Colegio de Postgraduados

# Microbiological quality of marketed fish and shrimp in San Luis Mextepec in the State of Mexico, Mexico

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**ABSTRACT**

**Objective**: To analyze the common and widely marketed fishing products in the popular area of San Luis Mextepec, in the state of Mexico belonging to the Mexican Republic to determine the hazards and potential risks to health from consumption of those products.

**Design/methodology/approach**: Samples of fish fillet and whole shrimp were collected from available fish shops in the popular aquatic food marketing area every week, for a month. The evaluation of their microbiological quality was performed through test aerobic mesophiles, total coliforms, *Salmonella*, fungi, and yeasts.

**Results**: The analysis of aerobic mesophiles in fish and shrimp indicated that they did not exceed the permissible limits of the health standard, while coliforms in fish and shrimp 50% exceeded the permissible limit in 100% and 50% of the samples respectively. For fungi in fish and shrimp they presented counts that ranged between 8 and 2150 CFU/g, while the yeast values ranged between 95 and 1010 CFU/g. Finally, in the analysis of *Salmonella*, 50% of fish and shrimp samples tested positive for the presence of the pathogen, exceeding the limit established by health standards and indicating a health risk for consumers.

**Limitations on study/implications**: This study should be replicated at another time of the year since the type and degree of contamination in fish and shrimp can vary, influencing microbiological hazards and risk to the health of consumers.

**Findings/conclusions**: The microbiological analysis of marketed fish and shrimp indicated the presence of microbiological contamination that influences their quality and safety, becoming a hazard and public health risk.

**Keywords**: Quality, pathogens, foodborne diseases, food safety, fish, public health.

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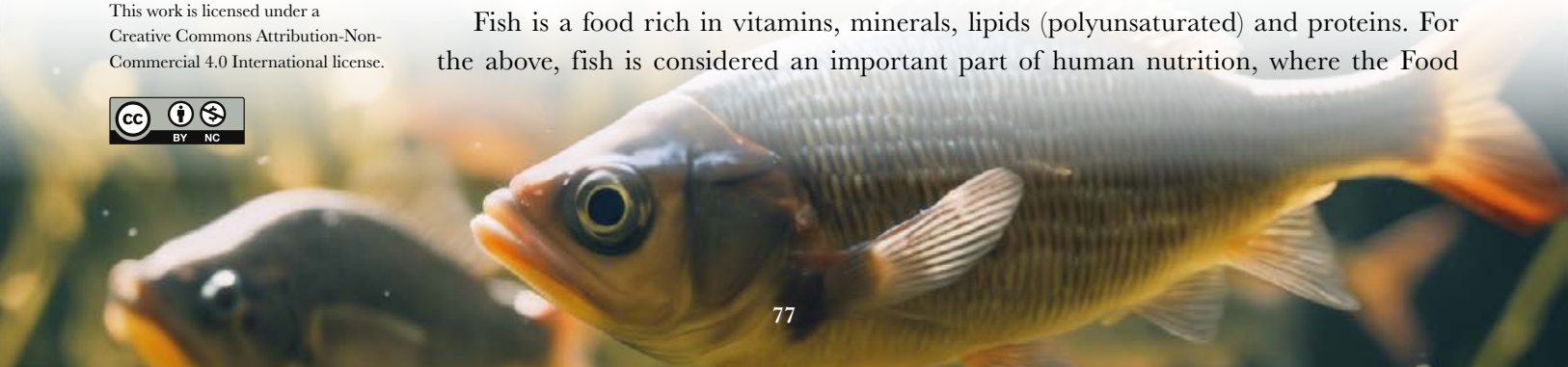
## INTRODUCTION

Fish is a food rich in vitamins, minerals, lipids (polyunsaturated) and proteins. For the above, fish is considered an important part of human nutrition, where the Food



and Agriculture Organization (FAO) has recommended its consumption twice or more times a week (de Oliveira & Amancio, 2012; Murillo *et al.*, 2023). For definition purposes, the term fish refers to fish, crustaceans, mollusks, among other members of aquatic environments intended for human consumption (de Paiva Soares & Gonçalves, 2012; de Oliveira & Amancio, 2012). As a food, fish is an important part of cultural traditions around the world, in addition to being among the most commercialized foods, and being fundamental in global and local economic aspects (Murillo *et al.*, 2023). Despite its nutritional benefits, fish tends to be very susceptible to deterioration and contamination due to autolysis, oxidation and microbiological activity, reducing its shelf life, and becoming a risk of disease for consumers (de Paiva Soares & Gonçalves, 2012). Foodborne diseases are currently an important public health problem worldwide due to the extent of their impact (de Paiva Soares & Gonçalves, 2012; Torrens *et al.*, 2015) and negative economic and social impact, being the most vulnerable populations the elderly, children and the immunocompromised, as well as the population living in high levels of poverty and unhealthiness (Torrens et al., 2015). Fish and related products have been identified as high-risk food implicated in various outbreaks around the world, where the main contaminating agents being microorganisms which are the main causes of contamination due to inadequate handling, conservation conditions and practices (Olea *et al.*, 2012; López *et al.*, 2013; Espinosa *et al.*, 2014). In Mexico, gastrointestinal diseases due to the consumption of microbiologically contaminated foods are also one of the main public health problems, with the low socioeconomic levels of the population being the most affected (Hernández *et al.*, 2011). Therefore, this study focuses on the analysis of common and widely marketed fishing products at San Luis Mextepec, in the state of Mexico, which is part of the Mexican Republic, to determine the hazards and potential risks to the health's public from consumption of these products.

## MATERIALS AND METHODS

### Area and sample collection

The fish samples consisted of carp (*Cyprinus carpio communis*) in fresh fillet presentation and whole frozen shrimp (*Farfantepenaeus brevirostris*) that were collected randomly from two available fish shop (A and B) in the central area of San Luis Mextepec, where the popular sale of foods of aquatic origin takes place. The samples collected consisted of 2 fillets (150 g) and 2 whole shrimp (603 g) per fish shop per week for 4 weeks between the months of June and July 2023, for a total of 32 samples.

### Methodology

The samples were collected following the NOM-109-SSA1-1994 procedure and transported in aseptic and cold conditions to the laboratory of the Universidad Autónoma Metropolitana, Lerma Unit, for analysis. Once in the laboratory, the samples were subjected to the analysis of total aerobic mesophiles (AM) (NOM-092-SSA1-1994), total coliforms (TC) (NOM-113-SSA1-1994), *Salmonella* spp. (NOM-114-SSA1-1994), fungi (F) and yeasts (Y) (NOM-111-SSA1-1994). The studies were done in triplicate.

### Analysis of data

The data analysis was performed using the Microsoft Excel spreadsheet software for Windows version 15 (2013).

## RESULTS AND DISCUSSION

### Aerobic mesophiles (AM) and total coliforms (TC)

The carp fillet samples from fish shop A, during their second week of study, obtained the highest values for AM ranging between 26,400 and 25,500 CFU/g, while for fish shop B the highest proportions were found in samples collected in the third week of the study, ranging between 22100 and 22600 CFU/g, where no one exceeded the permitted health limit. Meanwhile, for TC, all carp fillet samples exceeded the sanitary limit, with the highest proportions in samples from fish shops having values between 9300 and 18450 CFU/g in the second week of the study. For shrimp, the highest proportions of AM found were 16,400 and 14,500 CFU/g in samples from week 2 of the study from fishery B, although without exceeding the sanitary limit. Finally, for TC in shrimp, 50% of the samples exceeded the sanitary limit, being the samples from fish shop B, in week 1 (W), with the highest proportions obtained ranging from 2450 to 5300 CFU/g (Table 1).

AM are microbiological indicators of food quality, where high counts indicate contaminated raw materials or unsatisfactory processing treatments, inadequate time/

**Table 1**. Microbiological analysis of AM and TC in carp samples (*Cyprinus carpio communis*) in fresh fillet presentation and frozen whole shrimp (*Farfantepenaeus brevirostris*).

| FS | W | C | AM CFU/g | TC CFU/g | S | AM CFU/g | TC CFU/g | MSAM CFU/g*▲ | MSC CFU/g+ |
|---|---|---|---|---|---|---|---|---|---|
| A | 1 | 1 | 13800±282 | 2320±254 | 1 | 2250±353 | 275±35 | $1\times10^{7}$ | $1\times10^{3}$ |
| | | 2 | 15050±777 | 4000±707 | 2 | 2500±282 | 750±70 | | |
| | 2 | 1 | 26400±1979 | 18450±2192 | 1 | 2400±141 | 2375±106 | | |
| | | 2 | 25500±707 | 9300±989 | 2 | 2050±212 | 1350±70 | | |
| | 3 | 1 | 21600±989 | 13900±1555 | 1 | 4800±282 | 1400±141 | | |
| | | 2 | 22150±212 | 9350±919 | 2 | 5450±353 | 1150±212 | | |
| | 4 | 1 | 13950±1060 | 5350±919 | 1 | 1750±212 | 550±70 | | |
| | | 2 | 14850±212 | 4050±1343 | 2 | 2002±144 | 450±70 | | |
| B | 1 | 1 | 13450±550 | 2550±450 | 1 | 9050±950 | 2450±50 | | |
| | | 2 | 13550±650 | 1600±400 | 2 | 7600±400 | 5300±200 | | |
| | 2 | 1 | 20700±2700 | 9650±350 | 1 | 16400±600 | 2160±40 | | |
| | | 2 | 21000±2400 | 9300±700 | 2 | 14500±500 | 2065±35 | | |
| | 3 | 1 | 22100±1100 | 12450±550 | 1 | 2400±200 | 730±20 | | |
| | | 2 | 22600±600 | 8800±1200 | 2 | 2800±200 | 665±45 | | |
| | 4 | 1 | 11300±500 | 4200±800 | 1 | 5000±1000 | 675±75 | | |
| | | 2 | 11050±750 | 2700±500 | 2 | 6500±1500 | 325±25 | | |

FS: Fish shop. W: Study week C: Carp sample. S: Shrimp sample. AM: aerobic mesophiles, TC: total coliforms, CFU: Colony-Forming Unit. MSAM: Microbiological specification for aerobic mesophiles, MSC: Microbiological specification for coliforms. *NOM-027-SSA1-1993. ▲ ICMSF. +BOE-A-1991-2073.

temperature conditions during storage. It should also be noted that the presence in a high proportion may indicate that there were favorable conditions for the multiplication of possible mesophilic pathogenic microorganisms of human or animal origin (Obregón & Zambrano, 2017). Coliforms are Gram-negative bacteria, whose presence in food can come from an environmental origin or from fecal contamination. Their presence is considered an indicator of inadequate cleaning operations, unsanitary conditions, or contamination during or after processing stages, failures in process conditions such as temperature management or critical control points (NOM-113-SSA1-1994). On the other hand, a high presence of coliforms can lead to the monitoring of pathogens. It has been pointed out that they are indicators of fecal contamination and the possible presence of viral or bacterial pathogens (Barrera-Escorcia *et al*., 2013). In related studies Quintero *et al*. (2012) reported that through the analysis of AM in fresh fillet of the species *Mugil cephalus*, *Scomberomorus sierra* and *Coryphaena hippurus*, sold in two different points Mazatlán, Sinaloa, Mexico, presented an average quality range of 5.2 to 5.9 $\log_{10}$ CFU/g, which was within the maximum permissible sanitary limit for marketing. Morales *et al*. (2004) in a microbiological study that involved different microorganisms, including total coliforms from the skin or surface of *O. niloticus* produced in the northern area of Costa Rica intended for human consumption, reported that 74% of the samples analyzed had a proportion $\geq 10^3$ CFU/g, reflecting poor hygiene in their production, high contamination of the waters of origin and involving a risk to public health.

**Fungi (F) and yeast (Y)**

In carp fillet, the highest proportions of fungi were found during week 4 in samples from both fish shops A and B with values that ranged between 2100 and 2150 CFU/g; meanwhile, for Y, the highest proportions found throughout the study were in samples from fish shop B during week 1 (W), having values of 2450 and 2260 CFU/g. For shrimp, the proportion of F in samples ranged between 8 and 101 CFU/g, while for Y the values were between 125 and 1010 CFU/g throughout the study (Table 2).

The determination of fungal organisms in food allows establishing an indicator of inadequate sanitary conditions and practices in raw materials, production and storage processes, in addition to health risks due to foods contaminated by the potential presence of mycotoxins (NOM-111-SSA1-1994; Centeno & Rodríguez, 2005). Currently, official Mexican standards do not have microbiological limits for fungi and yeasts in frozen fish fillets or shrimp. In related studies Centeno & Rodríguez (2005) reported average counts of F and Y in *Scomberomorus* spp., and *Merluccius* spp., of 1.9×103 CFU/g and 2.0 x 102 CFU/g respectively, both marketed in markets Sucre, Venezuela.

**Salmonella**

The analysis of carp and shrimp fillet samples from fish shops A and B indicated that 50% tested positive for *Salmonella* spp., presence, exceeding the limit established by health standards in food, and indicating a risk to the health of consumers (Table 3), especially if consumed in a raw state as in typical culinary preparations of the country as the ceviche.

**Table 2**. Microbiological analysis of F and Y in samples of fresh fillet carp (*Cyprinus carpio communis*) and whole frozen shrimp (*Farfantepenaeus brevirostris*).

| FS | W | C | F CFU/g | Y CFU/g | S | F CFU/g | Y CFU/g |
|---|---|---|---|---|---|---|---|
| A | 1 | 1 | 8±3 | 113±17 | 1 | 95±7 | 225±35 |
| | | 2 | 20±4 | 115±21 | 2 | 90±14 | 212±17 |
| | 2 | 1 | 250±70 | 325±35 | 1 | 93±10 | 450±70 |
| | | 2 | 105±7 | 317±24 | 2 | 96±6 | 350±70 |
| | 3 | 1 | 125±35 | 110±14 | 1 | 15±7 | 235±49 |
| | | 2 | 112±17 | 105±7 | 2 | 8±3 | 290±14 |
| | 4 | 1 | 2150±70 | 102±3 | 1 | 95±7 | 215±21 |
| | | 2 | 2100±141 | 190±14 | 2 | 90±14 | 222±31 |
| B | 1 | 1 | 1125±25 | 2450±50 | 1 | 95±5 | 550±50 |
| | | 2 | 725±25 | 2260±40 | 2 | 97±3 | 650±50 |
| | 2 | 1 | 225±25 | 190±10 | 1 | 96±5 | 1010±110 |
| | | 2 | 325±25 | 290±10 | 2 | 95±5 | 230±30 |
| | 3 | 1 | 125±25 | 95±5 | 1 | 45±5 | 125±25 |
| | | 2 | 110±10 | 105±5 | 2 | 9±1 | 240±40 |
| | 4 | 1 | 2150±50 | 103±3 | 1 | 101±1 | 325±25 |
| | | 2 | 2125±75 | 190±10 | 2 | 95±5 | 315±15 |

FS: Fish shop. W: Study week. C: Carp sample. S: Shrimp sample. F: Fungi, Y: Yeasts, CFU: Colony-Forming Unit.

**Table 3**. Microbiological analysis of *Salmonella* spp., in samples of carp (*Cyprinus carpio communis*) in fresh fillet presentation and whole frozen shrimp (*Farfantepenaeus brevirostris*).

| FS | W | C | *Salmonella* spp. Presence/ Absence in 25g. | S | *Salmonella* spp. Presence/ Absence in 25g. | Microbiological specification for fish and products *△ ▲ $\delta$ |
|---|---|---|---|---|---|---|
| A | 1 | 1 | Absence | 1 | Absence | Absence in 25g. |
| | | 2 | Absence | 2 | Absence | |
| | 2 | 1 | Absence | 1 | Presence | |
| | | 2 | Absence | 2 | Presence | |
| | 3 | 1 | Presence | 1 | Presence | |
| | | 2 | Presence | 2 | Presence | |
| | 4 | 1 | Presence | 1 | Presence | |
| | | 2 | Presence | 2 | Presence | |
| B | 1 | 1 | Absence | 1 | Presence | |
| | | 2 | Absence | 2 | Presence | |
| | 2 | 1 | Absence | 1 | Absence | |
| | | 2 | Absence | 2 | Absence | |
| | 3 | 1 | Presence | 1 | Absence | |
| | | 2 | Presence | 2 | Absence | |
| | 4 | 1 | Presence | 1 | Absence | |
| | | 2 | Presence | 2 | Absence | |

FS: Fish shop. W: Study week. C: Carp sample. S: Shrimp sample. *NOM-027-SSA1-1993, △ NOM-242-SSA1-2009, ▲ NTE-INEN 183-2013, $\delta$ BOE-A-1991-20734.

*Salmonella* spp., is a bacteria considered one of the zoonotic agents responsible for numerous cases of foodborne illnesses, including fish, around the world (Arias & Buelga, 2005; Espinosa *et al.*, 2014), mainly from waters contaminated with fecal matter and associated with inadequate hygiene conditions and practices during the processing, conservation, or post-capture handling of fish (Arias & Buelga, 2005). In this study, the variation in the qualitative and quantitative microbiological analysis found in fish and shrimp may be associated with changes in hygienic handling conditions, post-capture product temperature control and marketing in sampling fisheries during the study period. In a related study Cedeño *et al.* (2021) reported that the marketed tuna (*Thunnus alalunga*), sold at the municipal market of Chone, Ecuador, had a presence of *Salmonella* of 100% in the samples analyzed, considering them as risk to the health of consumers.

## CONCLUSIONS

The evaluation of fish and shrimp sold in the area indicated the presence of microbiological contamination that may influence their quality and safety, becoming a hazard and risk to the health of consumers. In the microbiological analysis, the proportion of AM in 100% of the samples was below the limit of the health standard. For TC in fish, 100% of the samples and 50% of the shrimp samples were above the permissible sanitary limit, while *Salmonella* spp., was found in 50% of the fish and shrimp samples, exceeding the permissible sanitary limit and being considered a risk to the health of consumers. As a recommendation, it is essential to reinforce training in the hygienic handling of fish in post-capture and marketing conditions to reduce the microbial load and risk of food-borne diseases.

## REFERENCES

Arias, F.C.H., & Buelga, J.A.S. (2005). Prevalencia de *Salmonella* spp en pescado fresco expendido en Pamplona (Norte de Santander). *Bistua: Revista de la Facultad de Ciencias Básicas, 3*(2), 34-42. https://www.redalyc.org/pdf/903/90330205.pdf

Barrera-Escorcia, G., Fernández-Rendón, C. L., Wong-Chang, I., & Ramírez Romero, P. (2013). La sensibilidad del grupo coliforme como indicador de la presencia de enterobacterias patógenas en cuatro cuerpos acuáticos de México. *Hidrobiológica, 23*(1), 87-96.

BOE-A-1991-20734. (1991). Reglamentación técnico-sanitaria de los establecimientos y productos de la pesca y acuicultura con destino al consumo humano. Real Decreto 1521/1984. Boletín Oficial del Estado (BOE). 195, 27153-27155. Gobierno de España. https://www.boe.es/buscar/doc.php?id=BOE-A-1991-20734

Cedeño Mendoza, A.L., Vargas Zambrano, P.A., Talledo Solórzano, V., & Cuenca Nevárez, G. (2021). La Evaluación Microbiológica de Pescado Fresco Albacora (*Thunnus alalunga*) en el Mercado Central del Cantón Chone. *La Técnica*, 69-81. https://dialnet.unirioja.es/descarga/articulo/8232819.pdf

Centeno, S., & Rodríguez, R. (2005). Evaluación microbiológica de pescados congelados producidos en Cumaná, estado Sucre, Venezuela. *Revista Científica, 15*(2), 168-175. https://www.redalyc.org/pdf/959/95915212.pdf

de Oliveira Sartori, A.G., & Amancio, R.D. (2012). Pescado: importância nutricional e consumo no Brasil. *Segurança alimentar e nutricional, 19*(2), 83-93. https://doi.org/10.20396/san.v19i2.8634613

de Paiva Soares, K. M., & Gonçalves, A. A. (2012). Qualidade e segurança do pescado. *Revista do Instituto Adolfo Lutz, 71*(1), 1-10. https://docs.bvsalud.org/biblioref/ses-sp/2012/ses-25855/ses-25855-3684.pdf

Espinosa, L., Varela C., Martínez, E.V., & Cano-Portero, R. (2014). Brotes de enfermedades transmitidas por alimentos. España, 2008-2011 (excluye brotes hídricos). *Boletín Epidemiológico Semanal, 22*(11), 130-145.

Hernández Cortez, C., Aguilera Arreola, Ma. G., & Castro Escarpulli, G. (2011). Situación de las enfermedades gastrointestinales en México. *Enfermedades infecciosas y microbiología, 31*(4), 137-151. https://www.medigraphic.com/pdfs/micro/ei-2011/ei114f.pdf?fbclid=IwAR2fYzcA3m

ICMSF (1998). Microorganisms in foods: microbiological ecology of food contaminants. The International Commission on Microbiological Specifications for Foods (ICMSF). Blackie Academic and Professional, London.

López Aday, D., Rivero Álvarez, E., Martínez Torres, A., & Alegret Rodríguez, M. (2013). Enfermedades transmitidas por alimentos en Villa Clara. *Revista Cubana de Higiene y Epidemiología, 51*(2), 203-213.

Morales, G., Blanco, L., Arias, M. L., & Chaves, C. (2004). Evaluación de la calidad bacteriológica de tilapia fresca (*Oreochromis niloticus*) proveniente de la Zona Norte de Costa Rica. *Archivos Latinoamericanos de Nutrición, 54*(4), 433-437.

Murillo Cisneros, D. A., E. Symon, T., & Zenteno Savín, T. (2023). Salud alimentaria en las cadenas tróficas marinas. *Recursos Naturales y Sociedad, 8*(3), 43-57. https://doi.org/10.18846renaysoc.2023.08.08.01.0005

NOM-092-SSA1-1994. Método para la cuenta de bacterias aerobias en placa. Secretaria de Salud. Gobierno de México. http://www.economia-noms.gob.mx/normas/noms/1995/092-ssa1.pdf

NOM-109-SSA1-1994. Procedimientos para la toma, manejo y transporte de muestras de alimentos para su análisis microbiológico. Secretaria de Salud. Gobierno de México.

NOM-111-SSA1-1994. Método para la cuenta de mohos y levaduras en alimentos. Secretaria de Salud. Gobierno de México. http://www.economia-noms.gob.mx/normas/noms/1995/111-ssa1.pdf

NOM-113-SSA1-1994. Método para la cuenta de microorganismos coliformes totales en placa. Secretaria de Salud. Gobierno de México. http://www.economia-noms.gob.mx/normas/noms/1995/113-ssa1.pdf

NOM-114-SSA1-1994. Método para la determinación de Salmonella en alimentos. Secretaria de Salud. Gobierno de México. http://www.economia-noms.gob.mx/normas/noms/1995/114-ssa1.pdf

NTE INEN 183. (2013). Instituto Ecuatoriano de Normalización. Normativa Técnica Ecuatoriana. Pescado fresco refrigerado o congelado. Requisitos. Enmienda (2014-03-18). Primera Revisión. Quito, Ecuador. https://faolex.fao.org/docs/pdf/ecu122184anexo.pdf

Obregón Dionicio, D.C., & Zambrano Charca, Z.J. (2017). Evaluación microbiológica (aerobios mesófilos, *Bacillus cereus* y *Staphylococcus aureus*) y químico – toxicológica de metales pesados (pb, hg) en leche para consumo humano en el distrito de Puente Piedra – Lima. (Licenciatura). Universidad Nacional Mayor de San Marcos. Perú. https://core.ac.uk/download/pdf/323341338.pdf

Olea, A., Díaz J., Fuentes, R., Vaquero, A., & García, M. (2012). Vigilancia de brotes de enfermedades transmitidas por alimentos en Chile. *Revista chilena de infectología, 29*(5), 504-510. https://dx.doi.org/10.4067/S0716-10182012000600004

Quintero, G. B., De León, J. A. R., Ruiz, J. A. C., Humaran, I. L. S., Inzunza, J.R.R., & Hernández, J. M. M. (2012). Contenido de histamina y calidad microbiológica de pescado comercializado en Mazatlán, Sinaloa. *BIOtecnia, 14*(1), 3-12. https://www.redalyc.org/pdf/6729/672971151001.pdf

Torrens, H.R., Argilagos, G. B., Cabrera, M.S., Valdés, J. B., Sáez, S.M., & Viera, G. G. (2015). Las enfermedades transmitidas por alimentos, un problema sanitario que hereda e incrementa el nuevo milenio. *REDVET. Revista Electrónica de Veterinaria, 16*(8), 1-27.