Imperial Journal of Interdisciplinary Research (IJIR)
Vol-3, Issue-4, 2017
ISSN: 2454-1362, http://www.onlinejournal.in

Microbial Spoilage in Fish

Dhanya.P.R [1*] & Saleena Mathew [2]
[1,2] School of Industrial Fisheries,
Cochin University of Science and Technology, Cochin.

Abstract: *Seafoods are high on list of foods associated with outbreaks of food borne diseases. In raw fish, spoilage takes place mainly due to enzymatic, microbial and chemical action. Among these three, fish spoilage due to bacteria gains greater concern as a health hazard. In dead fish, bacteria begin to invade the tissues causing spoilage and production of undesirable compounds leading to food safety issues. Gram-negative genera including: Acinetobacter, Flavobacterium, Moraxella, and Pseudomonas dominates the autochthonous bacteria flora of fish. Vibrio, Photobacterium and Aeromonas spp. are also common aquatic bacteria, and typical of fish flora. Various bacteria are found in the digestive tracts and feaces of animals and humans. Some of these bacteria, i.e. faecal coliforms, E.coli and Enterococcus spp., are used as hygiene indicators. Viruses, bacterial spores and sexual spores of fungi are likely to be preserved by freezing, irrespective of the composition of food and the rates of freezing and thawing. The extent to which freezing and subsequent frozen storage reduces the number of any organism may be trivial if the population is in a resistant physiological state. Unwanted microorganisms access fish processing environments through raw material, mobile equipment such as forklifts and through pests. Poor hygiene, particularly deficient or absence of hand washing has been identified as the causative mode of transmission. Proper hand washing and disinfection has been recognized as one of the most effective measures to control the spread of pathogens when considered along with the restriction of ill workers.*

1. Introduction

Fish is an important part of a healthy diet since they contain high quality protein. It is also a highly perishable commodity. They are also prone to contamination at various stages of handling and processing. Contamination is a very important aspect as this is the mode that most unwanted microorganisms may be transmitted onto seafood and other food products. There is substantial evidence that seafoods are high on list of foods associated with outbreaks of food borne diseases [1] (Huss *et al*., 2003). In raw fish, spoilage takes place mainly due to enzymatic, microbial and chemical action. Among these three, fish spoilage due to bacteria gains greater concern as a health hazard. Bacteria are present on the surface slime, skin, gills and intestine of fish. In dead fish, bacteria begin to invade the tissues causing spoilage and production of undesirable compounds leading to food safety issues.

2. Bacterial flora in fish

The subsurface flesh of live healthy fish is usually sterile and does not contain any bacteria or other organisms. But, microorganisms colonize the skin, gills and the gastrointestinal tract of fish. The geographical location, the season and the method of harvest are the reasons deciding the number and diversity of microbes. The natural fish microflora tends to reflect the microbial communities of the surrounding waters. Fish harvested from eutrophic and warm waters will present higher bacterial numbers than fish from clean and cold waters. But, potential human pathogens may be present in both cases [2] (Arias, 2009).

Gram-negative genera including: *Acinetobacter, Flavobacterium, Moraxella, Shwenella* and *Pseudomonas* dominates the autochthonous bacteria flora of fish. *Vibrio, Photobacterium* and *Aeromonas spp.* are also common aquatic bacteria, and typical of fish flora. Gram-positive organisms such as *Bacillus, Micrococcus, Clostridium, Lactobacillus* and *coryneforms* can also be found in varying proportions on fish.

The initial microflora of fish can contain human pathogenic bacteria, posing a concern for seafood borne illnesses [3] (Davies *et al*., 2001). These pathogens can be divided into two groups: organisms naturally present on the fish and those that although not autochthonous to the aquatic environment, are present there as a result of contamination or are introduced to the fish during harvest, processing or storage. However, number of pathogenic organisms in fresh raw fish tends to be low and risk associated with the consumption of seafood is low. In addition, potential pathogenic bacteria is outgrown by indigenous spoilage bacteria during storage. Shelf life depends on the initial microflora on the fish, potential contaminants added during handling, processing, and conditions of storage [2] (Arias, 2009).

3. Spoilage of fish

Food spoilage is considered as any change that renders the product unacceptable for human consumption [4] Sivertsvik *et al*., 2002). Spoilage of fish starts upon death due to autoxidation, autolytic activity and metabolic activities of microorganisms present in the fish.

Microbial food spoilage occurs as a consequence of either microbial growth in a food or release of microbial extracellular and intracellular enzymes into the food environment. Some of the detectable parameters associated with spoilage of different types of foods are changes in color, odor, and texture; formation of slime; accumulation of gas; and accumulation of liquid. Between initial production and final consumption, different methods are used to preserve the qualities of foods, which include the reduction of microbial numbers and growth. Yet, microorganisms grow and cause spoilage, which for some foods like fish could be relatively high.

4. Significance of bacteria in spoilage

Raw and processed foods normally contain many types of microorganisms capable of multiplying and causing spoilage. Bacteria, because of their shorter generation time, are in a favourable position over moulds to cause rapid spoilage of foods. Therefore, among the three microbial groups, the highest incidence of spoilage, especially rapid spoilage, of processed foods is caused by bacteria, followed by yeasts and molds. Due to this reason the initial microbial load and the percentage of spoilage bacteria in it decide the shelflife of any product.

5. Effects of freezing on microorganisms

Most water in foods usually contains more or less complex blend of solutes. The presence of solutes in water depresses the temperature at which freezing can initiate, usually to a temperature between -1°C and -3°C[5] (Bogh and Jul.,1985). Once ice crystals start forming in the solution, the concentrations of solutes in the remaining liquid water increases [6] (Berg, 1968). On freezing the water available for the microorganisms for maintaining their metabolic activities decreases. The availability water in a food, frozen or otherwise can be expressed as its water activity (a_w), which is the ratio of the water vapour pressure of food to that of pure water at the same temperature [7] (Leistner and Russell, 1991). For any frozen food, a_w will be that of ice at the same temperature.

Microorganisms that can grow at chiller temperature are referred to as psychrophilic or psychrotrophic, depending on the temperature range within which they can grow [8] (Olson and Nottingham, 1980). The former term is applied to organisms that does not tolerate warm temperatures and are mainly derived from cold environments. The latter term has been applied to organisms responsible for the spoilage of chilled foods, and usually have maximum temperatures for growth between 30°C and 35°C [9] (Kraft, 2000).

The minimum temperature for growth of a bacteria is regarded as a characteristic feature, but the lowest temperature at which growth occurs is usually higher when an organism is subjected to other stresses in addition to low temperature[10] (Mc Meekin *et al*., 1993). The minimum temperature for growth in the absence of other stresses has been determined for some organisms capable of growth at freezing temperature by cultivating the organisms in supercooled media. The growth of *Vibrios* at -4°C [11] (Sasajima, 1974), have been established using this technique. Yet, in practice, microorganisms in frozen foods will almost inevitably be exposed to osmotic stress or desiccation and to inhibiting concentration of some solutes as well as to low temperatures. Moreover, even when the growth of various organisms is possible, the rate of growth of some may be slow as to render any increase in their number or size inconsequential for the safety or storage stability of the product.

Temperature gradients commonly exist within refrigerated facilities and temperatures can rise during periodic defrosting of refrigeration equipment [12] (Jul, 1984). Consequently, if frozen foods are stored in commercial facilities with refrigeration equipment operating at temperatures close to -10°C, some of the products may be exposed to higher temperatures at which microorganisms may grow to cause spoilage. Measurement of sensory, chemical and physical changes have shown that deterioration of fish quality continues to some extent during frozen storage[13] (Haard, 1992). This results in undesirable changes associated with lipids and proteins [14] (Abdalla *et al*., 1989).

6. Indicator microorganisms

Various bacteria are found in the digestive tracts and feaces of animals and humans. Some of these bacteria, i.e. faecal coliforms, *E.coli* (the predominant group of the faecal coliform group), and *Enterococcus* spp., are used as hygiene indicators [15] (Frahm and Obst, 2003). Indicator microorganisms are microorganisms or a group of microorganisms indicative for the possible presence of pathogens whose presence in given numbers points to inadequate safety in processing [16] (Mossel *et al*., 1995). In general, they are most often used to assess food sanitation [17] (Jay, 1992).

There is no universal agreement on which indicator microorganism is most useful, nor are there federal regulations mandating a single standard for bacterial indicators. Thus, different indicators and different indicator levels identified as standards are used in different states, countries, and regions. Today, the most commonly measured bacterial indicators are total coliforms (TC), faecal coliforms (FC), and enterococci (EC). More recently, *E.coli* (a subset of the FC group) and EC were established as prefered indicators [18] (Noble *et al*., 2003).

Food plants and many other institutions require sanitary conditions in order to prevent microbial contamination. The continuous evaluation of these environments is particularly important in order to assure the safety and quality of products, and the number of microbial cells contaminating food surfaces must be determined for this assessment [19] (Yamaguchi *et al*., 2003). Many methods have been developed to detect microorganisms, and although some methods of analysis are better than others, every method has certain inherent limitations associated with its use [17] (Jay, 1992).

7. Routes of contamination

Unwanted microorganisms may access fish processing environments through raw material, personnel or mobile equipment such as forklifts, through leakage and openings in buildings, or through pests and some pathogens may even become established in the processing plant and form niches where they can survive for long periods of time[20] (Reij *et al*., 2003). Many of these microorganims occur naturally in aquatic and general environments, and may be transmitted onto seafood before capture, during and after processing. Also, contamination through air can occur through dust particles or via aerosols which are formed especially when contaminated surfaces, floors or drains are sprayed with high pressure-jets, resulting in formation of droplets that can be suspended in the air [21] (Aantrekker *et al*., 2003). Water is also a vehicle for transmission of many agents of diseases[22] (Kirby *et al*., 2003).

Liston [23] estimated the total number of microorganisms to vary enormously from a normal range of 10^5-10^7 cfu (colony forming units)/cm^2 on the skin surface. Contamination of fish products through contaminated surfaces has also been observed in many cases [20] (Reij *et al*., 2003). Unclean, insufficiently or inadequately cleaned processing equipment have been identified as a source of bacterial contamination in processed seafood. Containers, pumps or tanks used for holding or transporting unprocessed raw materials, have occasionally been used for processed products without any cleaning and disinfection. It is therefore necessary that equipment in the processing establishment, coming in contact with food, be constructed in such a way as to ensure adequate cleaning, disinfection and proper maintenance to avoid the contamination [24] (CAC, 1997a).

Transfer of microorganisms by personnel, particularly from hands, is of vital importance [25] (Bloomfield, 2003). During handling and preparation, bacteria are transferred from contaminated hands of workers to food and subsequently to other surfaces [26] (Montville *et al*., 2002). Low infectious doses of organisms such as *Shigella* and pathogenic *Escherichia coli* have been linked to hands as a source of contamination [27] (Snyder, 1998). Poor hygiene, particularly deficient or absence of hand washing has been identified as the causative mode of transmission [20] (Reij *et al*., 2003). Proper hand washing and disinfection has been recognized as one of the most effective measures to control the spread of pathogens, especially when considered along with the restriction of ill workers [28] (Montville *et al*., 2001).

8. Conclusion

Bacteria are present on the surface slime, skin, gills and intestine of fish. In dead fish, bacteria begin to invade the tissues causing spoilage and production of undesirable compounds leading to food safety issues. Gram-negative genera including: *Acinetobacter, Flavobacterium, Moraxella, Shwenella* and *Pseudomonas* dominates the autochthonous bacteria flora of fish. *Vibrio, Photobacterium* and *Aeromonas spp.* are also common aquatic bacteria, and typical of fish flora. Various bacteria are found in the digestive tracts and feaces of animals and humans. Some of these bacteria, i.e. faecal coliforms, *E.coli* and *Enterococcus* spp., are used as hygiene indicators. Viruses, bacterial spores and sexual spores of fungi are likely to be preserved by freezing, irrespective of the composition of food and the rates of freezing and thawing. Other microorganisms are likely to be damaged by freezing, but the extent to which freezing and subsequent frozen storage reduces the number of any organism may be trivial if the population is in a resistant physiological state. Unwanted microorganisms access fish processing environments through raw material, mobile equipment such as forklifts and through pests. Poor hygiene, particularly deficient or absence of hand washing has been identified as the causative mode of transmission of pathogens.

References

[1] Huss, H. H., Ababouch, L. and Gram, L. (2003). Assessment and management of seafood safety and quality. *FAO Fisheries Technical Paper No. 444*. Rome, FAO. pp 230. ftp://ftp.fao.org/docrep/fao/006/y4743e/y4743e00.pdf).

[2] Arias, C. (2009). Chilled and Frozen raw fish. In Rhea Fernandes (ed.) *Microbiology hand book: Fish and Seafood*, Leatherhead publishin and RSC Publishing, Cambridge, UK. pp 1-25.

[3] Davies, A. R., Capell, C., Jehanno, D., Nychas, G.J.E. and Kirby, R.M. (2001). Incidence of foodborne pathogens in European fish. *Food Control* 12: 67-71.

[4] Sivertsvik, M., Jeksrud, W. K. and Rosnes, J. T. (2002). A review of modified atmosphere packaging of fish and fishery products-significance of microbial growth, activities and safety. *International Journal of Food Sciences and Technology* 37: 107-127.

[5] Bogh-Sorensen, L. and Jul, M. (1985). Effects of freezing/thawing on foods. In R.K.. Robinson (ed.) *Microbiology of frozen foods*. London :Elsevier Applied Science. pp 41-82.

[6] Berg, Vanden, L. (1968). Physicochemical changes in foods during freezing and subsequent storage. In J. Hawthorne, E. J. Rolfe (eds.) *Low temperature biology of foodstuffs*. Oxford: Pergamon Press. pp 205-219.

[7] Leistner, L. and Russell, N. J. (1991). Solutes and low water activity. In N.J.Russell, G.W.Gould (eds.) *Food Preservatives*. Glasgow, UK, pp 111-134.

[8] Olson Jr, J. C. and Nottingham, P.M. (1980). Temperature. In *International Commission on microbiological specifications for foods, Microbial Ecology of foods*, Vol.1. Academmic Press, New York, pp. 1-37.

[9] Kraft, A. K. (2000). *Psychrotrophic bacteria in foods: Disease and Spoilage*. CRC Press, Boca Raton, FL, pp 147-184.

[10] McMeekin, T. A., Olley, J. N., Ross, T. and Ratkowsky, D. A. (1993). In *Predictive Microbiology: Theory and Application.* Wiley, New York, pp. 165-190.

[11] Sasajima, M. (1974). Studies of psychrotolerant bacteria in fish and shellfish V. The growth or viability of trimethylamineoxide reducing psychrotrophic bacteria and their activity at subzero temperatures. *Bulletin Japanese Society of Scientific Fisheries* 40: 625-630.

[12] Jul, M. (1984). Freezer management. In *The quality of frozen foods*. Academic Press, London, pp. 156-208.

[13] Haard, N. F. (1992). Biochemical reactions in fish muscle during frozen storage. Ch. 20. In *Seafood Science and Technology,* E.G. Bligh (Ed.). Fishing News Books, Oxford, U.K, pp 176-20.

[14] Abdalla, M.A., Hassan, I.M., Shalaby, A.R. and Nabuib, K. (1989). Correlation between biogenic amines, chemical and stability of sea bream fish during storage at -18°C. *Grasas y Aceites* 40: 406-412.

[15] Frahm, E. and Obst, U. (2003). Application of the fluorogenic probe technique (TaqMan PCR) to the detection of *Enterococcus* spp. and *Escherichia coli* in water samples. *Journal of Microbiological Methods* 52: 123-131.

[16] Mossel, David, A. A., Corry, Janet, E. L., Struijk, Corry, B. and Baird, Rosamund, M. (1995). In Alberth Possinger Samakupa (2003). Hygiene indicators in a fish processing establishment-a case study in a white fish processing establishment. *UNU-Fisheries Training Programme.*
www.unuftp.is/static/fellows/document/alberthprf.pdf

[17] Jay, J. M. (1992). In Elmer H. Marth (1998). Extended Shelf Life in Refrigerated Foods: Microbiological Quality and Safety. *Food Technology* 52: 57-62.

[18] Noble, R. T., Moore, D. F., Leecaster, M. K., McGee, C. D. and Weisberg, S. B. (2003). Comparison of total coliform, feacal coliform, and enterococcus bacterial indicator response for ocean recreational water quality testing. *Water Research*. 37: 1637-1643.

[19] Yamaguchi, N., Ishidoshiro, A., Yoshida, Y., Saika, T., Senda, S. and Nasu, M. (2003). Development of an adhesive sheet for direct counting of bacteria on solid surfaces. *Journal of Microbiological Methods* 53: 405-410.

[20] Reij, M. W., Aantrekker, D. E. D. and ILSI (2003). Chilled and Frozen raw fish. In Rhea Fernandes (ed.) *Microbiology hand book: Fish and Seafood*, ed., Leatherhead publishin and RSC Publishing, Cambridge, UK, pp 1-25.

[21] Aantekker, D. E. D., Boom, R. M., Zwietering, M. H. and van Schothorst, M. (2003). Quantifying recontamination through factory environments - a review. *Int J Food Microbiol.* 80:117-30.

[22] Kirby, R. M., Bartram, B. and Carr, R. (2003). Water in food production and processing-Quality and quality concerns. *Food Control.* 14: 283-299.

[23] Liston, J. (1980). Microbiology in fishery science. In: Connell J. J. (ed.) *Advances in Fish Science and Technology.* Farnham, Fishing News Books, U.K, pp 138-157.

[24] **C**AC (Codex Alimentarius Commission). (1997). *Hazard Analysis and Critical Control Point (HACCP)-System and Guidelines for its Application.* Codex Alimentarius Commission CAC/RCP 1-1969, Rev. 3, Rome.
Website: www.fao.org/docrep/W8088E/w8088e05.htm

[25] Bloomfield, S. F. (2003). Home Hygiene: a risk approach. International *Journal of Hygiene and Environmental Health.* 206: 1-8.

[26] Montville, R., Chen, Y., and Schaffner, D. W. (2002). Risk assessment of hand washing efficacy using literature and experimental data. *International Journal of Microbiology*. 73: 305-313.

[27] Snyder, O. P. (1998). Hand washing for retail food operations - a review. *Diary Food Environment Sanitation*. 18: 149-162.

[28] Montville, R., Chen, Y., and Schaffner, D. W. (2001). Determination of bacterial cross-contamination rates from hand to food through a glove barrier. *Journal of Food Protection*. 64: 845-849.