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# A BACTERIOLOGICAL STUDY OF COMMERCIAL ICE CREAM.

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*(A study conducted in the Bacteriological Laboratory of the City of Philadelphia, during 1905 and 1906.)*

The very common occurrence of streptococci in untreated and apparently fresh milk and cream has led to a search for these organisms in various other food products. Among the most widely distributed milk foods are the many frozen dainties which, under the name of ice creams, hokey pokey, milk balls, and such like, are almost universally used throughout the United States by all classes of people.

A very great opportunity for chemical adulteration is afforded the makers of ice cream by the nature of the product, and, judging from the advertised cream thickeners on the market, as well as the characteristics of the melted ice cream, but few are quite free from artificial thickening material of some sort. Such thickeners have usually been based upon corn starch or gelatin, products harmless in themselves, but more gratifying to the purse of the makers than to the feelings of the consumers who pay for pure cream.

Comparatively recently the Federal government has decided that ice cream "is a frozen product made from cream and sugar, with and without a natural flavor, and contains not less than 14 per cent. of milk fat.—Fruit ice cream is a frozen product made from cream and sugar and sound, clean, mature fruit, and contains not less than 12 per cent. of milk fat.—Nut ice cream is a frozen product made from cream and sugar and sound, nonrancid nuts, and contains not less than 12 per cent. of milk fat."

The pure food bill, adopted in 1907 by the commonwealth of Pennsylvania, requires that the butter fat in ice cream shall be 12 per cent. unless it be flavored with fruit, when it may fall to 10 per cent. Eggs and gelatin as thickeners are permitted, but corn starch excluded. Such laws should make for greater justice in the production and selling of this food product.

Though the adulterations which have been so widely practised may not have been detrimental to health, the bacterial contamination of ice cream, on the other hand, is oftentimes productive of serious illness in the consumer, either by way of direct infections or by ptomaine decomposition products. One is constantly meeting enteric affections of greater or less severity traceable to the eating of ice cream. This is a matter of importance from any standpoint, but especially when one considers the great extent to which these foods are used by invalids and young children, since they are grateful to one and nutritious to the other.

In the direct bacterial infections from milk the streptococcus is very often the culpable organism. Of the many investigators who have looked into this subject one may mention Petruschky and Kriebel who lay stress upon the pathogenicity of the streptococcus in milk; Eserich who blames much of the enteritis of young children upon the presence of this organism; Kaiser who attributes the increased infant mortality in summertime very largely to streptococci; and Ruhlmann and Tromsdorff, Brüning, Müller and Heinemann, all of whom have proved the pathogenicity of various strains of streptococci isolated from milk.

One of the most recent contributions to this subject is that by Heinemann who, in his summary, states that *Streptococcus lacticus* is closely related to *Streptococcus pyogenes* not only morphologically and culturally, but also pathogenically, and he explains the negative results of inoculation experiments obtained by some observers with milk streptococci in two ways:

"1. The lesions are often, especially in the beginning, insignificant, and are easily overlooked.

"2. Since lesions are insignificant with large doses, it is quite possible that small doses are unable to create any noticeable disturbances."

Heinemann found that the passing of streptococcus from milk through four or five animals resulted in an increase of virulence in the organisms until, finally, they were as swiftly virulent as the organisms freshly isolated from streptococci lesions in human beings.

Undoubtedly the streptococcus which is commonly found in market milk is an organism of low virulence, or, possibly, of no virulence, to a great majority of our laboratory animals and to the majority of human beings. However, one does find here and there certain people who, almost invariably, show indications of bacterial infection after eating ice cream, and the question naturally presents itself: Is this infection due to the presence of a streptococcus which, for these people at least, is virulent? Such queries make the determination of the frequency of living streptococci in ice cream a matter worthy of study. Accordingly, the investigation outlined below was undertaken, and the ice creams and frozen products reported represented the products sold by dealers patronized by every class of people, even to the hokey pokey man, who dispenses his wares chiefly to school children or tiny tots scarcely old enough to ask for the coveted dainty.

During the months of June, July, and August, 1905, sixty-eight samples of ice cream were examined bacteriologically, and an approximate count of leucocytes was also made.

These samples were collected by the city milk inspectors in wide mouthed, sterile bottles, packed in ice, and brought to the laboratory as promptly as possible. In some instances they were melted when received, but they were still very cold; in most cases they were partly solid. Some of them never melted, but remained as thick, syrupy, semiliquids. These contained thickeners which apparently were gelatin-like, and some contained cornstarch.

In fifty-five out of the sixty-eight samples, or 80 per cent., streptococci were found.

In forty-five examinations, or 66 per cent., not only the finished product, but the milk or cream used

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TABLE I.

BACTERIOLOGICAL EXAMINATION OF ICE CREAM AND ITS CONSTITUENTS.

(Unless otherwise specified all the creams are vanilla flavored.)

| | Material. | Leucocytes. | Count of organisms, per c.c. | Streptococci (morphologically). | Streptococci (pure culture). | Premises, ice cream dealers. | Premises, cream dealers. |
|---|---|---|---|---|---|---|---|
| 1 | Ice cream. | 13,221 | 4,686,000 | present | present | closed | clean |
| 2 | Ice cream. | 13,221 | 5,016,000 | present | present | fairly clean; milk balls a specialty | very clean |
| 3 | Ice cream. | 17,628 | 110,000 | absent | absent | dirty | fair |
| 4 | Ice cream. | 26,442 | 2,100,000 | absent | absent | absolutely filthy | closed |
| 5 | Ice cream. | 44,070 | 3,850,000 | present | present | dirty and ignorant | clean |
| 6 | Ice cream. | 44,070 | 46,200,000 | present | present | fair—ice cream made in cellar | |
| 7 | Ice cream. | 44,070 | 73,500,000 | present | present | absolutely filthy | |
| 8 | Ice cream. | 52,884 | innumerable | present | present | fairly clean | |
| 9 | Milk | 13,221 | 4,557,000 | present | present | out of business | |
| | Cream. | 0 | 34,700,000 | present | present | | |
| | Ice cream | 0 | innumerable | present | present | | |
| 10 | Cream. | 4,407 | 2,837,500 | present | present | fairly clean | clean bottles, steamed after washing with soda and soap |
| | Ice cream. | 70,512 | 1,965,000 | absent | absent | | |
| 11 | Cream. | 39,663 | 4,205,000 | present | present | intelligent clean | clean |
| | Ice cream. | 0 | 2,680,000 | present | present | shop | |
| 12 | Cream. | 0 | 4,755,000 | present | | fair | fairly clean |
| | Ice cream. | 26,442 | 4,510,000 | present | | made in cellar | |
| 13 | Cream. | 44,070 | 32,400,000 | present | | | |
| | Ice cream. | 52,884 | 19,900,000 | present | | clean | |
| 14 | Cream. | 44,070 | | present | present | clean | |
| | Ice cream. | 118,989 | | present | | clean | |
| 15 | Cream. | 114,024 | | present | | changed business | |
| | Ice cream. | 92,547 | | present | | | |
| 16 | Cream. | 26,442 | | present | | clean | clean, bottles steamed after washing with soda and soap |
| | Ice cream. | 35,256 | | present | | made in yard | |
| 17 | Ice cream. | 22,035 | 2,565,000 | absent | absent | | |
| 18 | Cream. | 114,024 | 3,672,500 | present | present | moved | |
| | Ice cream. | 35,256 | 5,400,000 | present | present | moved | |
| 19 | Cream. | 26,442 | | absent | absent | clean—kept by a woman—made in yard. | |
| | Ice cream. | 52,884 | 74,500 | | present | | |
| 20 | Milk. | 35,256 | | present | | fairly clean | |
| | Ice cream. | 70,512 | | present | | | |
| 21 | Milk. | 66,105 | 6,335,000 | present | present | dirty | clean |
| | Cream. | 105,768 | 1,200,000 | present | present | dirty | |
| | Ice Cream, | 52,884 | 2,990,000 | present | | | |
| | Condensed Cr. | 39,663 | 1,012,500 | absent | absent | | |
| 22 | Cream. | 13,221 | 5,520,000 | present | present | closed | clean |
| | Ice cream. | 17,628 | 3,965,000 | present | | | |
| 23 | Cream. | 88,140 | 13,795,000 | present | present | vacated | clean |
| | Ice cream. | 44,070 | 4,037,500 | present | present | | |
| 24 | Milk. | 154,245 | 1,287,500 | present | | closed | clean, bottles steamed after washing with soda and soap |
| | Ice cream. | 26,442 | 3,510,000 | present | | | |
| 25 | Cream. | 35,256 | 1,052,500 | present | | clean, ice cream made in rear shed | clean |
| | Ice cream (chocolate) | 4,407 | 24,260,000 | absent | present | | |
| 26 | Cream. | 26,442 | 3,510,000 | present | | clean | |
| | Ice cream. | 30,849 | 2,470,000 | present | | | |
| 27 | Cream. | 44,070 | 1,672,000 | present | | clean | |
| | Ice cream. | 39,663 | 6,535,000 | present | | | |
| 28 | Ice cream. | 35,256 | 1,052,500 | present | | dirty rooms, made in cellar | clean |
| 29 | Ice cream. | 61,698 | 8,080,000 | present | | dirty rooms, made in cellar | |
| 30 | Cream. | 13,221 | 50,000 | present | | fairly clean, made in cellar | clean |
| | Ice cream. | 52,884 | 70,000 | present | | | |
| 31 | Cream. | 616,080 | 5,400,000 | present | present | moved | fair |
| | Ice cream. | 8,814 | 1,400,000 | present | | | |
| 32 | Cream. | 0 | 160,000 | absent | absent | fairly clean, made in cellar | clean, woman in charge |
| | Ice cream. | 17,628 | | present | present | | |
| 33 | Cream. | 0 | 22,725,000 | | present | fair | clean |
| | Ice cream. | 0 | 16,080,000 | present | | | |
| 34 | Cream. | 0 | 4,055,000 | present | | clean, fairly intelligent | |
| | Ice cream. | 17,628 | 7,600,000 | present | | | |
| 35 | Cream. | 0 | 18,600,000 | present | present | fair | store in rear shed, fairly clean |
| | Ice cream. | 13,221 | 3,170,000 | present | | | |
| 36 | Cream. | 0 | 138,600,000 | absent | absent | fairly clean | |
| | Ice cream. | 88,140 | 11,800,000 | present | present | | |
| 37 | Cream. | 52,884 | 56,700,000 | | present | fairly clean | |
| | Ice cream. | 0 | 64,800,000 | absent | absent | | |
| 38 | Cream. | 26,442 | 42,400,000 | absent | absent | dirty cans, windows, etc. | |
| | Ice cream. | 22,035 | 18,200,000 | absent | absent | | |
| 39 | Cream. | 66,105 | 5,490,000 | present | present | fairly large ice cream plant | clean, bottles steamed after cleansing with soda and soap |
| | Ice cream. | 79,326 | 9,040,000 | present | | | |
| 40 | Cream. | 145,431 | 46,920,000 | present | present | fair, ice cream made in rear of factory | fair |
| | Ice cream. | 189,501 | 74,600,000 | present | present | | |
| 41 | Cream. | 0 | 11,365,000 | present | | fair, made in cellar | fair |
| | Ice cream. | 414,258 | 6,195,000 | present | present | | |
| 42 | Cream. | 440,700 | 151,200,000 | present | | filthy, use gold dust | |
| | Ice cream. | 202,722 | 57,300,000 | present | | | |
| 43 | Cream. | 88,140 | 5,790,000 | present | | dirty, ice cream made in yard | clean, use soda water |
| | Ice cream. | 66,105 | 31,580,000 | present | present | | |
| 44 | Ice cream. | 176,280 | 74,000,000 | present | | dirty, made in cellar | clean, bottles steamed after cleansing in soda and water |

TABLE I—*Continued.*

| | Material. | Leucocytes. | Count of organisms, per c.c. | Streptococci (morphologically. | Streptococci (pure culture.) | Premises, ice cream dealers. | Premises, cream dealers. |
|---|---|---|---|---|---|---|---|
| 45 | Cream. | 740,376 | 20,700,000 | present | present | clean, made in | |
| | Ice cream. | 154,245 | 3,460,000 | present | present | shed | |
| 46 | Cream. | 533,247 | innumerable | present | | filthy, made in | |
| | Ice cream. | 242,385 | 6,690,000 | present | present | back yard | |
| 47 | Ice cream. | 0 | 79,800,000 | | present | clean | |
| 48 | Ice cream. | 0 | 33,120,000 | present | | clean | |
| 49 | Ice cream. | 0 | 20,550,000 | absent | absent | clean | |
| 50 | Ice cream. | 0 | 9,390,000 | present | | | |
| 51 | Cream. | 8,814 | 52,400,000 | present | | filthy, made in | clean |
| | Ice cream. | 0 | 63,200,000 | present | | cellar | |
| 52 | Cream. | 0 | 126,000,000 | present | absent | dirty, made in | |
| | Ice cream (chocolate). | 0 | 8,740,000 | absent | absent | back yard | |
| 53 | Cream. | 44,070 | 2,250,000 | present | | clean | |
| | Ice cream. | 48,477 | 557,500 | present | | | |
| 54 | Cream. | 132,210 | 63,280,000 | present | present | fairly clean | |
| | Ice cream. | 22,035 | 5,730,000 | present | present | | |
| 55 | Cream. | 13,221 | 14,105,000 | | present | clean, ice cream | clean |
| | Ice cream. | 17,628 | 35,000,000 | | present | made in yard | |
| 56 | Cream. | 0 | 335,000 | absent | absent | fair, ice cream | |
| | Ice cream. | 0 | 2,290,000 | | present | made in yard | |
| 57 | Cream. | 66,105 | | absent | absent | fairly clean | clean, bottles steamed after washing with soda and water |
| | Ice cream. | 52,884 | | absent | | | |
| 58 | Cream. | 26,442 | | present | | fairly clean | fairly clean |
| | Ice cream. | 79,326 | | present | | | |
| 59 | Ice cream. | 13,221 | | | | absolutely filthy | |
| 60 | Ice cream. | 594,945 | | absent | | moved | |
| 61 | Cream. | 224,757 | | present | | | |
| | Ice cream. | 229,154 | | present | | | |
| 62 | Ice cream. | 52,884 | | absent | absent | clean | |
| 63 | Ice cream. | 110,175 | | present | | clean | |
| 64 | Ice cream. | 105,768 | 0 | present | | fair, made in cellar | |
| 65 | Ice cream. | 17,628 | 0 | absent | absent | fair, made in yard | clean, bottles washed in soda and water, then steamed |
| 66 | Ice cream. | 105,768 | 0 | present | | fair, made in yard | |
| 67 | Cream. | 264,420 | 0 | present | | clean | fair |
| | Ice cream. | 35,256 | 0 | present | | | |
| 68 | Cream. | 22,035 | 0 | present | | fair | clean |
| | Ice cream. | 17,628 | 0 | present | | | |
| 1 | Milk ball. | 13,221 | 1,908,000 | absent | absent | out of business | |
| 2 | Hokey pokey. | 0 | too old | absent | absent | bought from street peddler | |
| 3 | Hokey pokey. | 4,407 | 2,475,000 | absent | absent | " | |
| 4 | Chocolate hokey pokey. | 8,814 | 5,520,000 | absent | absent | " | |
| 5 | Water ice. | 0 | 170,000 | absent | absent | " | |
| 6 | Chocolate hokey pokey. | 0 | 5,100,000 | | present | " | |
| 7 | Hokey pokey. | 0 | 700,000 | absent | absent | " | |
| 8 | Chocolate hokey pokey. | 0 | 5,555,000 | absent | absent | " | |
| 9 | Hokey pokey. | 0 | 14,420,000 | absent | absent | " | |

in its manufacture was investigated. In thirty-five of the forty-five cases, or 77 per cent., streptococci were found in the milk or cream and in the ice cream as well. From twenty-three, or 33 per cent. of all examined, the streptococci were isolated in pure culture. They grew fairly easily. In only three samples were these organisms found in the cream alone; and, where both cream and ice cream were examined, only twice in the ice cream alone. The foregoing figures are summarized from Table I.

The question of the original source of streptococci in ice cream is of importance from a sanitary standpoint. The conditions under which the mixtures are made and frozen, the cleansing of the utensils, etc., are such that very often almost any kind of bacterial infection may gain access to it.

The usual source of streptococci in milk or cream, however, is the cow, and, judging from the results set forth here, it is the cream or milk entering into the ice cream which is the carrier of the germs.

The cleanliness of the surroundings under which the ice cream is made does not seem to greatly affect the presence of streptococci. Sixty different ice cream makers were visited and their premises inspected. What constitutes a standard of cleanliness in the production of such a food stuff as ice cream depends very largely upon the inspector's ideas on the subject. The very nature of the process—the mixture of ice and salt, wooden tubs for freezing, fruit flavoring, etc.—makes it a difficult matter to preserve immaculate surroundings, even when interiors of utensils and constituents of the ice creams are strictly clean. The final division of these sixty different makers' establishments was made on the basis of four classes: (1) Clean; (2) fair; (3) dirty; (4) filthy. In rating them the building, drain-

age, opportunities for ventilation, conditions of walls, ceilings, windows, adjoining rooms or buildings, as well as the condition of the utensils, methods of cleaning, attempts at sterilization, etc., were taken into account. The results are as indicated:

TABLE II.

*Division of Sixty Different Establishments.*

| | Number of establishments. | Percentage having streptococci in ice cream. | Average count of organisms per c.c. |
|---|---|---|---|
| Clean | 20 | 90 | [1]12 460 863 |
| Fair | 26 | 77 | 15 857 800 |
| Dirty | 6 | 66 | 22 491 833 |
| Filthy | 8 | 75 | 29 225 714 |

While the cleanliness of the manufactory does not, according to this investigation, bear any constant relation to the presence of streptococci, it does affect the cleanliness of the finished product as indicated by the total bacterial content, a gradual rise being observed from the "clean" shops to the "filthy" ones. The latter were sometimes almost beyond description. For instance, sample 42 was made in a shed adjoining both a dwelling and a stable for eight or ten horses. The workmen went from horses and stable-cleaning to the ice cream shed without restraint, handling the utensils in the latter as necessity demanded, regardless of soiled clothes or hands. Ice cream cans and milk cans stood in a passageway common to both shop and ice cream manufactory and part of which was bordered on each side by stalls for horses. The stench of this place finally caused complaint from the neighborhood and it was dealt with on the ground of a nuisance. On the other hand, a large ice cream manufacturer had endeavored to preserve the strictest cleanliness possible. Employees engaged in ice cream making did no other work, and each man had only certain duties or portions of the process assigned to him. He changed his clothing and took a bath when beginning the day's work, and clean lockers and plentiful showers were provided to enable the fulfillment of this regulation. The utensils were cleaned with soda and finally placed on a steam table for sterilization. Such precautions resulted in the counts given in samples 27 and 48 and 49, namely, 6,535,000, 33,120,000, and 20,550,000.

Through the courtesy and interest of the head of this ice cream firm a bacteriological study of each step in the process was made possible. The cream in the supply tank was first sampled; a portion was then drawn off by the employee, mixed with the necessary sugar (cane) for sweetening, and a sample of this taken for examination. After adding the vanilla and transferring to the freezing cans it was again sampled, and then the frozen product was also examined. In the freezing the bulk a little more than doubled. Although frozen, the ice cream was soft enough to measure in a wide mouthed 10 c.c. pipette, and it was plated,

[1]Among the eleven available counts from clean shops one gave over 79,000,000 to the c.c. This was so far in excess of the other ten that it was deemed more just to exclude it when taking the average.

TABLE IV.

*Comparisons of Inoculated Samples Kept at Refrigerator,*

| | Immediate. | | | 24 hours later. | | | | | | 48 hours later. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1906 | Refrigerator. | Room. | Incubator. | Refrigerator. | Percentage of increase. | Room. | Percentage of increase. | Incubator. | Percentage of increase. | Refrigerator. | Percentage of increase. | Room. | Percentage of increase. |
| January 29th. | | | | | | | | | | | | | |
| No. 1. | | | | | | | | | | | | | |
| Milk | 45 | 70 | 18 | 118 | 162.22 | 599 | 755.71 | 15,470 | 85,844.4 | 1,558 | 3,362.0 | 5,528 | 7,797.0 |
| Cream | 130 | 97 | 58 | | | 1,915 | 1,874.22 | 22,700 | 39,037.9 | | | 34,198 | 35,155.0 |
| No. 2. | | | | | | | | | | | | | |
| Milk | 22 | 76 | 42 | 115 | 422.72 | 426 | 460.52 | 23,270 | 55,304.7 | 968 | 4,300.0 | 14,708 | 19,252.0 |
| Cream | 132 | 142 | 74 | 511 | 287.12 | 2,526 | 1,678.8 | 33,353 | 44,971.62 | 11,920 | 8,930.0 | 30,400 | 21,308.0 |
| February 5th. | | | | | | | | | | | | | |
| No. 3. | | | | | | | | | | | | | |
| Milk | 13 | 10 | 13 | 25 | 92.3 | 5,490 | 54,800.0 | innumerable. | | 49 | 276.92 | 16,635 | 166,250.0 |
| Cream | 16 | 13 | 10 | 29 | 81.25 | 24,048 | 184,884.0 | innumerable. | | 83 | 418.0 | 77,760 | 598,053.0 |
| No. 4. | | | | | | | | | | | | | |
| Milk | 10 | 10 | 11 | 21 | 110.0 | 8,780 | 87,700.0 | innumerable. | | 30 | 200.0 | 23,520 | 235,100.0 |
| Cream | 11 | 19 | 9 | 36 | 227.0 | 32,268 | 169,731.0 | innumerable. | | 33 | 200.0 | 128,760 | 677,584.0 |
| February 15th. | | | | | | | | | | | | | |
| No. 5. | | | | | | | | | | | | | |
| Milk | 21 | 17 | 12 | 16 | 23.0 | 8,440 | 49,547.0 | 7,817 | 65,041.0 | 120 | 471.0 | | |
| Cream | 20 | 11 | 9 | 76 | 280.0 | 30,146 | 273,954.0 | 4,031 | 44,688.0 | 521 | 2,505.0 | 11,360 | 103,172.0 |
| No. 6. | | | | | | | | | | | | | |
| Milk | 8 | 19 | 13 | 27 | 237.0 | 14,198 | 74,626.0 | 325 | 2,400.0 | 131 | 1,537.0 | | |
| Cream | 23 | 20 | 15 | 68 | 195.0 | 50,112 | 250,460.0 | 890 | 5,833.0 | 595 | 2,486.0 | 15,060 | 75,200.0 |
| March 19th. | | | | | | | | | | | | | |
| No. 7. | | | | | | | | | | | | | |
| Milk | 1,362 | 1,135 | 932 | 10,750 | 689.0 | 5,760,000 | 507,388.0 | 14,280,000 | 1,532,082.0 | 7,700 | 465.0 | | |
| Cream | 1,097 | 1,392 | 597 | 15,500 | 1312.0 | 6,720,000 | 482,658.0 | 15,360,000 | 2,572,764.0 | 16,800 | 1,431.0 | | |
| No. 8. | | | | | | | | | | | | | |
| Milk | 1,347 | 990 | 885 | 14,375 | 967.0 | 600,000 | 60,506.0 | 8,640,000 | 976,171.0 | 4,900 | 263.0 | | |
| Cream | 1,387 | 2,420 | 2,335 | 8,925 | 543.0 | 1,020,000 | 42,048.0 | 9,560,000 | 409,321.0 | 7,500 | 440.0 | | |
| March 26th. | | | | | | | | | | | | | |
| No. 9. | | | | | | | | | | | | | |
| Milk | 9,300 | 7,825 | 8,050 | 9,150 | —1.61 | 2,610,000 | 33,254.0 | 71,700,000 | 890,583.0 | 11,000 | 18.0 | 21,360,000 | 272,871.0 |
| Cream | 1,430 | 8,100 | 9,725 | 14,900 | 941.0 | 5,424,000 | 66,862.0 | innumerable. | | 13,250 | 826.0 | 32,720,000 | 403,850.0 |
| No. 10. | | | | | | | | | | | | | |
| Milk | 11,075 | 9,100 | 8,350 | 10,600 | —4.28 | 4,752,000 | 52,119.0 | 63,680,000 | 752,534.0 | 825 | —92.0 | 39,720,000 | 436,383.0 |
| Cream | 1,037 | 11,750 | 6,300 | 10,550 | 917.0 | 6,170,000 | 52,410.0 | innumerable. | | 13,200 | 1,172.0 | innumerable. | |

after appropriate dilution, at once. The results of the frozen cream, to be comparable with those of the preceding samples, should, therefore, be about doubled. The plates were of agar and were grown at 20° C.

TABLE III.

*Organisms in Ice Cream at Each Step in the Process of Making.*

| | On agar at 20° C. organisms per c.c. | Streptococci |
|---|---|---|
| Cream from tank..... | 2,840,000 | Present. About 25 per cent. of all organisms—and in an active condition. |
| Cream and sugar..... | 7,000,000 | |
| Cream, sugar and vanilla in freezer..... | 5,750,000 | |
| Frozen cream..... | 2,250,000×2= 4,500,000 | |

In this particular experiment the sugar carried in the greatest number of organisms. The cream itself was fairly free of living germs. It did contain streptococci, however, in an active condition. This fact is of interest, since the cream, immediately upon its receipt, is pasteurized in a continuous flow machine by the ice cream maker. A very large proportion of the cream coming into the city is pasteurized before it leaves the hands of the cream dealer; often it is so treated at the receiving station or creamery in the country district from which the milk is collected, and hence this ice cream is likely to have two pasteurizations. Nevertheless, vegetative streptococci are found in the finished product.

The proportion of streptococci as compared with other organisms in the finished ice cream is strikingly high. Often they seem, from microscopical examination, to be in almost pure culture. The number of streptococci in the average market cream is apt to exceed the number in milk of the same standard. If these organisms really do grow more luxuriantly in cream than in milk we have one explanation of their very frequent presence in ice cream. To determine this point, milk and cream of known fat content, as fresh as possible, and counting less than 5,000 organisms per c.c., were sterilized and inoculated with a strain of streptococcus isolated originally from milk and scraped for inoculation from a 48 hour agar slant.

The inoculated samples were kept at refrigerator, room, and incubator temperatures, and plated immediately, and at intervals of twenty-four hours, as indicated in Table IV. The plates were made on agar and grown for twenty-four to seventy-two hours at 37° C.

Comparative counts of streptococci when grown in sterilized milk or cream are difficult in that they vary among themselves, even though the greatest care be taken to have conditions the same. The method of diluting a measured quantity in sterile water or physiological salt solution and pipetting off the desired amount was found to be less satisfactory than the removal of the *oese* of the inoculated milk or cream, washing off the platinum wire in a good sized drop of sterile physiological salt which had previously been placed on the middle of the lower section of a Petri dish, and immediately

TABLE IV.

*Room, and Incubator Temperatures.*

| | | 72 hours later. | | | | 96 hours later. | | | | 120 hours later. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Incubator. | Percentage of increase. | Refrigerator. | Percentage of increase. | Room. | Percentage of increase. | Refrigerator. | Percentage of increase. | Room. | Percentage of increase. | Refrigerator. | Percentage of increase. | Room. | Percentage of increase. |
| | | 10,340 | 22,877.0 | 15,240 | 21,671 | 13,805 | 30,577.0 | 13,606 | 19,337.0 | 15,658 | 34,695.0 | 24,200 | 34,491.0 |
| | | | | 92,960 | 95,735 | | | 52,160 | 53,673.0 | | | 210,640 | 217,054.0 |
| | | 13,200 | 59,900.0 | 24,016 | 31,500 | 17,073 | 77,504.0 | 35,040 | 46,005.0 | 10,480 | 47,536.0 | 22,916 | 30,052.0 |
| | | 48,046 | 36,298.0 | 70,720 | 49,702 | 84,480 | 63,900.0 | 114,880 | 80,801.0 | 92,800 | 70,203.0 | 121,460 | 85,435.0 |
| coagulated. | | 111 | 753.0 | innumerable. | | 210 | 1,515.0 | | | 10,033 | 77,076.0 | | |
| coagulated. | | 353 | 2,106.0 | innumerable. | | 545 | 3,306.0 | | | 27,777 | 173,506.0 | | |
| coagulated. | | 50 | 400.0 | innumerable. | | 118 | 1,080.0 | | | 6,493 | 64,830.0 | | |
| coagulated. | | 185 | 1,581.0 | innumerable. | | 438 | 3,881.0 | | | 36,586 | 332,500.0 | | |
| | | 647 | 2,980.0 | 70,280 | 413,311 | | | | | | | | |
| | | 2,481 | 11,990.0 | 117,120 | 1,064,627 | | | | | | | | |
| | | 553 | 6,812.0 | 113,280 | 596,110 | | | | | | | | |
| | | 3,506 | 15,143.0 | | | | | | | | | | |
| innumerable. | | 8,200 | —11.82 | | | | | | | | | | |
| innumerable. | | 14,700 | 927.0 | | | | | | | | | | |
| innumerable. | | 3,450 | —68.84 | | | | | | | | | | |
| innumerable. | | 8,300 | 700.0 | | | | | | | | | | |

pouring on the top of the mixture the melted agar, shaking with a rotary motion to distribute the germs evenly. Plates so made, involving but little manipulation, and reducing to a minimum the effects of osmosis, were the most satisfactory, though they frequently left much to be desired. The counts of organisms as given represent, then, the number of streptococci in one *oese* of milk and of cream, the former containing 3.5 to 3.8 per cent. of fat, except in experiments 9 and 10, where it was 4.5 per cent., and the latter containing 27 per cent. of fat, except in experiments 9 and 10, where it was 25 per cent.

An analysis of the results given in Table IV shows that, during the first twenty-four hours, of the samples kept in the refrigerator the percentage of increase of streptococci in the cream was in six cases greater than the corresponding increase in the milk. The portions kept at room temperature showed a greater proportion of streptococci in the cream in seven instances out of the ten, while the portions in the incubator at 37° C. gave the greater increase in the milk in four out of six comparative counts. After forty-eight hours under these conditions the cream in the refrigerator had the greater number of organisms in eight out of ten comparable counts; at room temperature all the cream samples were ahead of the milk, and those in the incubator showed a curd with a separation of whey in the milk samples, and a practically solid mass, though without distinct flocking, in the cream. At the expiration of seventy-two hours six out of seven cream and milk counts showed the cream the richer in organisms, and the cream samples at room temperature had maintained the gain they had acquired at the end of forty-eight hours. Scattering counts of milk and cream kept in the refrigerator until ninety-six to one hundred and twenty hours old showed a very marked increase in the cream as compared with the milk. Indeed, the longer one keeps the culture, particularly when the temperature is about 15° C., the more regular and striking does the percentage of increase of streptococci in the cream become.

Throughout this work the thickening of the cream as the streptococci increased, rather than the curding that one finds in milk, was most pronounced. A fluid cream, which, at the beginning of the experiment, could be readily shaken without the production of an undue amount of froth, began after forty-eight hours in the refrigerator to thicken markedly, and shaken very soon produced "whipped cream." A number of samples were kept for six weeks, but curding did not occur unless heat was applied. Small yellow oil droplets, however, did separate from very old samples.

Milk dealers sell their stale cream to ice cream makers; first, because such cream is cheaper, and, second, because cream which is almost at the souring point is smoother, thicker, whips better, and, so the manufacturers of ice cream assert, makes an ice cream of more pleasing consistence than does a fresh cream. Judging from the frequency of the streptococcus in ice cream and its relative abundance there, it is possible that upon this organism depends, to some extent, the ripening of cream for this purpose.

The difficulty experienced by dealers, especially in warm weather, of transporting and preserving cream without souring, has led to its pasteurization. Much of it is pasteurized in the plants of dealers in this city, and some of it is pasteurized at the receiving stations in the country. After that certain ice cream makers, such as the one cited in the investigation, heat the cream after it is in their hands. In spite of all this we have isolated active streptococci in so many cases that one must gravely doubt the efficiency of commercial pasteurization for the destruction of this organism.

One must also bear in mind the work of Zelenski,[2] who has definitely proved that a considerably higher heat is necessary to kill bacteria of any kind when in cream than in milk, and that a higher heat is required for whole milk than for skimmed milk. Apparently the presence of fat exercises a protective action on the organisms present.

In this problem of clean ice cream, as in other dairy problems, one is thrown back upon the necessity of an originally clean milk or cream. The dirty shops have had a certain amount of influence bacteriologically upon the final condition of the ice cream made in them. A much larger factor, however, in the total bacterial content of the class of foodstuffs under discussion is the cream which originally enters into them. With the bacterial count of market creams in the many millions, one cannot expect the ice creams to be bacterially clean, no matter what the surroundings. To what extent these dirty ice creams are responsible for diseases, particularly the diarrhœal diseases which are generally prevalent during the heated term, is still an open question. It would seem, however, from the frequent activity of the streptococcus, that its presence in ice cream and the possible deleterious effects upon the organism which it may produce, should be taken into account when dealing with certain pathogenic conditions in human beings.

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