Sanitary Quality of Crushed and Cubed Ice As Dispensed to the Consumer

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INFORMATION on the sanitary quality of ice as it is served in iced drinks and used to chill foods in public eating places apparently is unavailable in the literature. There are references in the literature of the early nineteen hundreds to studies made on "natural" ice harvested in the winter season and stored for summer use, but these reports are conflicting as to the quality of the ice. At that time it was common belief that natural freezing would destroy any disease germs that might have been present in the original water.

At the present time most of the ice used for chilling food and drink for human consumption is commercially frozen. With the introduction of the use of high-quality water in producing ice, it was generally assumed that the ice would be of the same high quality. This assumption was questioned, however, as early as 1905. A study of a typhoid epidemic in the District of Columbia in that year necessitated the examination of both the "natural" and artificial ice sold in the area, and sanitary surveys revealed that the sanitary conditions in commercial ice plants left much to be desired (*1*).

In recent years sanitarians have formulated standards of quality for commercial ice and have introduced regulations covering such items as (*a*) the water supply used, (*b*) the plumbing and toilet facilities of the premises and surrounding area, and (*c*) the employees' health. If such regulations are adhered to, the ice (usually in 300-pound cakes) should be of high sanitary quality when pulled from the freezing tanks. As evidence that the cake ice in the area covered by the studies described in this report is of high quality, the following data are submitted. Ten samples of cake ice, representing at least five ice plants, were purchased, handled with the same aseptic precautions, and cultured in the same manner for coliform, clostridia, and standard plate count as subsequently described for crushed and cubed ice. No coliform or clostridia organisms were detected in any samples, and the average standard plate count for the 10 samples was only 6.8 per 1 ml. of water.

In a previous report attention was called to the gross inert material and high coliform, anaerobic, and total plate count of a limited number of crushed-ice samples (*2*). This paper reports more detailed studies of the sanitary quality of both crushed and cubed ice as it is dispensed to the consumer.

Mr. Foltz, professor and acting head, department of bacteriology, Kansas State College, and bacteriologist in charge, Kansas Agricultural Experiment Station, gave this paper before the American Public Health Association, October 21, 1952, at Cleveland, Ohio.

Test Methods

Standard Methods for the Examination of Water and Sewage (ninth edition) was followed in detail for all procedures relative to plate counts and tests for the presence of members of the coliform group.

The "stormy fermentation" test for the *Clostridium welchii* (*Clostridium perfringens*) group was made by inoculating sterile skim milk in test tubes covered with a paraffin-vase-

line seal, with 5 portions each of 10.0, 1.0, and 0.1 ml. of water, heating the tubes at 80° C. for 15 minutes, immediately chilling, and then incubating them at 35° C. for 5 days. No tube was called positive unless the seal was blown from the tube and the curd gave a typical "stormy" type of appearance.

Isolation of the dominant type of coliform was made from eosin-methylene blue agar plates streaked from the smallest inoculum giving a positive or a doubtful presumptive test. Identification was carried only to the point of determining the methyl red and Voges-Proskauer reactions on each isolate. Further studies on a limited number of samples were made by adding 50.0-ml. quantities of melted ice to 50.0 ml. of double strength selenite F enrichment medium. This mixture was incubated at 35° C. for 24 hours and subcultured onto bismuth sulfite and S S agar. Colonies suspected of being noncoliform enteric types were isolated and subjected to differential study, as outlined in Diagnostic Procedures and Reagents (third edition).

To detect the presence of and to identify micrococci and streptococci, incubation of 5 portions each of 10.0, 1.0, and 0.1 ml. of water in the enrichment medium designed by Ritter and Treece (*3*) for the isolation of cocci from swimming pool water was the first step. When growth appeared, all tubes were subcultured on 5.0 percent sheep blood agar. No tube was regarded as negative until 10 days' incubation at 35° C. revealed no growth.

From the blood agar plates incubated at 35° C. for 48 hours, colonies suspected of being micrococci and streptococci were isolated for further study and identification. Those colonies proving to be streptococci were grouped according to the methods outlined by Sherman (*4*). Micrococci were identified according to Bergey's Manual (sixth edition), and the identification was substantiated with additional tests.

Physical examination of ice samples was limited to the passage of 300 ml. of water through cotton sediment disks with an exposed surface of 0.68 sq. in. A comparison of the amount of sediment collected was made with standard sediment disk photographs, as described in Standard Methods for the Examination of Dairy Products (ninth edition). Sediment identification was made by wide-field binocular microscope examination.

Residual chlorine was determined colorimetrically by the orthotolidine method, using a Hellige comparator.

Field Procedure

Samples of ice were collected from hotels, restaurants, soda fountains, hospitals, and soft-drink parlors in sterile wide-mouthed jars. The filled jars were sealed immediately with a lid lined with sterile cellophane to prevent the possibility of lacquer from the jar lid flaking and confusing the sediment picture. Bagged ice was purchased and aseptically transferred to the same type of container. All samples reached the laboratory only partially melted. They were tempered at 40° C. until the ice melted and then immediately examined.

The ice samples were collected from establishments in central Kansas within an area having a radius of 150 miles. They included 77 samples of crushed ice and 37 samples of ice from automatic ice-cube machines. Ten of the ice-cube samples came from hospitals. It was thought that this latter group of samples would represent the ideal in sanitary machine care and ice-dispensing techniques. Collections of samples were made either in June, July, or August, or in December or January so that a comparison of the sanitary quality of ice during the two climatic extremes could be made.

Numbers of Bacteria

In table 1 are presented the data on the numbers of bacteria found in the 114 samples of ice included in this study. Only 27 (about 23 percent) of the 114 were free from coliform contamination and would be of acceptable quality on the basis of drinking water standards.

The 84 samples collected during June, July, and August contained the highest average MPN (most probable number) of both coliform and anaerobic bacteria and the second highest average standard plate count of the 6 groups of samples. The winter samples had a comparatively low average coliform count, indicating a decidedly better quality of ice than

Table 1. Numbers of bacteria found in 114 samples of crushed and cubed ice

Range of MPN coliform per 100 ml.	Number samples	Average MPN coliform per 100 ml.	Average MPN clostridia per 100 ml.	Average standard plate count per 1.0 ml.
All samples (114):				
0	27	0	1. 4	1, 330
2–23	24	8	9. 5	26, 300
24–920	32	235	48. 4	5, 200
1,600–>1,600	31	>1, 600	46. 8	58, 400
Average	----	506	28. 6	23, 000
Summer samples (84):				
0	14	0	14	1, 770
2–23	14	9	5. 9	43, 600
24–920	27	219	56. 8	5, 900
1,600–>1,600	29	>1, 600	42. 2	51, 900
Average	----	624	36. 3	27, 400
Winter samples (30):				
0	13	0	2. 7	852
2–23	10	6	44. 1	1, 983
24–920	5	322	3. 1	1, 370
1,600–>1,600	2	>1, 600	9. 5	152, 350
Average	----	162	17	11, 415
Commercial crushed ice (77):				
0	10	0	36	1, 028
2–23	18	7. 4	13	34, 997
24–920	23	267	67	6, 508
1,600–>1,600	26	>1, 600	499	69, 266
Average	----	615	32	33, 600
Ice-cube machine ice (37):				
0	17	0	. 11	1, 509
2–23	6	10	. 33	212
24–920	9	56	0	1, 874
1,600–>1,600	5	>1, 600	0	1, 795
Average	----	255	. 11	1, 561
Hospital samples (10):				
0	10	0	0	1, 029
2–23	0	0	0	0
24–920	0	0	0	0
1,600–>1,600	0	0	0	0
Average	----	0	0	1, 029

the summer samples. However, the coliform count coupled with an average MPN of 17 clostridia per 100 ml. of water and a standard plate count of 11,415 bacteria per 1 ml. indicates a poor quality product on the basis of the standards for acceptable drinking water.

Only 10 (13 percent) of the 77 samples of commercial crushed ice were found to be free of coliform bacteria, whereas 17 (46 percent) of the 37 samples of cubed ice were free of coliform organisms. All 10 of the hospital samples were free of both coliform and clostridia organisms.

Types of Organisms

The dominant coliform types isolated from the 87 samples giving positive and doubtful presumptive tests were *Escherichia coli* from 41 samples and *Aerobacter aerogenes* from 46. In some samples only one type of the coliform group appeared to be present; but in the majority of the samples a mixture was observed.

From the limited number of samples subjected to selenite F enrichment and subsequent streaking on S S and bismuth sulfite agar, a number of isolations were made from entericlike colonies. Examination of these cultures yielded organisms identified as *Proteus* spp. and *Paracolobactrum* spp.

Pseudomonas spp. were found in 25 of the 114 samples studied; *Pseudomonas aeruginosa* was isolated most frequently, followed by *Pseudomonas fragi.*

Thirty-two of the 37 machine ice-cube samples were cultured in sodium azide enrichment broth to make possible the isolation and subsequent identification of micrococci and streptococci. The results are recorded in table 2 in such a manner as to make possible a comparison between growth in azide broth and the isolation of coliform types. The frequency of micrococci and streptococci isolations from coliform-positive and coliform-negative samples is also shown.

Growth developed in sodium azide medium in 24 (75 percent) of the 32 samples cultured in this medium. From these azide-growth-positive samples coliform types were isolated from 16, streptococci from 19, and micrococci from 22. It is significant that coliform types were found in only 1 of the 8 azide-negative samples. Seventeen of the coliform-positive samples were found to contain streptococci and/or micrococci—streptococci in 14 and micrococci in 16. In contrast the 15 coliform-negative samples yielded only 6 streptococci and

Table 2. Number of samples from which isolations of micrococci, streptococci, and coliform organisms were made, and correlation of findings: 32 samples of cubed ice examined

	Azide broth		Coliform isolation	
	Growth	No growth	Positive	Negative
Micrococci isolated	22	------	16	7
Micrococci not isolated	2	------	1	8
Streptococci isolated	19	------	14	6
Streptococci not isolated	5	------	3	9
Coliform present	16	1	17	15
Coliform not present	8	7	------	------
Growth in azide broth	24	------	16	8
No growth in azide broth	------	8	1	7

7 micrococci isolations. One hundred and eighty-four cultures of micrococci were isolated from the 24 growth-positive-azide samples. A brief study of the micrococci revealed that 97 were hemolytic, and 87 nonhemolytic; 11 (5 percent) were coagulase positive, and 173 coagulase negative; and 63 produced yellow, 14 orange, and 107 white pigment. The organisms were identified as belonging to the following species: *Micrococcus pyogenes* var. *aureus* and var. *albus; Micrococcus citreus; Micrococcus flavus; Micrococcus epidermidis; Micrococcus candidus; Sarcina flava; Sarcina aurantiaca; Sarcina lutea.*

Ninety-eight streptococci cultures were isolated from the 24 azide-positive samples. Of these cultures 87 were found to belong to the enterococcus group, 10 to the lactic group, and 1 to the viridans group. A large percentage of the cultures grouped as enterococci grew at 10° C. and at 45° C. and in the presence of 6.5 percent sodium chloride, indicating that they were probably *Streptococcus fecalis.*

The MPN of micrococci ranged from 2 to more than 1,600 per 100 ml. of water, and the streptococci, from 4.5 to more than 1,600. The micrococci gave higher MPN values than the streptococci.

Sediment

Sediment collected by filtration and examined under the wide-field binocular microscope was found to contain sand, clay, assorted colored fibers, assorted colored threads, vegetable fibers, finger-nail-polish scales, insect fragments, rodent hairs, and wood splinters. The amount of sediment removed by the filtration of 300 ml. of water ranged from 10.5 mg. to 0.25 mg., averaging 2.25 mg. The ice-cube samples contained the least amount of extraneous material, and the group of summer samples contained the largest amount of sediment. Available residual chlorine was consistently low or entirely absent; the largest amount in any sample was 0.01 ppm.

Discussion

The finding of only 13 percent of the crushed-ice samples to be of satisfactory sanitary quality when judged by the standards used for public water supplies indicates that most of the crushed ice in the area covered by this survey is of extremely poor quality. In general, the same conclusion applies to automatically frozen cubed ice dispensed in commercial establishments.

The frequent isolation of *E. coli*, universally accepted in water analysis as an indicator of pollution of human or animal origin, suggested the desirability of testing for other types of organisms of possible sanitary significance. The subsequent tests for clostridia, enteric bacilli, micrococci, and streptococci revealed that one or more of these four groups of bacteria, which are intimately associated with the human body, were found in the majority of ice samples. Frequently the numbers were large enough to suggest recent heavy pollution of possible human origin.

The organisms found are of sanitary significance not only because ice is introduced directly into beverages, but also because it is used in direct contact with foods, some of which are eaten raw, to accomplish chilling. Micrococci, streptococci, coliform types, paracolon organisms (*5*), and *Proteus* (*6*) all have been identified as or suspected of being the causative agent in food poisoning. *Pseudomonas* spp., which were detected in 22 percent of all ice samples examined, are known to play an important role in the spoilage of certain foods (*7*). Thus, crushed ice in direct contact with

food may serve as a source of contamination with both food-spoilage and food-poisoning organisms.

Origin of Microorganisms

The question naturally arises as to the origin of the large numbers of bacteria found in ice when it reaches the consumer. Time has not permitted a thorough investigation of this phase of the problem, but some information is available.

Ice is usually manufactured from a water supply which is tested regularly and maintained at an acceptable sanitary level. Furthermore, cake ice as taken from the freezing tank was found to be entirely satisfactory, whereas crushed ice from the same plant was found to be highly contaminated. Finally, the temperature within a mass of crushed ice and the limited time interval between crushing and consumption would, for practical purposes, eliminate growth of all the organisms tested for in this investigation. Thus, it would seem reasonably certain that most of the microorganisms found in crushed ice when it reaches the consumer have gained entrance at one or more points between the freezer and the consumer.

No effort was made in this study to evaluate the relative significance of factors which may contribute to the contamination of crushed ice. Even a casual examination of the average ice plant and other facilities for handling ice, however, will indicate many possible points of contamination: the ice plant itself; the sawing, crushing, and grinding equipment; the containers in which the ice is transported; the loading and unloading docks; the delivery trucks and insulating blankets; and the dispensing facilities. Factors to be considered are the construction of the ice plant, the maintenance of the equipment, the protection afforded the ice after it leaves the freezing tank, and the practices used in handling the ice.

Although the bacterial content of cake ice was found to be practically nil, the producer is not relieved of all responsibility for the quality of the crushed ice delivered to the consumer. A rapidly expanding practice in the handling of ice is for the producer to deliver crushed ice to the dispenser. The ice may actually be packaged in bags which the retailer dispenses intact. Several samples of bagged crushed ice were included in this study, and no significant difference in quality was noted between this ice and the crushed ice collected from the individual dispensers.

The fact that ice from automatic freezers in hospitals was found to be of high sanitary quality whereas most of that from machines in retail establishments was found to be of poor quality indicates an absence of sanitary precautions in machine care and in dispensing techniques in the latter. The feasibility of producing high-quality ice with the automatic ice-cube machine is demonstrated by the finding of all hospital samples free of coliform and clostridia organisms.

Corrective Measures

Despite the fact that ice is by its very nature one of the products most amenable to sanitary production and handling, the data presented here leaves no question as to the poor sanitary quality of much of the ice dispensed to the consumer in the area covered by this survey. What are the reasons for this apparently paradoxical situation? Primarily, it is due to the absence of factual information concerning the quality of consumer ice; secondarily, to the lack of appreciation, on the part of producers and handlers, of the factors influencing the sanitary quality of ice. It is hoped that the facts presented here will stimulate such additional research as is necessary to evaluate the relative significance of the many factors contributing to the poor quality of crushed and cubed ice. Only with such information will it be possible for public health authorities to formulate adequate regulations concerning production and handling of this product.

In the meantime, any well-trained sanitarian can initiate an educational program in his community, a program which will acquaint the public with the need for a better product and provide the producer and handler with the necessary information to meet a demand for high-quality ice.

Summary

Data are submitted which show that the majority of crushed and cubed ice at the consumer level is of extremely poor sanitary quality.

Evidence is presented indicating that initially ice from both commercial and automatic freezers is of acceptable quality. The high plate counts, the presence of significant numbers of *Escherichia coli*, clostridia, micrococci, and streptococci, and the quantities and types of inanimate material present in crushed and cubed ice suggest recent, heavy contamination, at least a portion of which is of human origin. The implications associated with the extensive consumption of such a product are obvious, and the problem deserves early attention by public health authorities.

REFERENCES

(*1*) Lumsden, L. L., and Anderson, J. F.: The origin and prevalence of typhoid fever in the District of Columbia (1909–1910). Hygienic Laboratory Bulletin No. 78. Treasury Department, Public Health and Marine-Hospital Service of the United States. Washington, D. C., Government Printing Office, 1911.

(*2*) Foltz, V. D.: A bacteriological study of water supplies for tourists and work gangs. The Public Health Laboratory. 9: 50–55 (1951).

(*3*) Ritter, C., and Treece, E. L.: Sanitary significance of cocci in swimming pools. Am. J. Pub. Health 38: 1532–1538 (1948).

(*4*) Sherman, J. M.: The streptococci. Bact. Rev. 1: 3–97 (December 1937).

(*5*) Barnes, L. A., and Cherry, W. B.: A group of paracolon organisms having apparent pathogenicity. Am. J. Pub. Health 36: 481–483 (1946).

(*6*) Cherry, W. B., Lentz, P. L., and Barnes, L. A.: Implication of *Proteus mirabilis* in outbreak of gastro-enteritis. Am. J. Pub. Health 36: 484–488 (1946).

(*7*) Tanner, F. W.: Microbiology of foods. Ed. 2. Champaign, Ill., Garrard Press, 1944, 1196 pp.

Public Health Service Staff Announcements

Dr. James R. Shaw has been assigned as chief of the Branch of Health of the Bureau of Indian Affairs where he will supervise the administration of 59 Indian Service hospitals and the public health program of the Bureau. He has been chief of the Division of Hospitals, Public Health Service, the past year. Previously, he was medical officer in charge of the Public Health Service Hospital in Detroit. Dr. Shaw has also held medical staff positions in the Public Health Service Hospital in San Francisco and its clinics in Los Angeles and San Pedro, and has served as district medical officer of the Coast Guard at Long Beach, Calif. He was admitted to the commissioned corps of the Public Health Service in 1939.

Dr. Clifton K. Himmelsbach has been appointed assistant chief of the Division of Hospitals, Public Health Service, as successor to **Dr. Myron D. Miller**, recently assigned medical officer in charge of the Public Health Service Hospital in Seattle. For the past 5 years, Dr. Himmelsbach has been medical officer in charge of the Washington, D. C., Outpatient Clinic of the Public Health Service. He has held medical staff positions in several Public Health Service hospitals, and in the Service's hospital in Lexington, Ky., he directed clinical investigations on narcotic drugs and addiction. Before coming to Washington in 1947 as chief of the medical operations branch of the Federal Employee Health Program, he was a medical consultant for the Office of Vocational Rehabilitation.

Dr. Stanley E. Krumbiegel has been appointed medical officer in charge of the Public Health Service Outpatient Clinic at Washington, D. C., to succeed Dr. Himmelsbach. Dr. Krumbiegel has been medical director of the Bureau of Prisons, Department of Justice, since 1948. Since receiving his commission in the Public Health Service in 1939, he has served as medical staff officer in Public Health Service hospitals in Boston and on Ellis Island, and as staff psychiatrist and chief medical officer in a number of Federal penal and correctional institutions.