Quality of Water and Ice for Seafood Processing

FRANCIS THOMAS

Water and ice are used for a number of purposes in fish handling and processing. In fish handling, water is mainly used for washing the raw material and the containers in which it is packed. In fish processing, water is used for washing raw materials, utensils, equipments, processing halls etc. It is used for glazing frozen fish, preparation of brine and ice manufacture. Water is also used in boilers and in heating/cooling systems. Ice is used for chilling of fish during handling and at different stages of processing. Thus, fish handling and processing require a copious supply of potable water. On an average, 10-12 tonnes of water will be needed to process one tonne of shrimp. The impurities present in the water and ice influence the quality of the finished product adversely.

Significance of examination of water

Water is examined mainly for three types of characteristics: physical, chemical and bacteriological.

1. Physical characteristics

The main physical characteristics for which water is examined are colour, turbidity, odour, taste and pH.

a. Colour and turbidity

Some of the colours encountered in water and the probable reasons for these colours are presented in Table 1.

Table 1. *Colours encountered in water and the probable reasons for these colours*

Colour	Probable reasons
Yellow and brown	Organic matter
Yellowish brown tint	Traces of iron
Reddish brown	Peat
Green	Algae
Brown	Colloidal manganese and iron
Various colours	Industrial waste

Undissolved materials in water include inorganic substances such as rock dust, clay, ferric hydroxide, calcium carbonate etc. and organic substances such as vegetable and animal matter, oils, fats, grease and microorganisms. Size of undissolved materials may be in the colloidal range or as large as grains of sand. The larger granules settle down rapidly in quiescent water and are seen as sediment while the more finely divided particles remain suspended and are responsible for turbidity. Water used for fish handling and processing should have no noticeable colour/turbidity.

b. Odour and taste

Potable water should be of such a quality that it produces neither taste nor odour. Although the presence of odour is always accompanied by the presence of taste, it is possible for waters to possess taste without odour. When this occurs it is usually due to the presence of an excess amount of certain saline and/or mineral constituents. The tastes due to the constituents are presented in Table 2.

Table 2. *Taste due to the presence of saline or mineral constituents*

Saline or mineral constituents	Taste
Common salt	Brackish
Sodium sulphate	Saline
Iron, Manganese, Aluminium sulphate or excess lime	Bitter

The presence of hydrogen sulphide imparts odour to the water. Contact with painted surfaces such as bituminous linings of tanks gives rise to taste and odour to water. Contamination by organic matter from sewage, manure, soil and vegetation imparts taste and odour to water. Growth of living matter such as algae, fungi etc. in water produces taste and odour.

c. pH

pH of water is an indication of acidity or alkalinity of water. The pH range is 0-14. Seven is neutral pH. As the pH comes down from seven, the acidity increases. Similarly as the pH goes up from seven, alkalinity of the water increases. Water can be divided into 3 distinct classes on the basis of the pH value. They are:

i. pH 8 and above. The water in this group contains no free carbon dioxide but carbonates, with or without bicarbonates.

ii. pH above 4.5 but below 8. The water in this class contains no carbonates, but contains free carbon dioxide and bicarbonates.

iii. pH 4.5 and below. The water in this class contains some free acids besides carbon dioxide.

Waters having pH values above 8.5 and below 4.5 are generally corrosive. Sewage and sewage effluents are generally neutral or faintly alkaline. Factory effluents are often acidic.

2. Chemical characteristics

Chemical characteristics may be divided into four groups; main mineral constituents, constituents relating to the organic quality of water, metals and toxic substances.

a. Main mineral constituents

Main characteristics under this group are total dissolved solids, hardness, alkalinity, chlorides and sulphates.

An estimation of total dissolved solids affords a valuable check on the results of more detailed analysis. Total dissolved solids also give information with regard to the quality of water. When large blocks of ice are prepared, the minerals dissolved in the water tend to concentrate in the central part, which, when solidified, becomes undesirably cloudy in appearance. Removal of the central part before solidifying and replacement by fresh water can be resorted to as a means of obtaining uniformly clear blocks. The total dissolved solid content should not exceed 300 ppm. for clear transparent ice.

Hardness of water is due to the presence of bicarbonates, sulphates and chlorides of calcium and magnesium. Disadvantages of hard water are soap wastage, the production of adherent slime or curd in wash basins, baths and on textiles being laundered and the formation of scale or fur in boilers, hot water pipes, and household utensils.

Alkalinity above 100 ppm adversely affects the quality of the frozen prawn products, the defect being bleaching on cooking.

In most waters, the whole of the chloride is present in combination with sodium as sodium chloride. Near the sea the influx of sea water is indicated by an increase in chlorides and hardness.

b. Constituents relating to the organic quality of the water

The characteristics in the group are free and saline ammonia, albuminoid ammonia, nitrite, nitrate etc.

Almost all the natural waters contain traces of ammonium salts. By distillation of such water the ammonia is carried over in the distillate. This ammonia is free ammonia (free and saline ammonia). A further quantity of ammonia can be obtained by adding a strong alkaline solution of potassium permanganate to the concentrated water and continuing the distillation. This is albuminoid ammonia which is produced by the oxidation and hydrolysis of the nitrogenous organic matter present in the water.

Some of the sources from where free and saline ammonia may be derived are the following: Rain water contains traces, the first fall containing the most. All fertile soils and all decaying vegetable and animal matter contain free ammonia. Nitrifying organisms convert free ammonia into nitrates, while ferruginous sands convert nitrates into ammonia. Urine of man and animals yields large quantities of ammonium carbonate; hence sewage is rich in free ammonia.

Estimation of albuminoid ammonia is the most sensitive chemical test for organic pollution, when taken in conjunction with the free and saline ammonia, nitrate and nitrite contents. The free ammonia and albuminoid ammonia contents should be considered together, since their relative proportion is more important than the actual quantities. The reasons are discussed below. In all sewages and many sewage effluents, the amount of free ammonia greatly exceeds that of the albuminoid ammonia. In the crude sewage, the free ammonia is 2 1/2 times more than albuminoid ammonia. Hence, in many cases, sewage pollution is indicated when a natural or untreated water yields more free ammonia than albuminoid ammonia. Decaying vegetable matter in a water yields more albuminoid ammonia than free ammonia. During chlorination, if organic matter is present in water, its demand must be satisfied before any chlorine is available for germicidal action. Presence of free and saline ammonia in amounts more than traces cause considerable retardation of sterilization.

Nitrates are present in most waters. Their only concern with purity and wholesomeness relates to considerations of pollution by sewage or manure, since they may be derived from the oxidation of nitrogenous organic matter of animal origin. The more efficient the progress of sewage purification, the less is the amount of nitrogen as free ammonia, and the greater the amount of nitrogen as nitrites and nitrates.

c. Metals

The characteristics under this group are iron, manganese, zinc and copper. Iron in excess of 0.3 ppm can cause water to appear as rusty. Poisoning due to manganese in water is rare. Zinc salts are poisonous only in very large doses. Copper salts in natural surface waters occur in trace amounts. Their presence beyond this level is an indication of pollution.

d. Toxic substances

The main characteristics in the group are fluoride, cyanide, lead, arsenic, chromium, silver, selenium, cadmium and barium. As these substances are toxic, they should not be present in more than permitted levels in water and ice used for fish handling and processing.

3. Bacteriological examination of water

Contamination by sewage or faecal matter is the greatest danger associated with drinking water. If such contamination has occurred and if, among the contributors there are carriers of infectious diseases, the water can cause diseases such as typhoid and dysentery. Sewage-polluted water may also contain the viruses of poliomyelitis, other viruses of the Enterovirus group, or the virus of infectious hepatitis. Animals and birds may carry intestinal organisms pathogenic to man. The use of contaminated water for the preparation of food may allow the multiplication of intestinal pathogens and hence is harmful.

The direct search for the presence of specific pathogenic bacteria or viruses in water is impracticable for routine control purposes. Pathogens present in water are usually outnumbered by the normal intestinal organisms. These pathogens tend to die out more rapidly It is possible to isolate pathogens from water. But their isolation and identification are comparatively time consuming. The isolation of viruses is more difficult and requires lengthy procedures. Bacteriologists have therefore evolved simple and rapid tests for the detection of normal intestinal organisms such as coliforms, faecal streptococci and *Clostridium perfringens (Clostridium welchii).* These organisms are easier to be isolated and identified. The presence of normal faecal organisms in a water sample indicates that pathogens could be present.

The organisms most commonly used as indicators of faecal contamination are the coliform group as a whole, and particularly *Escherichia coli* which is the most frequent type of coliform organism present in human and animal intestine, numbering more than 100 millions per gram of fresh faeces. The distribution of coliform organisms in nature suggests that they may all be primarily faecal organisms but that outside the body, types other than *E. coli* have greater chances of survival and can multiply in certain circumstances.

The greatest value of the test for faecal streptococci lies in assessing the significance of doubtful results from the test for coliforms, particularly the occurrence of large numbers of coliforms, in the absence of *E. coli.* The presence of streptococci would confirm the faecal origin.

The test for *Clostridium perfringens* has uses similar to that for faecal streptococci. *Clostridium perfringens* forms spores which survive for a much longer time than the vegetative organisms of the coliform group. The presence of *Clostridium perfringens* in natural water indicates that faecal contamination has occurred. In the absence of *E. coli*, the occurrence of *Clostridium perfringens* in water together with other coliform organisms suggests that faecal pollution has not been recent.

Standards

Most of the uses of water in food industry necessitate certain standards of quality. In many cases, water of the standard of public suppliers is quite satisfactory. But for certain industries, water of a more specialised nature is required. A comparison of the Indian Standards for water for processed food industry and for ice manufacture is given in annexure 1.

Annexure - I

Standards for water for processed food industry and for ice manufacture

	Characteristic	Tolerance	
		Food industry	Ice manufacture
1.	Colour (Hazen units), Max.	20	5
2.	Turbidity (Units), Max.	10	5
3.	Odour	None	None
4.	pH	6.5 to 9.2	6.5 to 9.2
5.	Total dissolved solids mg/L, Max.	1000	1000
6.	Alkalinity (as $CaCO_3$), mg/L, Max.	–	100
7.	Total hardness (as $CaCO_3$), mg/L, Max.	600	600
8.	Sulphate (as SO_4), mg/L, Max.	200	200
9.	Fluoride (as F), mg/L, Max.	1.5	1.5
10.	Chloride (as Cl), mg/L, Max.	250	250
11.	Cyanide (asCN), mg/L, Max.	0.01	0.01
12.	Selenium (as Se), mg/L, Max.	0.05	0.05
13.	Iron (as Fe), mg/L, Max.	0.3	0.3
14.	Magnesium (as Mg), mg/L, Max.	75.0	125
15.	Manganese (as Mn), mg/L, Max.	0.2	0.2
16.	Copper (as Cu), mg/L, Max.	1.0	1.0
17.	Lead (as Pb), mg/L, Max.	0.1	0.1
18.	Chromium (as Cr^{+6}), mg/L, Max.	0.05	0.05
19.	Zinc (as Zn), mg/L, Max.	15.0	15.0
20.	Arsenic (as As), mg/L, Max.	0.2	0.2
21.	Nitrate (as N), mg/L, Max.	20	–
22.	Phenolic substances (as C_6H_5OH), mg/L, Max.	0.001	0.001

Tolerances for specific operations for food industries

Characteristic	Tolerance for		
	Cooling	Washing, flushing and general purposes	Processing
1. Total hardness (as $CaCO_3$), mg/L, Max.	30	30	–
2. Iron (as Fe), mg/L, Max	–	0.1	0.1
3. Manganese (as Mn), mg/L, Max.	–	0.1	0.1

Tolerance for canning

Operations	Characteristic	Tolerance
1. Cooking	a) Carbonate hardness	Zero
	b) Alkalinity (as $CaCO_3$), mg/L, Max.	50
2. Cleansing	Total hardness (as $CaCO_3$), mg/L, Max.	Preferably below 30
3. General	Iron (as Fe), mg/L, Max.	0.2

Bacteriological tolerances

Characteristic	Tolerance	
	Food industry	Ice manufacture
1. Coliform bacteria, MPN index per 100 ml	Less than 1	Less than 1
2. Standard plate count, per ml, Max.	50	100
3. Salmonella and other pathogens	To be absent	
4. Proteolytic and lipolytic organisms, combined count per ml, Max.	5	–
5. Slime forming organisms (for cooling water only)	Absent	–