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Association of Sanitary Conditions and Bacteriological Quality of Tube Ice in Ice Plants in Metropolitan Bangkok, Thailand

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Abstract

This investigation aimed at studying the correlation between ice plant sanitary conditions and bacteriological quality of ice. The sanitary conditions in accordance with GMP regulations, the bacteriological quality of tube ice, and the processing water in 20 plants in Bangkok were studied. A modified inspection form from the Office of Food and Drug Administration was used for sanitary condition surveys. Ice and processing water samples were collected 2 times per plant with 3 samples each time. All 120 samples were analyzed for bacteriological quality by means of Standard Plate Count technique (Pour plate method) and Most Probable Number technique (MPN method). The results indicated that forty percent (8 Tube plants) failed and the remaining passed sanitary condition criteria. 23% of Tube Ice samples were acceptable in the standard permission level in terms of Total coliform bacteria and Fecal coliform bacteria. All Tube Ice plant processing water samples were acceptable in comparison with the standard permission level. Ice plant sanitary conditions were significantly correlated to bacteriological quality of the ice ($p< 0.05$). Ice plant manufacturers should develop and implement Sanitary Standard and Operational Procedures (S.S.O.P.) in accordance with all GMP requirements to improve Ice plant sanitary conditions.

Keywords: sanitary conditions; bacteriological quality; ice tube; ice plant

1. Introduction

Thailand is located in tropical area with long hours of sunshine and high temperature along the year, so "ice" is important in human daily life. If ice is contaminated with pathogenic bacteria, it would be harmful for human life. The Division of Epidemiology of the Thai Ministry of Public Health showed that the morbidity rate from water and foodborne disease (Acute diarrhea and food poisoning) in 1989-1998 was high, with an increasing rate, and that it was the most common cause for diseases under surveillance. The trend of diarrhea mortality rate in Thailand has been increased since 1969 to 2006.

In the present study, we wanted to investigate the existing sanitation conditions in terms of good manufacuring practice, the contamination of ice processing, and quality of ice in tube ice plants located in Metropolitan Bangkok. The results of this study might be useful for involved organization, regulation and law enforcement according to the Public Healht Act (1992).

2. Materials and Methods

The sanitary conditions in accordance with Good Manufacturing Practice (GMP) regulations, and the bacteriological quality of ice and processing water in 20 Tube Ice plants located in Metropolitan Bangkok were studied. Modified inspection forms from The Office of Food and Drug Administration, Ministry of Public Health (GMP inspection form) were used for assessing the ice plants' sanitary conditions. In addition, observation and interviewing were used for supplementory information. Ice and processing water samples were collected two times for each plant with 3 samples taken each time. All samples colleted from each ice plant were brought for laboratory analyses at the Department of Environmental Health Science, Faculty of Public Health, Mahidol University, Thailand. The samples were analyzed for presence of bacteria in terms of Total bacteria, Total coliform bacteria, and Fecal coliform bacteria by means of the Standard Plate Count technique (Pour plate method) and Most Probable Number technique (MPN method),

respectively. Furthermore, the correlation between ice plant sanitary conditions and bacteriological quality of ice was also investigated.

2.1. Ice plants sanitary conditions survey criteria

The GMP inspection form consists of 6 requirements concerning location and manufacturing buildings, tools, machineries and production equipments, control of production processes, sanitation (Sanitary facilities), cleaning and maintenance, and personnel and hygiene workers. The survey results were classified into 2 types (Pass/ Fail) by applying criteria from The Office of Food and Drug Administration, Ministry of Public Health (1984). Pass criteria ice plants must have total scores of more than 50%; Fail have a score less than 50%. The correlation between ice plant sanitary conditions (in terms of percentage of total scores) and bacteriological quality of ice (in term of total bacteria) was analyzed by using simple regression at a significance level of 0.05 with curve estimation.

Table 1. Percentage of Tube Ice plant sanitary conditions scores and bacteriological quality of Tube Ice

Ice plants	Sanitary conditions scores of each requirement (%)						Total scores (%)	Bacteriological quality (CFU/ml)
	1	2	3	4	5	6		
T01	77.63	66.67	42.86	63.33	50.00	56.00	58.98	3
T02	69.74	83.33	71.43	90.00	60.00	76.00	75.15	4
T03	72.37	75.00	57.14	86.67	60.00	60.00	67.96	0
T04	73.68	50.00	57.14	70.00	50.00	68.00	63.47	0
T05	81.58	41.67	78.57	83.33	55.00	80.00	74.85	49
T06	96.05	91.67	71.43	80.00	80.00	80.00	82.33	0
T07	80.26	87.50	54.76	76.67	50.00	64.00	67.66	46
T08	86.84	87.50	50.00	76.67	60.00	56.00	67.96	10
T09	96.05	83.33	78.57	86.67	80.00	76.00	84.13	0
T10	76.31	25.00	30.95	76.67	40.00	48.00	52.69	96
T11	92.10	66.67	61.90	73.33	60.00	88.00	74.85	176
T12	65.79	70.83	42.86	76.67	50.00	56.00	58.96	7
T13	76.31	75.00	71.43	81.67	50.00	64.00	70.96	3
T14	84.21	83.33	69.05	90.00	60.00	72.00	76.65	0
T15	75.00	79.17	47.62	70.00	40.00	44.00	58.68	24
T16	56.58	54.17	57.14	75.00	40.00	50.00	56.88	6
T17	84.21	91.67	64.28	93.33	60.00	96.00	80.24	0
T18	88.16	83.33	59.52	76.67	50.00	60.00	69.76	4
T19	36.84	50.00	26.19	46.67	30.00	48.00	37.72	1,782
T20	78.94	83.33	47.62	75.00	50.00	60.00	64.37	6
Mean	77.43	71.46	57.02	77.42	53.75	65.10	67.21	
S.D.	13.68	18.40	14.58	10.48	12.23	14.15	11.22	

*1: Location and manufacturing buildings
2: Tools, machineries and production equipments
3: Control of production process
4: Sanitation (Sanitary facilities)
5: Cleaning and maintenances
6: Personnel and hygiene workers

Table 2. Regression analysis with curve estimation of correlation between Tube Ice plants sanitary conditions and bacteriological quality of Tube Ice

Correlation with 2 variables	Logarithmic equation	*r*	*p*
Sanitary conditions and Total bacteria	y = -1527Ln(x) + 6513.32	*0.7162*	*<0.001*
Requirement 1 and Total bacteria	y = -1453.3Ln(x) + 6404.58	*0.7816*	*<0.001*
Requirement 3 and Total bacteria	y = -831.08Ln(x) + 3440.90	*0.6123*	*<0.001*
Requirement 4 and Total bacteria	y = -988.39Ln(x) + 4024.46	*0.5770*	*<0.001*
Requirement 5 and Total bacteria	y = -2044.3Ln(x) + 8981.34	*0.7816*	*<0.001*

1: Location and manufacturing buildings
3: Control of production process
4: Sanitation (Sanitary facilities)
5: Cleaning and maintenances

3. Results

3.1. Bacteriological quality of Tube Ice

The results showed that total bacteria ranged from 0-360 CFU/ml. There were 25 samples (20.8%) from 8 Tube Ice plants in which CFU/ml exceeded the upper limit of 20 CFU/ml recommended by European Economic Community drinking water directives (Office for Official Publications of the European Communities, 1975). There were 28 samples (23.3%) from 9 plants that were unacceptable in terms of total coliform bacteria and fecal coliform bacteria.

3.2. The correlation between Tube Ice plant sanitary conditions and bacteriological quality of Tube Ice

The data on Tube Ice plant sanitary conditions were obtained from inspection scores (Total score of each plant was represented sanitary conditions of its performance in ice production). The data of bacteriological quality of Tube Ice were obtained from the averages of total bacteria (CFU/ml) in each plant. These data are presented in Table 1. It was found that Tube Ice plant sanitary conditions were significantly correlated to bacteriological quality of Tube Ice ($r = 0.7162$, $p<0.05$) which fits with a logarithmic curve as shown in Table 2. It demonstrates that location and manufacturing building requirements, control of production process requirements, sanitation requirements and cleaning and maintenances requirements were significantly correlated to the bacteriological quality with the correlation coefficient of 0.78, 0.61, 0.58 and 0.78 respectively and also fit with logarithmic curve as illustrated in Table 2. It was also found that the increasing of scores of sanitary conditions was correlated to the reduction of Total bacteria. In contrast, tools, machineries and production equipment requirements, and personnel and hygiene workers requirements were not significantly correlated to the bacteriological quality of Tube Ice.

4. Discussion

Falcão *et al*. (2002) studied microbiological quality of ice used to refrigerate foods. Sixty ice samples collected at six different retail points in the city of Araraquara, SP, Brazil, were studied. The following parameters were determined: total plate counts, most probable number (MPN) for total coliforms, fecal coliforms and Escherichia coli, presence of *Salmonella spp*., *Shigella spp*., *Yersinia spp*., *E. coli*, *Vibrio cholerae* and *Aeromonas spp*. The results suggested poor hygienic conditions of ice production due to the presence of indicator micro-organisms. Fifty strains of *E. coli* of different serotypes, as well as one *Y. enterocolitica* biotype 1, serogroup O: 5, 27 and phage type Xz (Ye1/O5, 27/Xz) and one *Salmonella Enteritidis* phage type 1 (PT1) were isolated. *Aeromonas spp*., *Shigella spp*. and *V. cholerae* were not detected. The presence of high numbers of coliforms, heterotrophic indicator micro-organisms and pathogenic strains suggested that commercial ice and ice used to refrigerate fish and seafood may represent a potential hazard to the consumer (Falcão, 2002). Vollaard *et al*. (2004) studied the risk factors for transmission of foodborne illness in restaurants and street vendor in Jakarta, Indonesia. The results indicated that poor hand-washing hygiene and direct hand contact with foods, male sex and low educational level were independent characteristics of street vendors in a logistic regression analysis. Faecal contamination of drinking water (in 65% of samples), dishwater (in 91%) and ice cubes (in 100%) was frequent.

4.1. Bacteriological quality of Tube Ice and its processing water

Of the Tube Ice samples from 9 plants 23.3% were unacceptable in terms of total coliform bacteria and fecal coliform bacteria, whereas no processing water samples from the same plants was unacceptable in terms of total coliform bacteria. After freezing the

processing water in ice making machine the ice was then cut into small size and fell into an ice tray or container and were then packed by hand or in an automatic machine, and stored. From the details given above, the cleanliness of ice making machine including ice hopper/tray and hand packing step might be the main causes of ice contamination.

If workers did not wash their hands with soap and water after visiting the toilet, their hands could spread pathogenic bacteria such as *Salmonella spp.* and *Vibrio parahaemolyticus* which were detected by Rectal Swab Culture in ice plant workers in Metropolitan Bangkok in 2001-2003 (Epidemiology unit. Environmental Health Department, 2003).

4.2. The correlation between Ice plant sanitary conditions and bacteriological quality of ice

Our data indicate that ice plant sanitary conditions were significantly related to bacteriological quality of ice ($p<0.05$) for tube ice plants. Similar results, obtained by Maneenil (2002) who reported that the ice quality in Hat Yai in Thailand depended on the production process and the factory environment. In the present study, the sanitary conditions surveyed were based on GMP regulations with 6 requirements (Location and manufacturing buildings, Tools, machineries and production equipments, Control of production process, Sanitation (Sanitary facilities), Cleaning and maintenances and Personnel and hygiene workers) which constitute the food quality assurance system approved by experts all over the world (Food Control Division, 2003). It may therefore be concluded from both previous studies and from our present investigation, that if sanitary conditions of food factories are good, or GMP regulations are implemented, the food products have a high probability for good quality with a low bacterial contamination. In addition, involved government organizations should survey bacteriological quality of ice in ice plants by means of sanitary conditions based on GMP requirements inspection.

Tools, machineries and production equipments requirement and personnel and hygiene workers requirement of Tube Ice plants were not significantly correlated with bacteriological quality of Tube Ice. In the case of tools, machineries and production equipments requirement, this could be explained by the details of this requirement which focuses on construction materials and design of ice making machines and other equipments in contact with ice. Our results showed that all of Tube Ice plants used ice making machine and other equipments which were in contact with ice were made from the same materials. Stainless steel was used for production materials, but the design was different in some points. The production equipment, therefore, might be not directly correlated with bacteriological quality of Tube Ice. However, as was previously pointed out, the cleanliness of equipment, such as the ice making machines, might be more correlated with bacteriological quality of Tube Ice. In case of personnel and hygiene workers requirement, we found that 6 out of 9 Tube Ice plants complied with the sanitary criteria of Thai GMP. However, the tube ice samples were contaminated with Coliform bacteria indicating that although workers wear net, apron, boots etc. and had no wounds on their hands; the ice could still be contaminated. For example, cleaned hands do not necessarily mean absence of microorganisms. Further studies should focus on ice handlers.

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