listeria monocytogenes* in 4.5% of fish samples.	Microbiological specification for *Listeria monocytogenes* absent in 25 g/NOM-242-SSA1-2009.	It represents a risk to the health of the population.	[135]
Municipal market of Tlalnepantla, State of Mexico/no analysis period specified.	Raw fish (*Mugil cephalus*).	Isolation of 57 bacterial strains, of which 59.6% corresponded to *Escherichia coli*, 14.05% *to Klebsiella* spp., 14.05% to *Proteus* spp., 8.77% to *Pseudomonas aeruginosa*, and 1.76% to *Enterobacter cloacae* and *Alcaligenes faecalis*.	Maximum value for fecal coliforms and/or *E. coli* 400 MPN g^{-1}/NOM-242-SSA1-2009. The standard does not present a microbiological specification for *Klebsiella* spp., *Proteus* spp., *Pseudomonas aeruginosa*, *Enterobacteria cloacae* and *Alcaligenes faecalis*.	Health risk from consumption of raw product or after inadequate cooking times and temperatures.	[136]

Table 3. *Cont.*

Place of Production or Marketing/Year	Product	Microbiological Assessment	Microbiological Specification/Mexican Standard Applicable to Products	Risk/Recommendation	Source
Food sold in establishments in the state of Veracruz (11 health jurisdictions)/2016.	Precooked seafood, fish, crustaceans, cephalopods, and fresh bivalve mollusks.	Presence of *E. coli*, fecal coliforms, *S. aureus*, *Salmonella* spp., and *Vibrio cholerae* non-O1.	58% of precooked seafood samples, 34.48% of fish, 29.63% of crustaceans, 33.33% of cephalopods, and 70.83% of mollusks were out of specification to the health standard/NOM-093-SSA1-1994.	Health risk to the population due to consumption of products.	[137]
Street food in the state of Tabasco/2003.	Cooked fish, raw fish of various varieties (carp, tilapia, and sea bass), and shrimp cocktail.	14% of samples showed contamination by *Vibrio cholerae*. The shrimp cocktail presented counts above 150,000 CFU of aerobic mesophiles.	Maximum value for total aerobic Mesophiles: 150,000 CFU g^{-1}/ NOM-093-SSA1-1994.	Risk to the health of the population. Improve hygiene measures in food processing to reduce contamination.	[138]
Local markets and supermarkets in Puebla City, Puebla/ unspecified period of time.	Vacuum-sealed tilapia filets.	Thirteen bacteria were isolated and identified in samples: 15.38% were non-pathogenic bacteria, 46.2% were pathogenic, and 38.5% were opportunistic pathogens.	Maximum value for fecal coliforms: 400 MPN g^{-1}; and *S. aureus* 1000 CFU g^{-1}/ NOM-242-SSA1-2009.	Despite the presence of bacteria, the microbial load is within the specifications established in NOM-242-SSA-2009. Good handling practices and hygiene conditions are implemented. Health risk for non-immunocompetent people.	[139]
Nine aquaculture farms in the northwest region of the State of Chihuahua/winter 1999 and summer 2000.	Fresh fish (*Oncorhynchus mykiss*).	Presence of total coliforms with means of 2.88 and 3.98 MPN mL^{-1} and aerobic mesophiles with means of 398.11 and 19,498.45 CFU g^{-1}.	Maximum value for total aerobic mesophiles log 7 CFU g^{-1} and maximum value for fecal coliforms: 400 MPN g^{-1}/ NOM-027-SSA1-1993.	The trout produced in this area have good microbiological quality.	[140]

MPN: Most Probable Number. CFUs: Colony-Forming Units.

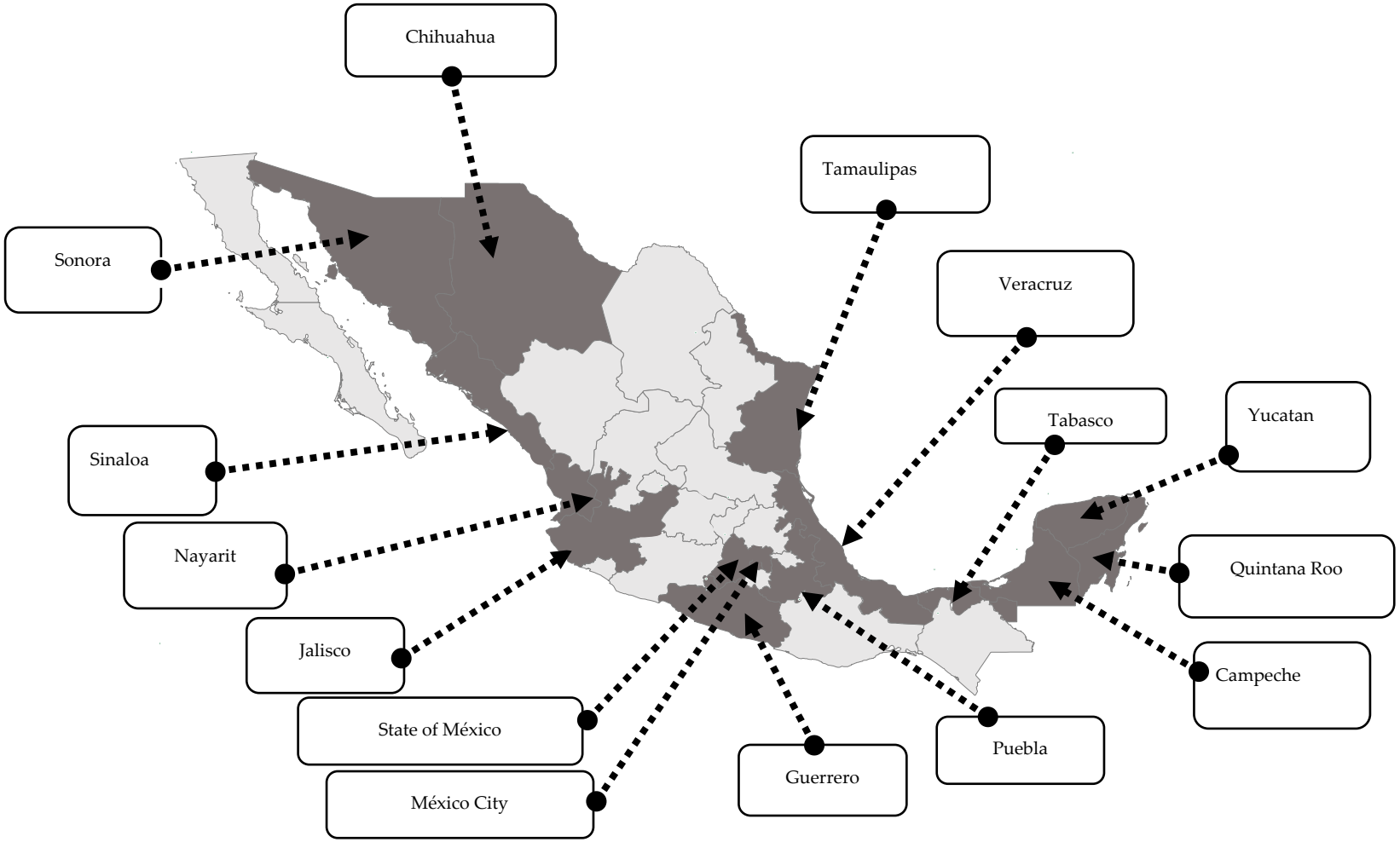


Figure 1. Geographic location of states of the Mexican Republic where microbiological evaluations of fish and fish products have been carried out according to Table 3.

In Table 3, it can be seen that the Mexican states where studies have been conducted on food that is offered to the population are generally those close to coastlines. In northwestern Mexico, facing the Pacific Ocean, are the states of Sinaloa, Sonora, Nayarit, Jalisco, and Guerrero. In the Gulf of Mexico area are the states of Veracruz, Campeche, Tamaulipas, Yucatan, and Tabasco. In the Caribbean Sea area is the state of Quintana Roo. In northern Mexico is the state of Chihuahua, and finally, there are central states such as the State of Mexico, Puebla, and Mexico City. There is a trend toward microbiological evaluation of fish and mollusks, focusing on bacteria of the genera *Vibrio* sp., *Salmonella* sp., and *Listeria monocytogenes*, as well as typical microbiological indicators such as coliforms and aerobic mesophiles. Likewise, the high risk of illness from consuming these foods raw or if inadequately cooked is highlighted, also emphasizing the need to implement or reinforce good hygiene practices in the handling and preparation of such foods. Furthermore, some studies point to the importance of food safety in terms of the presence of hazards such as viruses, *Pseudomonas* sp., or *Aeromonas* sp., which—although Mexican legislation on the safety of these products does not specifically address them—necessitates updating said legislation to strengthen health surveillance of these products.

7. Prevention of Foodborne Illnesses

Foodborne illnesses can occur anywhere, although they are most prevalent in areas with poor hygiene and sanitation practices and in overcrowded conditions [16]. Foods with high nutritional value, such as those of an animal origin (fish and shellfish), are also at the highest risk for foodborne illness. The increasing incidence of food- and waterborne illnesses calls for actions to ensure the quality and safety of food that is available and marketed to the population [141].

Throughout the production and final sale chain, fresh or processed fish for consumption can become contaminated with a variety of physical, chemical, or biological hazards that compromise its safety. Figure 2 shows the stages of production and potential contaminating hazards of fish filets, one of the most widely marketed fish products for human consumption. Freshly caught and farmed fish and shellfish may harbor pathogenic bacteria, but when these products are properly cooked, the health risks to consumers are low [42]. However, hygiene conditions and practices for the preservation and handling of these products should be considered after cooking.

While the process of cooking fish reduces or eliminates biological risks, factors such as the cooking method (smoking, grilling, roasting, frying, etc.), cooking time, and temperature should be considered important, as inadequate control has been linked to the formation of hazardous chemicals (heterocyclic amines, polycyclic aromatic hydrocarbons, and advanced glycation end products) associated with various diseases, including cancer [142–144]. Therefore, the population should be encouraged to control the cooking method, time, and temperature, as well as to adopt better diets, alternative cooking methods, and culinary preparations, to reduce the chemical health risks associated with the processing and consumption of fish [143,144].

Thus, the safety of fish and fish products depends on the application of a series of production conditions and practices and systematic control of critical points throughout the food chain (primary production, preservation, handling, processing, and marketing) [80,145].

Health agencies and the food industry traditionally rely on three basic strategies for monitoring microbial contamination in food. These strategies involve staff education, facility and operations inspections, and implementation of microbiological analyses. The aim is to improve our understanding of the causes and effects of microbial contamination and assess facilities, operations, and compliance with hygienic handling and product requirements and practices [46]. However, these strategies have limitations and deficiencies,

which is why it is necessary to use other tools to guarantee the safety of fish and fish products, such as the implementation of the Hazard Analysis and Critical Control Points (HACCP) system, which is one of the main requirements for the production and marketing of products to high-value markets [10,15,46,61,144]. To ensure the functioning of the HACCP system, it is also necessary to initially implement a series of requirements such as good aquaculture and fishing practices, Good Manufacturing Practices (GMPs), and Standard Sanitation Operating Procedures (SSOPs) [10,15,61,145,146].

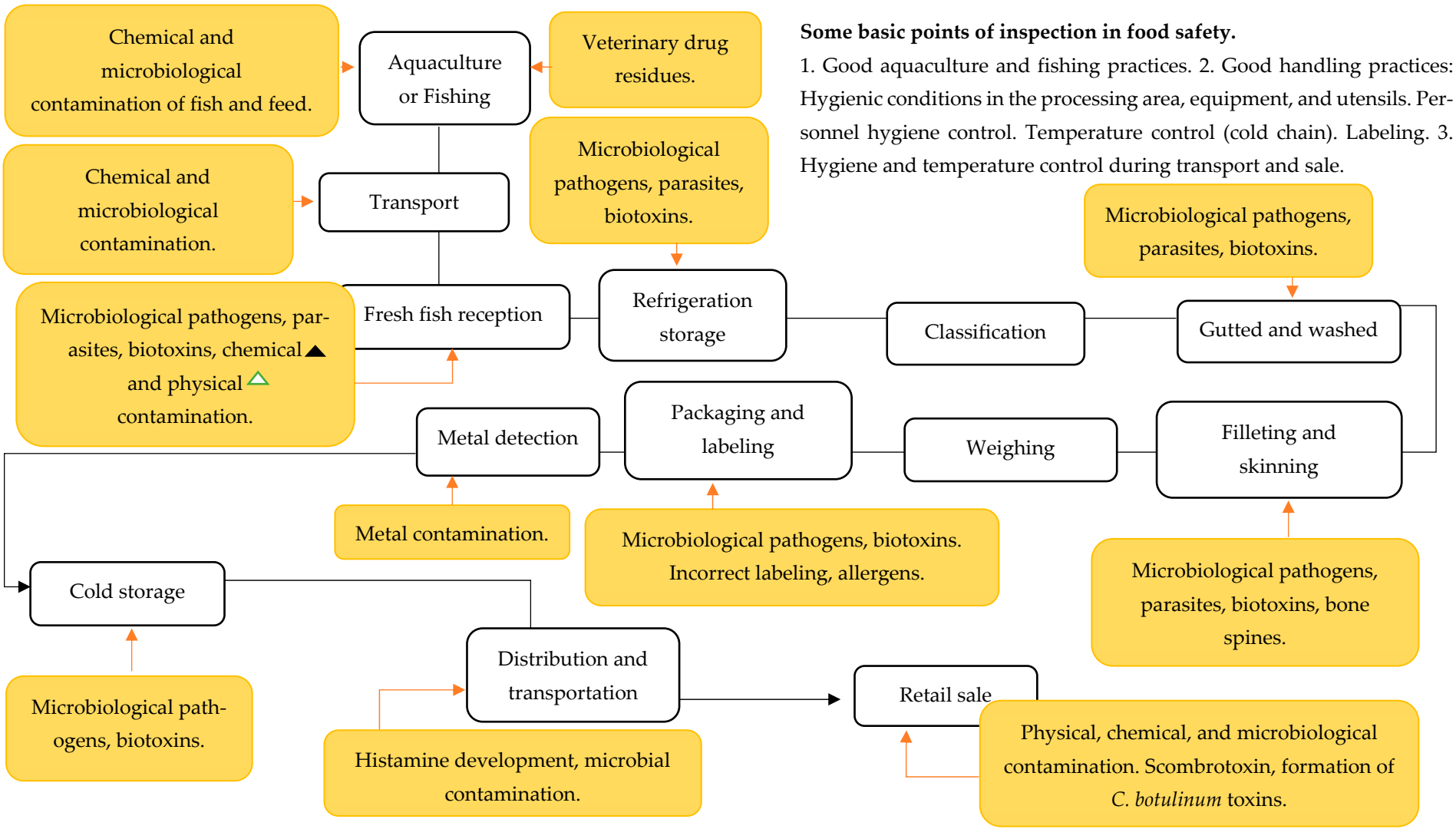


Figure 2. Flowchart of the production, preparation, and retail sale of fresh, chilled fish filets and the various contamination hazards in the production chain [147]. ▲ Includes veterinary drug residues, fuels, oil, and cleaning and disinfecting agents. △ Metal or glass fragments, sand, shells, and spines.

One of the main prevention mechanisms is to provide health education for the population. It has been indicated that to minimize the risk of disease by contaminating microorganisms, the recommendation is to avoid the consumption of fish or fish products in a raw state or if subjected to inadequate hygiene, conservation, and cooking conditions [8,49,61,64]. Additionally, immediate application at refrigeration temperatures (<4.4 °C) or freezing (≤−18 °C) after capture and post-mortem is necessary to preserve its quality and reduce spoilage and health risks [47,49]. For biotoxins and chemical contaminants, such as heavy metals, the control methods are to monitor and ban fishing activities in areas where they are located, and to reduce the presence of antibiotics, good practices must be applied in aquaculture production [47]. Likewise, the World Health Organization (WHO) and the United States Food and Drug Administration (FDA) have established and disseminated information to the population regarding key ways to maintain health through food safety, which involve maintaining cleanliness (hand washing), separating raw and cooked foods, cooking thoroughly, maintaining food at safe temperatures, and using safe water and raw materials [148,149].

8. Food Legislation: Mexico

Operations focused on the safety of the entire food chain in Mexico are the responsibility of different government entities, such as the Ministry of Health (SSA—acronym in Spanish) and the Ministry of Agriculture and Rural Development (SADER—acronym in Spanish). The Ministry of Health focuses primarily on processed foods, food services, and municipal slaughterhouses, with actions carried out through the Federal Commission for the Protection Against Sanitary Risks (COFEPRIS—acronym in Spanish), while SADER is primarily concerned with food safety in primary production, carrying out actions through the National Service for Agrifood Health, Safety, and Quality (SENASICA—acronym in Spanish) [150]. The Federal Consumer Protection Agency (PROFECO—acronym in Spanish) is an entity coordinated by the Ministry of Economy whose function is to protect and defend consumer rights, foster a culture of responsible consumption, and provide timely and objective information for consumer decision-making, like information from high-quality studies on products for human use and consumption [151].

The regulatory framework for food safety in Mexico comprises Article 4 of the Constitution (right to health protection), the General Health Law, and the Federal Law on Animal and Plant Health, which establish general requirements, including food safety inspections and controls. The aim is for the regulation and health control of products and services to regulate, control, and promote health in the processing, import, and export of food, as well as in food-related activities, services, and establishments. In addition, there are two types of standards: 1. the mandatory “NOM” and 2. the voluntary “NMX” [150]. Standards are considered the basis of the regulatory framework, a legal and technical tool that specifies how to comply with the laws and regulations associated with each element of the food value chain (production, processing, storage, distribution, sale, and labeling).

Aquatic food production activities such as fishing and aquaculture are considered to generate and meet the demand for foods with high nutritional value and good affordability in the face of a constantly growing population; therefore, the requirements for these products in terms of quality and safety have been increasing [152]. Fish in Mexico is subjected to control, surveillance, and regulation regarding the safety of fresh or processed products marketed in various presentations (frozen, cured, fresh, canned, semi-preserved, and others), using a variety of standards (NOM and NMX) within the regulatory framework (Table 4).

Likewise, the SSA, through the COFEPRIS, presides over, coordinates, and monitors compliance with the Mexican bivalve mollusk health program to guarantee the sanitary

quality of these products. It has established a technical guide with the requirements for harvesting areas, harvesters, processors, and marketing departments, established in official Mexican standards to safeguard public health (NOM) [153].

Table 4. Various Mexican standards developed for and applied to the regulation, control, health surveillance, and quality of fishery or aquaculture products intended for human consumption in Mexico.

Standard NOM/NMX	Product	Aspects Involved	Source
NOM-027-SSA1-1993	Fishery products. Fresh, chilled, and frozen fish. Sanitary specifications.	Definitions. Classification. Sanitary specifications: physical, chemical, and microbiological.	[154]
NOM-242-SSA1-2009	Fresh, chilled, frozen, and processed fish products. Sanitary specifications.	Testing methods and sanitary specifications for microbiological and physicochemical contaminants. Hygiene handling criteria. Permissible temperatures for refrigeration and freezing.	[155]
NOM-093-SSA1-1994	Hygiene and sanitation practices in the preparation of food offered in permanent establishments.	Sanitary provisions for personnel, utensils, and facilities that must be met in the preparation of food offered in permanent establishments. Microbiological specifications for products.	[156]
NOM-251-SSA1-2009	Hygiene practices for processing food, beverages, or food supplements.	Good hygiene practices. Cleaning and disinfection. Storage. Control of operations and raw materials. Food handling personnel. Implementation of the Hazard Analysis and Critical Control Points system (HACCP).	[157]
NOM-128-SSA1-1994	Establishes the application of a risk analysis and critical point control system in the industrial plant processing of fishery products.	Good hygiene practices. Application of the risk analysis and critical point control system.	[158]
NOM-127-SSA1-2021	Water for human use and consumption. Permissible limits for water quality.	Physicochemical and microbiological health specifications. Test methods.	[159]
NOM-201-SSA1-2015	Water and ice for human consumption, packaged and in bulk.	Sanitary control of water and ice for human consumption. Physicochemical and microbiological specifications. Conformity assessment procedure.	[160]
NOM-051-SCFI/SSA1-2010	General labeling specifications for prepackaged foods and non-alcoholic beverages. Commercial and health information.	General labeling specifications for prepackaged foods and non-alcoholic beverages. Commercial and health information.	[161]
NOM-235-SE-2020	Pre-packaged tuna and bonito.	Specifications—Commercial information and test methods.	[162]
NMX-F-605-NORMEX-2018	Foods—hygienic handling in the service of prepared food to obtain the “H” distinctive.	Applies to permanent establishments dedicated to handling food and beverages in all phases: reception, storage, preparation, and service. Establishes the provisions for good hygiene and sanitation practices that food and beverage service providers must comply with to obtain the “H” accreditation.	[163]
NMX-FF-032-SCFI-2001	Fish products—refrigerated fresh fish filets—specifications.	Applies to fresh, chilled fish filets that are produced and marketed. Testing methods. Filet quality grade. Physicochemical, microbiological, and sensory specifications.	[164]

Table 4. *Cont.*

Standard NOM/NMX	Product	Aspects Involved	Source
NMX-FF-003-SCFI-1994	Fishery products—fresh-frozen squid.	Classification and designation. Specifications. Sampling. Test methods.	[165]
NMX-F-536-SCFI-2004	Fish products—frozen fish filet—specifications.	Applies to frozen fish filets that are produced and marketed. Classification. Testing methods. Physicochemical, sensory, and microbiological specifications.	[166]
NMX-FF-002-SCFI-2011	Fish products—refrigerated freshwater fish—specifications.	Establishes the commercial quality aspects of fresh-refrigerated fish for consumption. Product classification. Physicochemical, sensory, and microbiological specifications. Testing methods.	[167]
NMX-F-179-SCFI-2001	Fish products—canned sardines and similar fishes.	For specialized or prepared products marketed with a sardine content exceeding 50% of the net contents of the package. Sensory, physicochemical, and microbiological specifications. Test methods.	[168]
NMX-F-220-SCFI-2011	Fish products—food products for human use—fishery—canned tuna fish and similar fishes in oil.	Classification and designation. Sensory, physicochemical, and microbiological specifications. Test methods.	[169]
NMX-F-363-SCFI-2001	Fishery products—canned shrimp in brine—specifications.	Minimum quality characteristics applicable to the product to ensure that it is suitable for consumption.	[170]
NMX-F-535-1993-SCFI	Fishing products—fresh-frozen octopus.	Specifications. Quality assessment.	[171]
NMX-F-546-SCFI-2011	Fishery products—fish meat content in frozen breaded products.	Sensory characteristics, sampling, test methods.	[172]
NMX-F-553-1999-SCFI	Fish products—canned fish in tomato sauce—specifications.	Definitions. Quality level. Packaging, packaging, labeling, storage, and transportation.	[173]
NMX-F-472-SCFI-2001	Fish products—frozen lobster—specifications.	Minimum quality characteristics for the product to ensure that it is suitable for consumption.	[174]
NMX-F-485-SCFI-2011	Fish products—canned octopus in its ink—specifications.	Classification and designation. Specifications. Sampling. Test methods. Packaging, packing, and labeling.	[175]
NMX-F-506-SCFI-2004	Fishery products—dried and salted fish—specifications.	Classification and designation. Specifications. Sampling. Test methods. Packaging, packing, and labeling.	[176]
NMX-F-524-SCFI-2011	Fish products—tuna fish packed in retort—commercial information and specifications.	Classification and designation. Process. Specifications. Sampling. Test methods.	[177]
NMX-F-540-SCFI-2011	Fishery products—freshness determination—test method.	Sampling and sensory evaluation of fish and mollusks.	[178]

Additionally, Mexico has a significant number of trade agreements with other countries or regions around the world. It is an emerging economy and a huge market for food consumption, both for its population and tourists (mainly from Colombia, the United Kingdom, Argentina, Canada, and the United States), as well as for people in other parts of the world, as it is also a food exporter [150,179].

Fishery products are subject to United States of America (US) and European Union (EU) food safety policies and systems, as these represent destination markets for Mex-

ico [150,180]. For the European Community, the regulatory framework consists of Regulation 178/2002, which establishes the general principles of food safety and the obligation of traceability for all foodstuffs [181]. Regulation 852/2004 on foodstuff hygiene sets general hygiene requirements for food business operators, indicating that they are primarily responsible for food safety, as well as guaranteeing food safety throughout the food chain and the general application of procedures based on the principles of Hazard Analysis and Critical Control Points (HACCP) [182]. Regulation 853/2004 shows specific hygiene rules for food of an animal origin and specifies the sanitary, transport, storage, and packaging standards for fishery products [183]. Regulation 2017/625 focuses on official controls and other official activities that are performed to ensure the application of food and feed laws, rules on animal health and welfare, and plant health and plant protection products [184]. Regulation 1881/2006 defines maximum levels for certain contaminants in foodstuffs [185], and Regulation 2073/2005 sets microbiological criteria for foodstuffs [186]. Finally, Regulation 2074/2005 establishes visual inspection guidelines for parasites, limits for total volatile basic nitrogen, and analysis methods for fishery products [187].

In the United States of America, there are different regulatory agencies, such as the Food and Drug Administration (FDA), which is the regulatory agency that ensures that the supply of fishery products is safe, hygienic, healthy, and with correct labeling and provides guidance on hazards and controls in fish and fishery products, including the implementation of HACCP systems [188]. The National Oceanic and Atmospheric Administration (NOAA) of Fisheries establishes policies and regulations for fishing and aquaculture activities [189].

The Department of Agriculture (USDA) is responsible for programs and services related to rural development, livestock, agriculture, and food safety through the Food Safety and Inspection Service (FSIS) [190]. The regulatory framework is made up of the code of federal regulations that presents the general and permanent laws of the country, which contain 50 titles, including Title 21 Chapter 1, Subchapter B, Part 123, referring to foods such as fish and mollusks; Section 123.5, referring to good manufacturing practices; Section 123.6, which refers to the HACCP system; and Section 123.11, which refers to sanitary control procedures; all of these are regulated by the FDA. Meanwhile, Title 9 Chapter II, Subchapter F, involves the mandatory inspection of fish of the *Siluriformes* order and derived products, which is regulated by the FSIS and USDA [191].

9. Conclusions

Fish and fish products are staple foods in the human diet due to their nutritional properties, availability, and low costs. However, these foods are highly susceptible to spoilage and microbiological contamination, compromising their shelf lives and safety and leading to foodborne illness.

Microbial contamination of fish and fish products can occur throughout the food chain, primarily due to inadequate or poor hygiene conditions and practices. Therefore, all participants in the food chain, from producers, processors, and marketers to the final consumer, are jointly responsible for the safety of fish and fish products.

Foodborne illnesses, such as fish-borne illnesses that can be attributed to pathogenic microorganisms, are frequently linked to the consumption of raw or improperly cooked products, coupled with unhygienic conditions and practices prior to consumption.

In Mexico, gastrointestinal illnesses occupy an important place on the public health agenda, where various causative agents have been associated with fish products. Fishing, aquaculture, and processing activities in Mexico generate a variety of products for human consumption. Nevertheless, these products can be vehicles of various biological hazards, such as bacteria and toxins, that may compromise the population's health, leading to

illnesses. Although these foods are subject to national and international health regulations (in cases of export), the wide diversity of products and locations for domestic acquisition and consumption makes surveillance coverage by health authorities to ensure compliance with the regulatory framework challenging.

A limitation in the development of this study was the availability of or access to reports of cases or outbreaks of diseases due to the consumption of fish and fish products, as well as the microbiological assessment of products in Mexico, possibly due to factors such as passive surveillance, underreporting, or a lack of uniformity in the analytical methods used. This led to a wide-ranging search for available information on fish-borne diseases caused by microorganisms, as well as information on the microbiological evaluation of products intended for human consumption.

Surveillance and assessment of the microbiological safety of fish and fish products, as well as strengthening the regulatory framework, are essential to guarantee the quality of products that are offered to the population and understand the potential challenges and strategies for protecting public health. Several actions remain to be carried out, involving the main sectors of society (government, industry, the academy, and civil society), and must be prioritized to ensure the safety of fish and fishery products in Mexico. These actions are as follows: 1. strengthen active surveillance (to prevent disease cases or outbreaks); 2. increase health promotion (consistent educational and technical efforts, support, and risk communication, particularly during periods of high consumption such as Lent) to promote good hygiene and safety practices throughout the production chain; 3. periodically review and update the regulatory framework (*Aeromonas* sp., *Pseudomonas* sp., and others); and 4. strengthen systematic surveillance of various specific hazards, such as *Vibrio* sp., in coastal, urban, and rural markets, both established and mobile. Reducing cases or outbreaks of illnesses caused by consumption of fish and fish products involves ongoing and coordinated action among various food safety regulatory agencies, disease surveillance, and hygiene education for those who are involved in production, harvesting, processing, and marketing, as well as the end consumer.

Author Contributions: A.D.J.C.-S.: conceptualization, information search and analysis, manuscript development, organization, and direction of the general activities of the working group. M.D.-R., E.B.L.-E., H.A.-V., M.D.l.P.S.-C., I.J.A.-M. and M.D.J.P.-F.: information search and analysis and manuscript development. All authors have read and agreed to the published version of the manuscript.

Funding: The development of this manuscript was supported by the Secretariat of Science, Humanities, Technology and Innovation of Mexico (SECIHTI) and researchers by Mexico program-SECIHTI.

Institutional Review Board Statement: Not applicable.

Informed Consent Statement: Not applicable.

Data Availability Statement: Not applicable.

Acknowledgments: Alejandro De Jesús Cortés Sánchez and Mayra Díaz Ramirez acknowledge the financial support given by the Secretariat of Science, Humanities, Technology and Innovation of Mexico (SECIHTI) to the "researcher" position and UAML for the facilities provided for the preparation of this document.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Kopper, G.; Calderón, G.; Schneider, S.; Domínguez, W.; Gutiérrez, G.; Rosell, C.; Mejía, D. Enfermedades Transmitidas por Alimentos y su Impacto Socioeconómico. In *Informe de la Organización de las Naciones Unidas para la Agricultura y la Alimentación*; FAO: Roma, Italy, 2009; pp. 1–194.
2. Cantero Barroso, D.; Brown Vega, W.; González Álvarez, M.; Fernández Triana, I.; Valdez González, A.C. Inocuidad alimentaria versus residuos de medicamentos de uso veterinario: Un acercamiento a la panorámica actual. *Rev. Cuba. De Aliment. Nutr.* **2021**, *31*, 236–257. Available online: https://revalnutricion.sld.cu/index.php/rcan/article/view/1104 (accessed on 4 July 2025).
3. Arispe, I.; Tapia, M.S. Inocuidad y calidad: Requisitos indispensables para la protección de la salud de los consumidores. *Agroalimentaria* **2007**, *12*, 105–118. Available online: http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S1316-03542007000100008&lng=es&tlng=es (accessed on 5 June 2025).
4. De la Fuente Salcido, N.M.; Corona, J.E.B. Inocuidad y bioconservación de alimentos. *Acta Univ.* **2010**, *20*, 43–52. Available online: https://www.redalyc.org/pdf/416/41613084005.pdf (accessed on 3 May 2025). [CrossRef]
5. Fernández, S.; Marcía, J.; Bu, J.; Baca, Y.; Chavez, V.; Montoya, H.; Ore, F. Enfermedades transmitidas por Alimentos (Etas); Una Alerta para el consumidor. *Cienc. Lat. Rev. Científica Multidiscip.* **2021**, *5*, 2284–2298. [CrossRef]
6. Gautam, R.K.; Kakatkar, A.S.; Debbarma, A.; Mishra, P.K.; Kumar, V.; Shashidhar, R.; Chatterjee, S. Shelf-life extension of ready-to-cook Tilapia (*Oreochromis* spp.) fish balls using hurdle technology. *Food Biosci.* **2025**, *63*, 105739. [CrossRef]
7. FAO. *El Estado Mundial de la Pesca y la Acuicultura 2024. La Transformación Azul en Acción*; FAO: Roma, Italy, 2024. [CrossRef]
8. Huss, H.H. *Aseguramiento de la Calidad de los Productos Pesqueros. Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO)*; FAO: Roma, Italy, 1997. Available online: https://www.fao.org/4/t1768s/T1768S00.htm (accessed on 4 June 2025).
9. Romero-Jarero, J.M.; Negrete-Redondo, M.d.P. Presencia de bacterias Gram positivas en músculo de pescado con importancia comercial en la zona del Caribe mexicano. *Rev. Mex. De Biodivers.* **2011**, *82*, 599–606. Available online: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S1870-34532011000200019&lng=es&tlng=es (accessed on 10 May 2025). [CrossRef]
10. Fuertes Vicente, H.G.; Paredes López, F.; Saavedra Gálvez, D.I. Buenas prácticas de manufactura y preservación a bordo: Pescado inocuo. *Big Bang Faustiniano* **2018**, *3*, 41–45. Available online: https://datos.unjfsc.edu.pe/index.php/BIGBANG/article/view/234/233 (accessed on 10 May 2025).
11. Rondón, E.J.; Ramos, D.D.; Vilca, L.M.; Salazar, S.E.; Mendoza, Q.Y.; González, V.R. Sanitary characterization and identification of microbial contamination points in the fishing marketing chain in the port of Pucallpa, Ucayali, Peru. *Rev. De Investig. Vet. Del Perú* **2020**, *31*, e17539. [CrossRef]
12. González Flores, T.; Rojas Herrera, R.A. Enfermedades transmitidas por alimentos y PCR: Prevención y diagnóstico. *Salud Pública México* **2005**, *47*, 388–390. Available online: https://www.scielosp.org/pdf/spm/2005.v47n5/388-390/es (accessed on 13 June 2025). [CrossRef]
13. Marin Mendez, M.; Rodríguez, J.; Arístides, R.; Minier Pouyou, L.; Zayas Tamayo, E.; Soler Santana, R. Caracterización de agentes bacterianos aislados en brotes de enfermedades transmitidas por alimentos. *MEDISAN* **2020**, *24*, 235–251. Available online: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1029-30192020000200235&lng=es&tlng=pt (accessed on 14 June 2025).
14. Rodríguez Torrens, H.; Barreto Argilagos, G.; Sedrés Cabrera, M.; Bertot Valdés, J.; Martínez Sáez, S.; Guevara Viera, G. Las enfermedades transmitidas por alimentos, un problema sanitario que hereda e incrementa el nuevo milenio. *REDVET. Rev. Electrónica De Vet.* **2015**, *16*, 1–27. Available online: https://www.redalyc.org/pdf/636/63641401002.pdf (accessed on 13 May 2025).
15. Palomino-Camargo, C.; González-Muñoz, Y.; Pérez-Sira, E.; Aguilar, V.H. Metodología Delphi en la gestión de la inocuidad alimentaria y prevención de enfermedades transmitidas por alimentos. *Rev. Peru. De Med. Exp. Y Salud Pública* **2018**, *35*, 483–490. [CrossRef]
16. Zúñiga Carrasco, I.R.; Caro Lozano, J. Enfermedades transmitidas por los alimentos: Una mirada puntual para el personal de salud. *Enfermedades Infecc. Y Microbiol.* **2017**, *37*, 95–104. Available online: https://www.amimc.org.mx/wp-content/uploads/2017/11/EIM3-2017w.pdf#page=25 (accessed on 5 April 2025).
17. Soto Varela, Z.; Pérez Lavalle, L.; Estrada Alvarado, D. Bacterias causantes de enfermedades transmitidas por alimentos: Una mirada en Colombia. *Rev. Salud Uninorte* **2016**, *32*, 105–122. [CrossRef]
18. Dewey-Mattia, D. Surveillance for foodborne disease outbreaks—United States, 2009–2015. *MMWR. Surveill. Summ.* **2018**, *67*, 1–11. [CrossRef] [PubMed]
19. Chong, A.; Peñuelas, M.; Guerrero, M.; Cabezas, C.; Díaz, O.; Martín, C.; Varela, C. Brotes de transmisión alimentaria. Red Nacional de Vigilancia Epidemiológica. 2012–2020. *Boletín Epidemiológico Sem.* **2021**, *29*, 53–63. Available online: https://revista.isciii.es/index.php/bes/article/view/1157 (accessed on 12 April 2025).
20. Friesema, I.H.; Slegers-Fitz-James, I.A.; Wit, B.; Franz, E. Surveillance and characteristics of food-borne outbreaks in the Netherlands, 2006 to 2019. *Eurosurveillance* **2022**, *27*, 2100071. [CrossRef]
21. European Food Safety Authority (EFSA); European Centre for Disease Prevention and Control (ECDC). The European Union One Health 2023 Zoonoses report. *EFSA J.* **2024**, *22*, e9106.

22. Hernández Cortez, C.; Aguilera Arreola, M.G.; Castro Escarpulli, G. Situación de las enfermedades gastrointestinales en México. *Enfermedades Infecc. Microbiol.* **2011**, *31*, 137. Available online: https://www.medigraphic.com/pdfs/micro/ei-2011/ei114f.pdf?fbclid=IwAR2fYzcA3 (accessed on 20 May 2025).
23. Olaiz-Fernández, G.A.; Gómez-Peña, E.G.; Juárez-Flores, A.; Vicuña-de Anda, F.J.; Morales-Ríos, J.E.; Carrasco, O.F. Panorama histórico de la enfermedad diarreica aguda en México y el futuro de su prevención. *Salud Pública México* **2020**, *62*, 25–35. [CrossRef]
24. Menchaca-Armenta, I.; Gutiérrez-Jaimes, L.W. Diarrea aguda en México. Revisión epidemiológica actual. *Gac Hidalguense de Inv en Salud.* **2022**, *10*, 8–11. Available online: https://s-salud.hidalgo.gob.mx/Informacion/Gaceta/Gaceta (accessed on 28 April 2025).
25. Boletín Epidemiológico Sistema Nacional de Vigilancia Epidemiológica Sistema Único de Información 2024. Dirección General de Epidemiología. Número 52/Volumen 41/Semana 52/Del 22 al 28 de diciembre del 2024. Available online: https://www.gob.mx/salud/documentos/boletinepidemiologico-sistema-nacional-de-vigilancia-epidemiologica-sistema-unico-de-informacion-355523 (accessed on 13 July 2025).
26. INEGI. *Principales Causas de Mortalidad por Residencia Habitual, Grupos de Edad y Sexo del Fallecido*; Instituto Nacional de Geografía y Estadística (INEGI). Gobierno de México: Mexico City, Mexico, 2025. Available online: https://www.inegi.org.mx/default.html (accessed on 10 July 2025).
27. Sheng, L.; Wang, L. The microbial safety of fish and fish products: Recent advances in understanding its significance, contamination sources, and control strategies. *Compr. Rev. Food Sci. Food Saf.* **2021**, *20*, 738–786. [CrossRef]
28. de Paiva Soares, K.M.; Gonçalves, A.A. Qualidade e segurança do pescado. *Rev. Do Inst. Adolfo Lutz* **2012**, *71*, 1–10. Available online: https://docs.bvsalud.org/biblioref/ses-sp/2012/ses-25855/ses-25855-3684.pdf (accessed on 6 July 2025). [CrossRef]
29. Izquierdo Córser, P.; Torres Ferrari, G.; Barboza de Martínez, Y.; Márquez Salas, E.; Allara Cagnasso, M. Análisis proximal, perfil de ácidos grasos, aminoácidos esenciales y contenido de minerales en doce especies de pescado de importancia comercial en Venezuela. *Arch. Latinoam. Nutr.* **2000**, *50*, 187–194. Available online: http://ve.scielo.org/scielo.php?script=sci_arttext&pid=S0004-06222000000200013&lng=es. (accessed on 12 August 2025).
30. Demelash Abera, B.; Alefe Adimas, M. Health benefits and health risks of contaminated fish consumption: Current research outputs, research approaches, and perspectives. *Heliyon* **2024**, *10*, e33905. [CrossRef] [PubMed]
31. Taylor, B.; Ofori, K.F.; Parsaeimehr, A.; Akdemir Evrendilek, G.; Attarwala, T.; Ozbay, G. Exploring the Complexities of Seafood: From Benefits to Contaminants. *Foods* **2025**, *14*, 1461. [CrossRef]
32. CONAPESCA. *Anuario Estadístico de Acuacultura y Pesca 2023 de la Comisión Nacional de Acuacultura y Pesca. Comisión Nacional de Acuacultura y Pesca (CONAPESCA)*; Gobierno de México: Mexico City, Mexico, 2023. Available online: https://www.gob.mx/conapesca/documentos/anuario-estadistico-de-acuacultura-y-pesca (accessed on 3 July 2025).
33. CONAPESCA. *Semana Santa, la Mejor Época del Año para el Consumo de Pescados y Mariscos. Comisión Nacional de Acuacultura y Pesca (CONAPESCA)*; Gobierno de México: Mexico City, Mexico, 2018. Available online: https://www.gob.mx/conapesca/articulos/semana-santa-la-mejor-epoca-del-ano-para-el-consumo-de-pescados-y-mariscos-152435#:~:text=La%20Semana%20Santa%20es%20considerada,el%20pa%C3%ADs%20aproximadamente%20325%20mil (accessed on 3 July 2025).
34. Huss, H.H. *El Pescado Fresco: Su Calidad y Cambios de su Calidad*; FAO Documento Técnico de Pesca 348; Organización de las Naciones Unidas para la Agricultura y la Alimentación (FAO): Copenhagen, Denmark, 1999; Available online: https://www.fao.org/4/v7180s/v7180s00.htm#Contents (accessed on 9 July 2025).
35. Olea, A.; Díaz, J.; Fuentes, R.; Vaquero, A.; García, M. Vigilancia de brotes de enfermedades transmitidas por alimentos en Chile. *Rev. Chil. Infectología* **2012**, *29*, 504–510. [CrossRef]
36. Espinosa, L.; Varela Bustos, C.; Martínez, E.V.; Cano-Portero, R. Brotes de enfermedades transmitidas por alimentos. España, 2008-2011 (excluye brotes hídricos). *Boletín Epidemiológico Sem.* **2014**, *22*, 130–145. Available online: https://repisalud.isciii.es/rest/api/core/bitstreams/fe6b0f99-70ce-49e7-8bda-781db94a003b/content (accessed on 30 May 2025).
37. White, A.E.; Tillman, A.R.; Hedberg, C.; Bruce, B.B.; Batz, M.; Seys, S.A.; Walter, E.S. Foodborne illness outbreaks reported to national surveillance, United States, 2009–2018. *Emerg. Infect. Dis.* **2022**, *28*, 1117. [CrossRef]
38. Holst, M.M.; Wittry, B.C.; Crisp, C.; Torres, J.; Irving, D.; Nicholas, D. Contributing Factors of Foodborne Illness Outbreaks—National Outbreak Reporting System, United States, 2014–2022. *MMWR. Surveill. Summ.* **2025**, *74*, 1–12. [CrossRef]
39. Bryan, F.L.; Guzewich, J.J.; Todd, E.C. Surveillance of foodborne disease III. Summary and presentation of data on vehicles and contributory factors; their value and limitations. *J. Food Prot.* **1997**, *60*, 701–714. [CrossRef]
40. Dissasa, G.; Lemma, B.; Mamo, H. Isolation and identification of major bacteria from three Ethiopian rift valley lakes live and processed fish, and water samples: Implications in sanitary system of fish products. *BMC Vet. Res.* **2022**, *18*, 439. [CrossRef]
41. Elotmani, F.; Assobhei, O.; Revol-Junelles, A.; Millière, J. Microflora de la sardina (*Sardina pilchardus*) fresca y refrigerada de la costa Atlántica marroquí. *Cienc. Mar.* **2004**, *30*, 627–635. Available online: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0185-38802004000500011&lng=es&tlng=es. (accessed on 3 July 2025). [CrossRef]
42. Feldhusen, F. The role of seafood in bacterialfoodborne diseases. *Microbes Infect.* **2000**, *2*, 1651–1660. [CrossRef] [PubMed]

43. Diaz Jaramillo, A.J. Presencia de Bacterias Saprofitas y Patógenas en Piel y Branquias de Pescado Fresco. Bachelor's Thesis, Universidad austral de Chile, Valdivia, Chile, 2004. Available online: http://cybertesis.uach.cl/tesis/uach/2004/fad542p/pdf/fad542p.pdf (accessed on 13 June 2025).
44. Novoslavskij, A.; Terentjeva, M.; Eizenberga, I.; Valciņa, O.; Bartkevičs, V.; Bērziņš, A. Major foodborne pathogens in fish and fish products: A review. *Ann. Microbiol.* **2016**, *66*, 1–15. [CrossRef]
45. Flores, B.; González, N.; Bravo, A.; Mora-Sánchez, B.; Torres, D.; Jirón, W.; Sheleby-Elías, J.; Balcázar, J.L. Identificación de bacterias patógenas en peces capturados en el Pacífico frente a Nicaragua. *Cienc. Mar.* **2021**, *47*, 175–184. [CrossRef]
46. Salama, Y.; Chennaoui, M. Microbial spoilage organisms in seafood products: Pathogens and quality control. *Eur. J. Microbiol. Infect. Dis* **2024**, *1*, 66–89. [CrossRef]
47. Goulding, I.C. *Guía Relativa a los Peligros para la Seguridad de los Alimentos in los Productos de la Pesca del Caribe*; CRFM Publicación Espec: Belize City, Belize, 2016; Volume 11, pp. 1–54. Available online: https://www.crfm.int/~uwohxjxf/images/Guide_to_Food_Safety_Hazards_in_Caribbean_fishery_Products_Sp._No._11.pdf (accessed on 10 August 2025).
48. Mines, D.; Stahmer, S.; Shepherd, S.M. Poisonings: Food, fish, shellfish. *Emerg. Med. Clin. N. Am.* **1997**, *15*, 157–177. [CrossRef]
49. Rabiela Sotelo, M. Higiene y conservación del pescado. *Hosp. ESDAI* **2015**, *28*, 41–60. Available online: https://scripta.up.edu.mx/server/api/core/bitstreams/94643c9e-35f2-4da5-8c34-bddabcb1940f/content (accessed on 23 July 2025).
50. Friedman, M.A.; Fleming, L.E.; Fernandez, M.; Bienfang, P.; Schrank, K.; Dickey, R.; Reich, A. Ciguatera fish poisoning: Treatment, prevention and management. *Mar. Drugs* **2008**, *6*, 456–479. [CrossRef]
51. Hernández-Orozco, M.L.; Gárate-Lizárraga, I. Síndrome de envenenamiento paralizante por consumo de moluscos. *Rev. Biomédica* **2006**, *17*, 45–60. Available online: http://www.uady.mx/sitios/biomedic/revbiomed/pdf/rb061717.pdf (accessed on 15 August 2025). [CrossRef]
52. Watkins, S.M.; Reich, A.; Fleming, L.E.; Hammond, R. Neurotoxic shellfish poisoning. *Mar. Drugs* **2008**, *6*, 431–455. [CrossRef]
53. Cetinkaya, F.; Mus, T.E. Shellfish poisoning and toxins. *J. Biol. Environ. Sci.* **2012**, *6*, 115–119. Available online: https://dergipark.org.tr/en/download/article-file/497510 (accessed on 29 July 2025).
54. Graü de Marín, C.; Muñoz, D.; Márquez, E.; Figueroa, G.; Maza, J. Identificación de hongos con potencial micotoxigénico en harinas de pescado destinadas para la elaboración de alimentos concentrados. *Rev. Científica* **2011**, *XXI*, 256–264. Available online: https://www.redalyc.org/articulo.oa?id=95918239010 (accessed on 23 July 2025).
55. Cortés-Sánchez, A.D.J.; Garza-Torres, R.; Espinosa-Chaurand, L.D. Food, fish and mycotoxins. *Acta Aquat. Turc.* **2020**, *16*, 571–584. [CrossRef]
56. Golomazou, E.; Karanis, P. Cryptosporidium species in fish: An update. *Environ. Sci. Proc.* **2020**, *2*, 13. [CrossRef]
57. Moratal, S.; Dea-Ayuela, M.A.; Cardells, J.; Marco-Hirs, N.M.; Puigcercós, S.; Lizana, V.; López-Ramon, J. Potential risk of three zoonotic protozoa (*Cryptosporidium* spp., *Giardia duodenalis*, and *Toxoplasma gondii*) transmission from fish consumption. *Foods* **2020**, *9*, 1913. [CrossRef] [PubMed]
58. Rojas Cruz, C. *Cryptosporidium* spp: Un parásito emergente asociado a diarrea. *Rev. Gastrohnup* **2012**, *14*, S20–S24. Available online: https://d1wqtxts1xzle7.cloudfront.net/66970360/12_20cryptosporidium-libre.pdf?1620520726=&response-content-disposition=inline%3B+filename%3DCryptosporidium_spp_un_parasito_emergent.pdf&Expires=1761238883&Signature=BVMTAiIbDhzqBP549QK6BhIglQAOKsNsCF1OlJ9OC-ksJ2OyCbXGjICAUKvdJNU0B7DesWEKhgnM~MkWQisQyPl9fQB3U-P8vAnswwoLmHIeSPaZrxzTt5qsmIMa8hY0cEjIOQ3agqcE8dZhiu33HcufZK-BfK9OxsCqsaAah80IVcMzk~jZwsX12tWd~G~JNnl7~8IUvRN85f52-TAfHgRRXBTPfDFK6yHkJlYnQfz7-Rc4XVGiNWebsWh6UEL-Te45DUgU1slbt-Q8hNr1wnm1tPqK6Wtl~I-i-Hh8f2dI4o0M86EAu3ZR3wwExlPqjAaU2kuc5~Usia3gqq0n7Q__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA (accessed on 29 June 2025).
59. Samudio, M.; Acosta, M.E.; Castillo, V.; Guillén, Y.; Licitra, G.; Aria, L.; Cibils, P.; Rojas, A.; Cibils, D.; Meza, T.; et al. Aspectos clínico-epidemiológicos de la toxoplasmosis en pacientes que consultan por problemas de visión. *Rev. Chil. Infectología* **2015**, *32*, 658–663. [CrossRef]
60. Nantes, O.; Zozaya, J.M.; Prieto, C.; Beloqui, R.; Arín, A. Síndrome general y diarrea como manifestación de infección por Giardia lamblia. *Gastroenterol. Hepatol.* **2005**, *28*, 558–560. [CrossRef]
61. Quijada, J.; Lima dos Santos, C.A.; Avdalov, N. Enfermedades parasitarias por consumo de pescado. Incidencia en América Latina. *Infopesca Int.* **2005**, *24*, 16–23. Available online: http://www.simcope.com.br/II_Simcope/pdf/palestra_nelson_avdalov.pdf (accessed on 17 June 2025).
62. Branciari, R.; Ranucci, D.; Miraglia, D.; Valiani, A.; Veronesi, F.; Urbani, E.; Franceschini, R. Occurrence of parasites of the genus *Eustrongylides* spp. (Nematoda: Dioctophymatidae) in fish caught in Trasimeno lake, Italy. *Ital. J. Food Saf.* **2016**, *5*, 6130. [CrossRef]
63. Chintagari, S.; Hazard, N.; Edwards, G.; Jadeja, R.; Janes, M. Risks associated with fish and seafood. In *Preharvest food safety*; Siddhartha, T., Kalmia, E.K., Eds.; Wiley: Hoboken, NJ, USA, 2018; pp. 123–142. [CrossRef]
64. Garrido-Olvera, L.; García-Prieto, L.; Osorio-Sarabia, D. Ictiozoonosis potenciales de Tamaulipas. *Rev. Cienc.* **2023**, *23*, 14–19. Available online: https://cienciauanl.uanl.mx/ojs/index.php/revista/article/view/167 (accessed on 10 July 2025).
65. Qian, M.B.; Utzinger, J.; Keiser, J.; Zhou, X.N. Clonorchiasis. *Lancet* **2016**, *387*, 800–810. [CrossRef]

66. RACVE. Zoonosis e Intoxicaciones Humanas de Origen Ictiológico. Real Academia de Ciencias Veterinarias de España (RACVE), 2025. Available online: https://www.racve.es/publicaciones/zoonosis-e-intoxicaciones-humanas-de-origen-ictiologico/ (accessed on 5 July 2025).
67. Sohn, W.M.; Yong, T.S.; Eom, K.S.; Pyo, K.H.; Lee, M.Y.; Lim, H.; Chai, J.Y. Prevalence of *Opisthorchis viverrini* infection in humans and fish in Kratie Province, Cambodia. *Acta Trop.* **2012**, *124*, 215–220. [CrossRef]
68. El-Seify, M.A.; Sultan, K.; Elhawary, N.M.; Satour, N.S.; Marey, N.M. Prevalence of heterophyid infection in tilapia fish "*Orechromas niloticus*" with emphasize of cats role as neglected reservoir for zoonotic *Heterophyes heterophyes* in Egypt. *J. Parasit. Dis.* **2021**, *45*, 35–42. [CrossRef] [PubMed]
69. Haile, A.B.; Getahun, T.K. Isolation and identification *of Escherichia coli* and *Edwardsiella tarda* from fish harvested for human consumption from Zeway Lake, Ethiopia. *Afr. J. Microbiol. Res.* **2018**, *12*, 476–480. [CrossRef]
70. Castañeda-Ruelas, G.; Eslava-Campos, C.; Castro-del Campo, N.; León-Félix, J.; Chaidez-Quiroz, C. Listeriosis en México: Importancia clínica y epidemiológica. *Salud Pública México* **2014**, *56*, 654–659. Available online: https://www.scielosp.org/pdf/spm/2014.v56n6/654-659/es (accessed on 8 May 2025).
71. FDA. Foodborne Pathogens Resources for Medical Professionals (Food Safety for Moms-to-Be). US. Food and Drugs Administration (FDA), 2025. Available online: https://www.fda.gov/food/people-risk-foodborne-illness/foodborne-pathogens-resources-medical-professionals-food-safety-moms-be (accessed on 6 July 2025).
72. Massoc, P.A. Enfermedades asociadas a los alimentos. *Rev. Chil. Infectología* **2008**, *25*, 395–397. [CrossRef]
73. Félix-Fuentes, A.; Campas-Baypoli, O.N.; Meza-Montenegro, M. Calidad sanitaria de alimentos disponibles al público de Ciudad Obregón, Sonora, México. *RESPYN Rev. Salud Pública Y Nutr.* **2005**, *6*, 3. Available online: https://respyn.uanl.mx/index.php/respyn/article/download/149/131 (accessed on 10 August 2025).
74. Janda, J.M.; Abbott, S.L. The genus Aeromonas: Taxonomy, pathogenicity, and infection. *Clin. Microbiol. Rev.* **2010**, *23*, 35–73. [CrossRef]
75. Pessoa, R.B.G.; de Oliveira, W.F.; Correia, M.T.D.S.; Fontes, A.; Coelho, L.C.B.B. Aeromonas and Human Health Disorders: Clinical Approaches. *Front. Microbiol.* **2022**, *13*, 868890. [CrossRef]
76. Sierralta Chichizola, V.; Mayta Huatuco, E.; León Quispe, J. Primer Registro de *Plesiomonas shigelloides* como Patógeno Oportunista de Tilapia *Oreochromis niloticus* (Linnaeus, 1758) en una Piscigranja de Lima, Perú. *Rev. Investig. Vet. Del Perú* **2016**, *27*, 565–572. [CrossRef]
77. Vázquez, E.G.; Torres, A.H.; Martínez, J.H.; Gómez, J.G. Infecciones por *Salmonella* y Yersinia. *Med. -Programa Form. Méd. Contin. Acreditado* **2014**, *11*, 3322–3326. [CrossRef]
78. Hennechart-Collette, C.; Dehan, O.; Fraisse, A.; Martin-Latil, S.; Perelle, S. Development of an extraction method to detect Hepatitis A Virus, Hepatitis E Virus, and Noroviruses in fish products. *Microorganisms* **2023**, *11*, 624. [CrossRef]
79. Acheson, D.; Fiore, A.E. Hepatitis A transmitted by food. *Clin. Infect. Dis.* **2004**, *38*, 705–715. [CrossRef]
80. Orban, E.; Poli, B.I.A.N.C.A.; Guandalini, E. Fish production chain: Safety and quality for consumers. In *The State of Italian Marine Fisheries and Aquaculture S. Cautadella e M. Spagnolo*; Ministero Delle Politiche Agricole Alimentari e Forestali: Roma, Italy, 2011; pp. 589–610. Available online: https://flore.unifi.it/handle/2158/834891 (accessed on 13 June 2025).
81. Coppola, C. Seafood Inspection: Current Issues. Ph.D. Thesis, Università Degli Studi di Milano, Milan, Italy, 2020. Available online: https://tesidottorato.depositolegale.it/handle/20.500.14242/85655 (accessed on 9 May 2025).
82. Espinoza-Tellez, T.; Quevedo-León, R.; Ávila-Pizarro, Y. Food as a transmitter of viruses: A review. *Sci. Agropecu.* **2022**, *13*, 25–42. [CrossRef]
83. Liu, X.; Steele, J.C.; Meng, X.Z. Usage, residue, and human health risk of antibiotics in Chinese aquaculture: A review. *Environ. Pollut.* **2017**, *223*, 161–169. [CrossRef]
84. de Assis, D.C.S.; de Vasconcelos Cançado, S.; Teixeira, L.V.; da Silva, G.R.; Rodrigues, F.L.P. Resíduos de antimicrobianos em pescado. *Cad. Técnicos Veterinária Zootec.* **2018**, *89*, 41–50. Available online: https://repositorio.ufmg.br/bitstream/1843/56415/2/Res%C3%ADduos%20de%20antimicrobianos%20em%20pescado.pdf (accessed on 6 July 2025).
85. Mora Yanquen, J.K. Modelo para la Determinación de Sustancias con Actividad Estrogénica Presentes en Pescado Fresco Obtenido en Diferentes Puntos de una Plaza de Mercado de Girardot. Bachelor's Thesis, Universidad Colegio Mayor de Cundinamarca, Facultad de Ciencias de la Salud, Programa de Bacteriología y Laboratorio Clínico, Bogotá, Colombia, 2020. Available online: http://178.32.55.102/bitstream/handle/unicolmayor/120/TG%20FINAL%20UCMC%2018.05%20%281%29.pdf?sequence=1&isAllowed=y (accessed on 4 June 2025).
86. Islam, P.; Hossain, M.I.; Khatun, P.; Masud, R.I.; Tasnim, S.; Anjum, M.; Islam, M.A. Steroid hormones in fish, caution for present and future: A review. *Toxicol. Rep.* **2024**, *13*, 101733. [CrossRef]
87. Vargas Licona, S.P.; Marrugo Negrete, J.L. Mercurio, metilmercurio y otros metales pesados en peces de Colombia: Riesgo por ingesta. *Acta Biol. Colomb.* **2019**, *24*, 232–242. [CrossRef]

88. Garnero, P.L.; Bistoni, M.d.; Monferran, M.V. Trace element concentrations in six fish species from freshwater lentic environments and evaluation of possible health risks according to international standards of consumption. *Environ. Sci. Pollut. Res.* **2020**, *27*, 27598–27608. [CrossRef]
89. Vandermeersch, G.; Lourenço, H.M.; Alvarez-Muñoz, D.; Cunha, S.; Diogène, J.; Cano-Sancho, G.; Robbens, J. Environmental contaminants of emerging concern in seafood–European database on contaminant levels. *Environ. Res.* **2015**, *143*, 29–45. [CrossRef]
90. Peng, L.; Fu, D.; Qi, H.; Lan, C.Q.; Yu, H.; Ge, C. Micro-and nano-plastics in marine environment: Source, distribution and threats—A review. *Sci. Total Environ.* **2020**, *698*, 134254. [CrossRef]
91. Unuofin, J.O.; Igwaran, A. Microplastics in seafood: Implications for food security, safety, and human health. *J. Sea Res.* **2023**, *194*, 102410. [CrossRef]
92. Ponce, D.G.; Velazco, K.P.; Vargas, N.A.; Gabriel, B.; Galindo, G. Presencia de microplásticos en pescados aptos para consumo humano, agua y playas de la bahía de Santa Lucia, Acapulco, México. *LATAM Rev. Latinoam. Cienc. Soc. Humanidades* **2023**, *4*, 239–250. [CrossRef]
93. Harris, S.A.; Jones, J.L. Fish consumption and PCB-associated health risks in recreational fishermen on the James River, Virginia. *Environ. Res.* **2008**, *107*, 254–263. [CrossRef]
94. Tuomisto, J. Dioxins and dioxin-like compounds: Toxicity in humans and animals, sources, and behaviour in the environment. *WikiJournal Med.* **2019**, *6*, 8. [CrossRef]
95. Otles, S.; Yildiz, H. Dioxin in food and human health. *Electron. J. Environ. Agric. Food Chem.* **2003**, *2*, 593–608.
96. Iko Afe, O.H.; Kpoclou, Y.E.; Douny, C.; Anihouvi, V.B.; Igout, A.; Mahillon, J.; Scippo, M.L. Chemical hazards in smoked meat and fish. *Food Sci. Nutr.* **2021**, *9*, 6903–6922. [CrossRef]
97. López-Moreno, D.; Morales Serna, F.N. Conocimiento sobre la zoonosis por Anisakis en consumidores de pescado y mariscos en Sinaloa, México. *Bioc Sci.* **2025**, *1*, 1–11. [CrossRef]
98. Linares Cánovas, L.P.; Márquez Rodríguez, H. Current issues in epidemiological surveillance of outbreaks of foodborne diseases. *Rev. Cienc. Médicas Pinar Del Río* **2019**, *23*, 5–6. Available online: http://scielo.sld.cu/scielo.php?script=sci_arttext&pid=S1561-3194201900010005&lng=es&tlng=en (accessed on 9 May 2025).
99. Zaidi, M.B.; Calva, J.J.; Estrada-Garcia, M.T.; Leon, V.; Vazquez, G.; Figueroa, G.; Tollefson, L. Integrated food chain surveillance system for *Salmonella* spp. in Mexico. *Emerg. Infect. Dis.* **2008**, *14*, 429. [CrossRef]
100. Leyva-López, N.; Mendieta-Vega, R.A.; Zazueta-Matías, E.; Santiago-Osuna, J.; Grano-Maldonado, M.I. Ocurrencia de enfermedades gastrointestinales en turistas nacionales e internacionales entre 2014-2018, en Mazatlan, Sinaloa, Mexico. *Biotempo* **2020**, *17*, 127–136. [CrossRef]
101. Mathur, P.; Schaffner, D.W. Effect of lime juice on Vibrio parahaemolyticus and Salmonella enterica inactivation during the preparation of the raw fish dish ceviche. *J. Food Prot.* **2013**, *76*, 1027–1030. [CrossRef]
102. Semenas, L. Sushi y ceviche: ¿peligrosamente ricos? Desde La Patagonia. *Difundiendo Saberes* **2013**, *10*, 26–33. Available online: https://revele.uncoma.edu.ar/index.php/desdelapatagonia/article/view/3903/60910 (accessed on 16 July 2025).
103. Berkelman, R.L.; Cohen, M.L.; Yashuk, J.; Barrett, T.; Wells, J.G.; Blake, P.A. Traveler's diarrhea at sea: Two multi-pathogen outbreaks caused by food eaten on shore visits. *Am. J. Public Health* **1983**, *73*, 770–772. [CrossRef]
104. Parrilla, M.C.; Vázquez, J.L.; Saldate, E.O.; Nava, L.M. Brotes de toxiinfecciones alimentarias de origen microbiano y parasitario. *Salud Pública México* **1993**, *35*, 456–463. Available online: https://www.redalyc.org/pdf/106/10635505.pdf (accessed on 15 August 2025).
105. Cabanillas-Beltrán, H.; LLausás-Magaña, E.; Romero, R.; Espinoza, A.; García-Gasca, A.; Nishibuchi, M.; Gomez-Gil, B. Outbreak of gastroenteritis caused by the pandemic Vibrio parahaemolyticus O3: K6 in Mexico. *FEMS Microbiol. Lett.* **2006**, *265*, 76–80. [CrossRef]
106. Hernández-Díaz, L.; Leon-Sicairos, N.; Velazquez-Roman, J.; Flores-Villaseñor, H.; Guadron-Llanos, A.M.; Martinez-Garcia, J.J.; Vidal, J.E.; Canizalez-Roman, A.; Canizalez-Roman, A. A pandemic Vibrio parahaemolyticus O3: K6 clone causing most associated diarrhea cases in the Pacific Northwest coast of Mexico. *Front. Microbiol.* **2015**, *6*, 221. [CrossRef]
107. Ogata, K.; Nawa, Y.; Akahane, H.; Camacho, S.D.; Lamothe-Argumedo, R.; Cruz-Reyes, A. Agnathostomiasis in Mexico. *Am. J. Trop. Med. Hyg.* **1998**, *58*, 316–318. Available online: https://d1wqtxts1xzle7.cloudfront.net/11192080 0/316-libre.pdf?1709131289=&response-content-disposition=inline%3B+filename%3DShort_report_gnathostomiasis_in_Mexico.pdf&Expires=1758920653&Signature=RbLTHjDC6Kv0Bz6zkjYTFHr5cC9hBajAEBPoyz-PWxIDnTH1lAPry~sPaa1H0tVgcT72dWZI2WOLYFOT~r0onQSNSRpXOsPdmVSCLX-6-667~dRsQCqwOJSVmbygA8xIWyGsBKxOXn8bvPM9cHddFTN1cAXGH2Waij5xf2Nzdbm9pDPI8VTiKq6JZwra-VtQzFwTGJUcNlIn40EHjsLncxcxAcBZ3RFtYiV8octbtVmqsivTX0sUArCTZ9RZcRWMeADhjYFQ2QOzCC2k4Jk8eSZQJ8eaNB2vSJSiHwQWjy8guCegApXOO9MttUokFMEOtR3qpZRsIzL~iYj9Iv40vA__&Key-Pair-Id=APKAJLOHF5GGSLRBV4ZA (accessed on 23 June 2025). [CrossRef]
108. Argumedo, R.L. La gnatostomiasis en México: Un problema de salud pública. *An. Del Inst. Biología. Ser. Zool.* **2003**, *74*, 99–103. Available online: https://www.redalyc.org/pdf/458/45874109.pdf (accessed on 23 June 2025).

109. Gómez Torres, J.R.; Lamothe-Argumedo, M.R.; de León González, A.H.; Herrera, S.; Silva Briano, M.; Montañez Díaz, M.E. Registro de dos casos de gnatostomiasis intraocular humana, con descripción morfométrica de la larva L3, en Aguascalientes, México. *Rev. Mex. Patol. Clínica Med. Lab.* **2004**, *51*, 231–236. Available online: https://www.medigraphic.com/pdfs/patol/pt-2004/pt044h.pdf (accessed on 25 July 2025).
110. Rojas-Molina, N.; Pedraza-Sanchez, S.; Torres-Bibiano, B.; Meza-Martinez, H.; Escobar-Gutierrez, A. Gnathostomosis, an emerging foodborne zoonotic disease in Acapulco, Mexico. *Emerg Infect Dis.* **1999**, *5*, 264–266. [CrossRef]
111. Camacho, S.P.D.; Willms, K.; de la Cruz, M.D.C.; Ramos, M.L.Z.; Gaxiola, S.B.; Velázquez, R.C.; Gonzáles, S.S. Acute outbreak of gnathostomiasis in a fishing community in Sinaloa, Mexico. *Parasitol. Int.* **2003**, *52*, 133–140. [CrossRef]
112. Vázquez-Garcidueñas, M.S.; Romero-Pérez, N.L.; Figueroa-Aguilar, G.A.; Jaime-Sánchez, J.L.; Vázquez-Marrufo, G. Investigación de un brote de Salmonella Oranienburg transmitida por alimentos en una prisión mexicana. *J. Infect. Dev. Ctries.* **2014**, *8*, 143–153. [CrossRef]
113. Álvarez-Contreras, A.K.; Quiñones-Ramírez, E.I.; Vázquez-Salinas, C. Prevalence, detection of virulence genes and antimicrobial susceptibility of pathogen Vibrio species isolated from different types of seafood samples at "La Nueva Viga" market in Mexico City. *Antonie Van Leeuwenhoek* **2021**, *114*, 1417–1429. [CrossRef]
114. Quintero, G.B.; De León, J.A.R.; Ruiz, J.A.C.; Humaran, I.L.S.; Inzunza, J.R.R.; Hernández, J.M.M. Contenido de histamina y calidad microbiológica de pescado comercializado en Mazatlán, Sinaloa. *BIOtecnia* **2012**, *14*, 3–12. Available online: https://www.redalyc.org/pdf/6729/672971151001.pdf (accessed on 12 June 2025). [CrossRef]
115. Cabrera-García, M.E.; Vázquez-Salinas, C.; Quiñones-Ramírez, E.I. Serologic and molecular characterization of *Vibrio parahaemolyticus* strains isolated from seawater and fish products of the Gulf of Mexico. *Appl. Environ. Microbiol.* **2004**, *70*, 6401–6406. [CrossRef]
116. Estrada-Garcia, T.; Lopez-Saucedo, C.; Arevalo, C.; Flores-Romo, L.; Luna, O.; Perez-Martinez, I. Street-vended seafood: A risk for foodborne diseases in Mexico. *Lancet Infect. Dis.* **2005**, *5*, 69–70. [CrossRef]
117. Ramos-González, L.K.; Meza-Espinoza, L.; Espinosa-Chaurand, L.D.; Diaz-Ramírez, M.; Cortés-Sánchez, A.D.J. Microbiological analysis of fish (*Centropomus robalito*) marketed for human consumption. *Food Res.* **2025**, *9*, 37–46. [CrossRef]
118. Estrella-Gómez, N.; Escalante-Réndiz, D.; González-Burgos, A.; Sosa-Cordero, D.; Rojas-Herrera, R. Análisis microbiológico del pulpo rojo en puertos pesqueros de Campeche, México. *Salud Pública México* **2016**, *58*, 453–460. [CrossRef]
119. Zavala Núñez, M. Inocuidad Alimentaria para la Calidad en Restaurantes de Hoteles: Franja de Playa Zona Dorada, Acapulco, Guerrero, México. Master's Thesis, Universidad Autónoma de Guerrero, Chilpancingo, México, 2015. Available online: http://ri.uagro.mx:8080/bitstream/handle/uagro/340/13304086_TM2015_OK.pdf?sequence=1&isAllowed=y (accessed on 25 August 2025).
120. Torres-Vitela, M.R.; Castillo, A.; Finne, G.; Rodriguez-Garcia, M.O.; Martinez-Gonzales, N.E.; Navarro-Hidalgo, V. Incidence of Vibrio cholerae in fresh fish and ceviche in Guadalajara, Mexico. *J. Food Prot.* **1997**, *60*, 237–241. [CrossRef]
121. Parada-Fabián, J.C.; Juárez-García, P.; Natividad-Bonifacio, I.; Vázquez-Salinas, C.; Quiñones-Ramírez, E.I. Identification of enteric viruses in foods from Mexico City. *Food Environ. Virol.* **2016**, *8*, 215–220. [CrossRef]
122. Villicaña, C.; Amarillas, L.; Soto-Castro, L.; Gómez-Gil, B.; Lizárraga-Partida, M.L.; León-Félix, J. Occurrence and abundance of pathogenic Vibrio species in raw oysters at retail seafood markets in northwestern Mexico. *J. Food Prot.* **2019**, *82*, 2094–2099. [CrossRef] [PubMed]
123. Canizalez-Roman, A.; Gonzalez-Nuñez, E.; Vidal, J.E.; Flores-Villaseñor, H.; León-Sicairos, N. Prevalence and antibiotic resistance profiles of diarrheagenic *Escherichia coli* strains isolated from food items in northwestern Mexico. *Int. J. Food Microbiol.* **2013**, *164*, 36–45. [CrossRef]
124. Guardiola-Avila, I.; Martínez-Vázquez, V.; Juárez-Rendón, K.; Alvarez-Ainza, M.; Paz-González, A.; Rivera, G. Prevalence and virulence of Vibrio species isolated from raw shrimp from retail markets in Reynosa, Mexico. *Lett. Appl. Microbiol.* **2020**, *71*, 280–286. [CrossRef] [PubMed]
125. Castro-Escarpulli, G.; Figueras, M.J.; Aguilera-Arreola, G.; Soler, L.; Fernández-Rendón, E.; Aparicio, G.O.; Chacón, M.R. Characterisation of *Aeromonas* spp. isolated from frozen fish intended for human consumption in Mexico. *Int. J. Food Microbiol.* **2003**, *84*, 41–49. [CrossRef]
126. Guardiola-Avila, I.; Noriega-Orozco, L.; Acedo-Félix, E.; Lara, A.E.; Tapia-Olea, M.M. Presence of the hemolysin gene of *Vibrio mimicus* in fish and seafood products in Sonora, México. *J. Food Res.* **2015**, *4*, 66. [CrossRef]
127. Valenzuela-Armenta, J.A.; Díaz-Camacho, S.P.; Cabanillas-Ramos, J.A.; Uribe-Beltrán, M.d.J.; de la Cruz-Otero, M.; del Osuna-Ramírez, I.C.; Báez-Flores, M.E. Microbiological analysis of tilapia and water in aquaculture farms from Sinaloa. *Biotecnia* **2018**, *20*, 20–26. [CrossRef]
128. González-Díaz, R.L.; Mercado-Silva, N.; Reynaga-Delgado, E.; Martínez-Rivera, L.M. Bacterial microbiota from wild freshwater fish utilized for subsistence in western Mexico. *Rev. Int. Contam. Ambient.* **2020**, *36*, 215–222. [CrossRef]

129. Torres, D.T.; Keb, C.A.C.; Alcántara, J.G.; Balan, R.A.P.; Baldemar, A.C.; Rodríguez, G.V.; Mayari, T.R.P.; Gastélum, J.L.A.; Alcocer, B.S.; Alcantara, E.J.G. The prevalence of multidrug-resistant Salmonella in raw shrimp and octopus in Campeche, Mexico. *J. Health Sci.* **2022**, *12*, 193–197. [CrossRef]
130. Acuña-Ramírez, S.; Jiménez-Badillo, M.D.L.; Galindo-Cortes, G.; Marval-Rodríguez, A.; Castaneda-Chavez, M.D.R.; Reyes-Velázquez, C.; De Donato-Capote, M. Environmental and Anthropogenic Influences on Coliform Concentrations in the *Octopus insularis* Production Chain in the Veracruz Reef System, Gulf of Mexico. *Animals* **2023**, *13*, 3049. [CrossRef] [PubMed]
131. Santillán-Pérez, A.; Posadas-Corral, V.D.; Diaz-Ramírez, M.; Guadarrama-Lezama, A.Y.; Aguilar-Toalá, J.E.; Pérez-Ruiz, R.V.; Espinosa-Chaurand, L.D.; Cortés-Sánchez, A.D.J. Microbiological quality of marketed fish and shrimp in San Luis Mextepec in the State of Mexico, Mexico. *Agro Prod.* **2024**, *17*, 77–83. [CrossRef]
132. Ramírez-Martínez, M.E.; Rodríguez-Castillejos, G.C.; Hernández-Jiménez, M.C.; Ramírez-Quintanilla, L.Y.; Siller-López, F.; Acosta-Cruz, E.; Martínez-Montoya, H. Analysis of bacterial diversity in raw fish ceviche. *J. Microbiol. Biotechnol. Food Sci.* **2022**, *11*, e3321. [CrossRef]
133. Franco-Monsreal, J.; Dzib-García, M.R.; Serralta-Peraza, L.E.d.S.; Sánchez-Uluac, M.S.; Flores-Abuxapqui, J.J. *Vibrio vulnificus* in seafood of animal origin from establishments in the city of Telchac Puerto, Yucatan, Mexico. *South Fla. J. Dev.* **2022**, *3*, 5094–5108. [CrossRef]
134. Franco-Monsreal, J.; Serralta-Peraza, L.E.d.S.; Flores–Abuxapqui, J.J. *Vibrio alginolyticus* in marine foods of animal origin from establishments in the port of Chabihau, Yucatan, Mexico: Vibrio alginolyticus. *South Fla. J. Dev.* **2021**, *2*, 7523–7538. [CrossRef]
135. Rodas-Suárez, O.R.; Flores-Pedroche, J.F.; Betancourt-Rule, J.M.; Quinones-Ramirez, E.I.; Vázquez-Salinas, C. Occurrence and antibiotic sensitivity of *Listeria monocytogenes* strains isolated from oysters, fish, and estuarine water. *Appl. Environ. Microbiol.* **2006**, *72*, 7410–7412. [CrossRef]
136. Dávila Ramírez, L.R. Evaluación Bacteriológica de Pescado Fresco Lisa (*Mugil cephalus*), Expendido en el Mercado de Tlalnepantla Edo. de México. Bachelor's Thesis, Universidad Nacional Autónoma de México, Mexico City, Mexico, 2006; pp. 1–67. Available online: https://ru.dgb.unam.mx/server/api/core/bitstreams/7bfa6f8a-bfc0-464e-960e-b205ceb05a6a/content (accessed on 26 August 2025).
137. Arizmendi, R.A.A.; Muñoz, X.R.; Benavides, O.L.M.; Vallejo, J.D. Análisis de la calidad microbiológica de los alimentos en el estado de Veracruz. *Universalud* **2014**, *14*, 37–48. Available online: https://www.uv.mx/msp/files/2019/03/revista27.pdf (accessed on 28 July 2025).
138. Borbolla-Sala, M.E.; Vidal-Pérez, M.D.R.; Piña-Gutiérrez, O.E.; Ramírez-Messner, I.; Vidal-Vidal, J.J. Contaminación de los alimentos por *Vibrio cholerae*, *Coliformes fecales*, *Salmonella*, *hongos*, *levaduras* y *Staphylococcus aureus* en Tabasco durante 2003. *Salud Tabasco* **2004**, *10*, 221–232. Available online: https://www.redalyc.org/articulo.oa?id=48710206 (accessed on 28 August 2025).
139. Cornejo-Huerta, J.Y.; Marín-Ramos, E.A.; Pérez-Díaz, L.M.; Girgir, E.; El Kassis, D.; Contreras-Mioni, L.; Rodríguez-Soria, V. Contaminación por Bacterias Patógenas en Tilapia (*Oreochromis* spp.) en Mercados y Supermercados de la Ciudad de Puebla. *Rev. Cienc. Tecnol. Soc.* **2023**, *3*, 23–32. Available online: https://static1.squarespace.com/static/55564587e4b0d1d3fb1eda6b/t/6531a5df05afb959801ce54a/1697752543965/Rodr%C3%ADguez+Soria+Ver%C3%B3nica+{-}{-}+CTS+{-}{-}+23-32.pdf (accessed on 29 August 2025).
140. García Macías, J.A.; Núñez González, F.A.; Chacón Pineda, O.; Alfaro Rodríguez, R.H.; Espinosa Hernández, M.R. Estudio microbiológico de tejido superficial de trucha arco iris (*Oncorhynchus mykiss*) y del agua circundante. *Hidrobiológica* **2003**, *13*, 111–118. Available online: http://www.scielo.org.mx/scielo.php?script=sci_arttext&pid=S0188-88972003000200003&lng=es&tlng=es. (accessed on 30 July 2025).
141. Ramos, J.G. La situación actual de las zoonosis más frecuentes en México. *Gac. Medica Mex.* **2010**, *146*, 430–436. Available online: https://www.medigraphic.com/pdfs/gaceta/gm-2010/gm106k.pdf (accessed on 27 August 2025).
142. Tanveer, M.; Kanwal, N.; Rafeeq, H.; Arshad, A.; Ur Rehman, S.; Manzoor, S. Potential mutagenicity in Meat and Fish: An Outcome of High Heat Cooking. *Preprints* **2023**, 2023081995. [CrossRef]
143. Sugimura, T.; Wakabayashi, K.; Nakagama, H.; Nagao, M. Heterocyclic amines: Mutagens/carcinogens produced during cooking of meat and fish. *Cancer Sci.* **2004**, *95*, 290–299. [CrossRef]
144. Dutta, K.; Shityakov, S.; Zhu, W.; Khalifa, I. High-risk meat and fish cooking methods of polycyclic aromatic hydrocarbons formation and its avoidance strategies. *Food Control* **2022**, *142*, 109253. [CrossRef]
145. OMS. *Cinco Claves para una Mayor Inocuidad de los Productos de Acuicultura con Objeto de Proteger la Salud Pública*; Organización Mundial de la Salud (OMS): Geneva, Switzerland, 2016; pp. 1–40. Available online: https://iris.who.int/bitstream/handle/10665/251672/9789243510316-spa.pdf?sequence=1 (accessed on 14 August 2025).
146. Soledispa-Lucas, F.F. Sistema de gestión de inocuidad alimentaria y la calidad en empresas pesqueras: Artículo de investigación. *Rev. Científica Arbitr. Investig. Comun. Mark. Empresa Reicomunicar* **2020**, *3*, 67–82. [CrossRef]
147. FAO y OMS. *Código de Prácticas para el Pescado y los Productos Pesqueros*; Organización Mundial de la Salud (OMS): Geneva, Switzerland; Organización de las Naciones Unidas para la Agricultura y Alimentación (FAO): Rome, Italy; Codex Alimentarius: Rome, Italy, 2022. [CrossRef]

148. OMS. *Manual Sobre las Cinco Claves para la Inocuidad de los Alimentos*; Organización Mundial de la Salud (OMS): Geneva, Switzerland, 2007. Available online: https://iris.who.int/bitstream/handle/10665/43634/9789243594637_spa.pdf?sequence=1 (accessed on 13 July 2025).
149. FDA. *Safe Food Handling*; US. Food and Drugs administration (FDA): Silver Spring, MD, USA, 2025. Available online: https://www.fda.gov/food/buy-store-serve-safe-food/safe-food-handling (accessed on 30 August 2025).
150. Leon, M.A.; Paz, E. A perspective of food safety laws in Mexico. *J. Sci. Food Agric.* **2014**, *94*, 1954–1957. [CrossRef]
151. PROFECO. *¿Qué Hacemos?* Procuraduría Federal del Consumidor (PROFECO), Gobierno de México: Mexico City, Mexico, 2025. Available online: https://www.gob.mx/profeco/que-hacemos (accessed on 25 August 2025).
152. Monsalve Tequen, E. Peligros Biológicos y Químicos, Legislación, Técnicas de Detección y su Disponibilidad en la Exportación de Trucha Arcoíris (*Oncorhynchus mykiss*) y Concha de Abanico (*Argopecten purpuratus*) Desde el Perú. *Salud Tecnol. Vet.* **2023**, *11*, 86–96. [CrossRef]
153. COFEPRIS. *Programa Mexicano de Sanidad de Moluscos Bivalvos (PMSMB)*; Comisión Federal para la Protección Contra Riesgos Sanitarios (COFEPRIS); Gobierno de México: Mexico City, Mexico, 2025. Available online: https://www.gob.mx/cofepris/acciones-y-programas/programa-mexicano-de-sanidad-de-moluscos-bivalvos (accessed on 29 August 2025).
154. *NOM-027-SSA1-1993*; Productos de la Pesca. Pescados Frescos-Refrigerados y Congelados. Especificaciones Sanitarias. Norma Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 1993. Available online: https://www.ordenjuridico.gob.mx/Documentos/Federal/wo69437.pdf (accessed on 13 July 2025).
155. *NOM-242-SSA1-2009*; Productos y Servicios. Productos de la Pesca Frescos, Refrigerados, Congelados y Procesados. Especificaciones Sanitarias y Métodos de Prueba. Norma Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2009. Available online: https://www.dof.gob.mx/normasOficiales/4295/salud2a/salud2a.htm (accessed on 14 August 2025).
156. *NOM-093-SSA1-1994*; Bienes y Servicios. Prácticas de Higiene y Sanidad en la Preparación de Alimentos que se Ofrecen en Establecimientos Fijos. Norma Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 1994. Available online: https://www.dof.gob.mx/nota_detalle.php?codigo=4882432&fecha=04/10/1995#gsc.tab=0 (accessed on 13 July 2025).
157. *NOM-251-SSA1-2009*; Prácticas de Higiene para el Proceso de Alimentos, Bebidas o Suplementos Alimenticios. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2009. Available online: https://www.dof.gob.mx/normasOficiales/3980/salud/salud.htm. (accessed on 14 July 2025).
158. *NOM-128-SSA1-1994*; Bienes y Servicios. Aplicación de un Sistema de Análisis de Riesgos y Control de Puntos Críticos en la Planta Industrial Procesadora de Productos de la Pesca. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 1994. Available online: https://www.dof.gob.mx/nota_detalle.php?codigo=4888152&fecha=12/06/1996#gsc.tab=0 (accessed on 14 July 2025).
159. *NOM-127-SSA1-2021*; Agua para uso y Consumo Humano. Límites Permisibles de la Calidad del Agua. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2021. Available online: https://www.dof.gob.mx/nota_detalle_popup.php?codigo=5650705 (accessed on 25 July 2025).
160. *NOM-201-SSA1-2015*; Productos y Servicios. Agua y Hielo para Consumo Humano, Envasados y a Granel. Especificaciones sanitarias. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2015. Available online: https://dof.gob.mx/nota_detalle.php?codigo=5420977&fecha=22/12/2015#gsc.tab=0 (accessed on 26 August 2025).
161. *NOM-051-SCFI/SSA1-2010*; Especificaciones Generales de Etiquetado para Alimentos y Bebidas no Alcohólicas Preenvasados-Información Comercial y Sanitaria. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2010. Available online: https://www.dof.gob.mx/normasOficiales/4010/seeco11_C/seeco11_C.htm (accessed on 25 July 2025).
162. *NOM-235-SE-2020*; Atún y Bonita Preenvasados-Denominación-Especificaciones-Información Comercial y Métodos de Prueba. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2020. Available online: https://www.dof.gob.mx/normasOficiales/8347/seeco11_C/seeco11_C.html (accessed on 13 July 2025).
163. *NMX-F-605-NORMEX-2018*; Alimentos-Manejo Higiénico en el Servicio de Alimentos Preparados para la Obtención del Distintivo "H". NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2018. Available online: https://www.dof.gob.mx/nota_detalle.php?codigo=5567750&fecha=13/08/2019#gsc.tab=0 (accessed on 24 June 2025).
164. *NMX-FF-032-SCFI-2001*; Productos de la Pesca—Filete de Pescado Fresco Refrigerado. Norma Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2001. Available online: http://www.economia-nmx.gob.mx/normas/nmx/2001/nmx-ff-032-scfi-2001.pdf (accessed on 13 July 2025).
165. *NMX-FF-003-SCFI-2011*; Productos de la Pesca-Calamar Fresco-Congelado-Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: https://platiica.economia.gob.mx/normalizacion/nmx-ff-003-scfi-2011/ (accessed on 15 July 2025).
166. *NMX-F-536-SCFI-2004*; Productos de la Pesca-Filete de Pescado Congelado. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2004. Available online: http://www.economia-nmx.gob.mx/normas/nmx/2004/nmx-f-536-scfi-2004.pdf (accessed on 30 July 2025).

167. *NMX-FF-002-SCFI-2011*; Productos de la Pesca—Pescados de Agua Dulce Refrigerados—ESPECIFICACIONES. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: http://www.economia-nmx.gob.mx/normas/nmx/2010/nmx-ff-002-scfi-2011.pdf (accessed on 23 July 2025).
168. *NMX-F-179-SCFI-2001*; Productos de la Pesca—Sardinas y Pescados Similares Enlatados—Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2001. Available online: http://www.cegaipslp.org.mx/webcegaip2018N.nsf/nombre_de_la_vista/4EBCF69D8034F4048625829F005E2208/\protect\T1\textdollarFile/NMX-F-179-SCFI-2001.pdf (accessed on 13 June 2025).
169. *NMX-F-220-SCFI-2011*; Productos de la Pesca—Productos Alimenticios para Consumo Humano—Atunes y Pescados Similares Enlatados en Aceite-Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: http://www.economia-nmx.gob.mx/normas/nmx/2010/nmx-f-220-scfi-2011.pdf (accessed on 14 April 2025).
170. *NMX-F-363-SCFI-2001*; Productos de la Pesca-Camarones Enlatados en Salmuera-Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2001. Available online: https://platiica.economia.gob.mx/normalizacion/nmx-f-363-scfi-2001/ (accessed on 13 May 2025).
171. *NMX-F-535-1993-SCFI*; Productos de la Pesca—Pulpo Fresco Congelado—Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 1993. Available online: https://platiica.economia.gob.mx/normalizacion/nmx-f-535-1993-scfi/ (accessed on 16 May 2025).
172. *NMX-F-546-SCFI-2011*; Productos de la Pesca—Contenido de Pescado en Productos Empanizados Congelados. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: http://www.economia-nmx.gob.mx/normas/nmx/2010/nmx-f-546-scfi11.pdf (accessed on 10 April 2025).
173. *NMX-F-553-1999-SCFI*; Productos de la Pesca—Pescado en Salsa de Tomate—Enlatado—Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 1999. Available online: http://www.economia-nmx.gob.mx/normas/nmx/1999/nmx-f-553-1999.pdf (accessed on 11 May 2025).
174. *NMX-F-472-SCFI-2011*; Productos de la Pesca-Langosta Congelada-Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: https://platiica.economia.gob.mx/normalizacion/nmx-f-472-scfi-2011/ (accessed on 9 August 2025).
175. *NMX-F-485-SCFI-2011*; Productos de la Pesca—Pulpo en su Tinta Enlatado—Especificaciones. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: http://www.economia-nmx.gob.mx/normas/nmx/2010/nmx-f-485-scfi11.pdf (accessed on 14 April 2025).
176. *NMX-F-506-SCFI-2004*; Productos de la Pesca—Pescado Seco Salado. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2004. Available online: http://www.economia-nmx.gob.mx/normas/nmx/2004/nmx-f-506-scfi-2004.pdf (accessed on 9 July 2025).
177. *NMX-F-524-SCFI-2011*; Productos de la Pesca—Atún Empacado en Envases Flexibles Retortables. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: https://platiica.economia.gob.mx/normalizacion/nmx-f-524-scfi-2011/ (accessed on 10 July 2025).
178. *NMX-F-540-SCFI-2011*; Productos de la Pesca-Determinación del Estado de Frescura-Método de Prueba. NORMA Oficial Mexicana, Gobierno de México: Mexico City, Mexico, 2011. Available online: https://platiica.economia.gob.mx/normalizacion/nmx-f-540-scfi-2011/ (accessed on 15 August 2025).
179. ST. *Entradas aéreas de turistas extranjeros por País de Residencia*; Secretaria de Turismo (ST), Gobierno de México: Mexico City, Mexico, 2025. Available online: https://datatur.sectur.gob.mx/SitePages/Visitantes%20por%20Residencia.aspx (accessed on 20 August 2025).
180. EC. *Trade and Economic Security*; European commission (EC): Mexico, 2025. Available online: http://ec.europa.eu/trade/policy/countries-and-regions/countries/mexico/ (accessed on 16 August 2025).
181. Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 Laying Down the General Principles and Requirements of Food Law, Establishing the European Food Safety Authority and Laying Down Procedures in Matters of Food Safety. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32002R0178 (accessed on 29 August 2025).
182. Regulation (EC) No 852/2004 of the European Parliament and of the Council of 29 April 2004 on the Hygiene of Foodstuffs. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004R0852 (accessed on 30 August 2025).
183. Regulation (EC) No 853/2004 of the European Parliament and of the Council of 29 April 2004 Laying down Specific Hygiene Rules for on the Hygiene of Foodstuffs. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32004R0853 (accessed on 29 August 2025).

184. Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on Official Controls and Other Official Activities Performed to Ensure the Application of Food and Feed Law, Rules on Animal Health and Welfare, Plant Health and Plant Protection Products. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R0625 (accessed on 13 August 2025).
185. Commission Regulation (EC) No 1881/2006 of 19 December 2006 Setting Maximum Levels for Certain Contaminants in Foodstuffs. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32006R1881 (accessed on 12 August 2025).
186. Commission Regulation (EC) No 2073/2005 of 15 November 2005 on Microbiological Criteria for Foodstuffs. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R2073 (accessed on 12 August 2025).
187. Commission Regulation (EC) No 2074/2005 of 5 December 2005 Laying Down Implementing Measures for Certain Products Under Regulation (EC) No 853/2004 of the European Parliament and of the Council and for the Organization of Official Controls Under Regulation (EC) No 854/2004 of the European Parliament and of the Council and Regulation (EC) No 882/2004 of the European Parliament and of the Council, Derogating from Regulation (EC) No 852/2004 of the European Parliament and of the Council and Amending Regulations (EC) No 853/2004 and (EC) No 854/2004. Available online: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005R2074 (accessed on 12 August 2025).
188. FDA. Seafood. US. Food and Drugs administration (FDA), 2025. Available online: https://www.fda.gov/food/resources-you-food/seafood (accessed on 18 August 2025).
189. NOAA. Fisheries Aquaculture. National Oceanic and Atmospheric Administration (NOAA) Fisheries, 2025. Available online: https://www.fisheries.noaa.gov/topic/aquaculture/overview (accessed on 20 August 2025).
190. FSIS Food Safety. Food Safety and Inspection Service (FSIS). 2025. Available online: https://www.fsis.usda.gov/food-safety (accessed on 20 August 2025).
191. eCFR The Code of Federal Regulations (CFR). The Electronic Code of Federal Regulations (eCFR). Federal Government of the United States, 2025. Available online: https://www.ecfr.gov/ (accessed on 29 August 2025).

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.