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SOME OF THE WAYS IN WHICH MILK BECOMES PATHOGENIC.*

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THIS communication contains the results of an examination of over 110 samples of milk sent to me by Professor Hope, of Liverpool, and Dr. Niven, of Manchester, for the purpose of determining the prevalence of tuberculous infection. While doing this work I was able to find evidence of the existence of contaminations which I considered went far towards explaining the occurrence of summer diarrhœa in artificially-fed infants and to a lesser extent in adults.

That diarrhœa is frequently caused by the consumption of milk is a view accepted by many authorities. What I have found is that milk very often becomes capable of producing considerable irritation through changes which take place after it has left the udder and has been under certain conditions. Part of the samples examined were obtained from diseased cows, the milk being carefully drawn into sterilised vessels and sent immediately to the laboratory. These I will call unmixed milks. The other samples were collected at railway stations in sterilised bottles from milk cans just arriving from the farm. These I will call mixed milks. These specimens were collected in summer and in winter. Some were necessarily kept longer than others.

* For a full account of this subject see *Journal of Comparative Pathology*, M'Fadyean, vol. x 1897, pp. 150 to 189.

The results obtained are summarised in the following tables:

Pathogenic Properties of Milk from Diseased and Healthy Udders.

Milk from Udders.		Producing Tuberculosis.			Producing Marked Irritation.			Producing no Marked Irritation.		
		Actual No.	Percentages.		Actual No.	Percentages.		Actual No.	Percentages.	
A. Certainly diseased	10	5	50.0	31.5	3	30.0	25.30	2	20.0	42.08
B. Probably diseased	9	1	11.1		2	22.2		6	66.6	
		6			5			8		
C. Healthy	5	0	0	0	2	40.0	40.00	3	60.0	60.00
Total ...	24	6			7			11		

Pathogenic Properties of Non-tuberculous Milk from Diseased and Healthy Udders.

Milk from Udders.		Producing Marked Irritation.			Producing no Marked Irritation.		
		Actual No.	Percentages.		Actual No.	Percentages.	
A. Certainly diseased ...	5	3	60.0	38.5	2	46.0	61.6
B. Probably diseased ...	8	2	25.0		6	75.0	
	13	5			8		
C. Healthy ...	5	2	40.0	40.0	3	60.0	60.0
Total ...	18	7			11		

Pathogenic Properties of Milk, Rich and Poor in Cells from the Udder.

	Producing Tuberculosis.		Producing Marked Irritation.		Producing no Marked Irritation.	
	Actual No.	Per Cent.	Actual No.	Per Cent.	Actual No.	Per Cent.
Cells abundant or very abundant...	6	46.2	3	23.1	4	30.8
Cells scanty or in moderate numbers	0	0	2	25.0	6	75.0

Pathogenic Properties of Non-tuberculous Milk.

—	Producing Marked Irritation.		Producing no Marked Irritation.	
	Actual No.	Per cent.	Actual No.	Per cent.
Cells abundant	3	42.9	4	56.2
Cells scanty or moderate...	2	25.0	6	75 0

Mixed Milks from the Town Market, and Unmixed Milks from Diseased Cows Compared.

Milk Producing.	Mixed Milks.		Unmixed Milks.	
	Actual No.	Percentage.	Actual No.	Percentage.
No marked irritation...	17	37·74	11	45·76
Marked local irritation but no general infection	17	37·74	7	29.12
Intense local irritation general infection	8	17 76	0	0
Tuberculosis ..	3	6.66	6	24.96
Total ...	45	99.90	24	99 84

The most striking outcome of this comparison is that even the milk of markedly diseased cows is much less often capable of producing irritation than the ordinary mixed milk supplied for consumption, and whilst 17 per cent. of the latter are capable of producing severe infection, rapidly fatal, none of the milks obtained direct from the udder, in sterilised vessels, produced any affection of comparable intensity.

Even with regard to the minor forms of irritation, such as local abscesses, inflammatory enlargement of lymphatic ganglia, mixed milk proved inferior in quality to unmixed milk from diseased cows.

The same difference is also shown by the comparatively small number of mixed milks which were free from all noxious properties, for whilst only 37.74 per cent. of the mixed milks proved perfectly innocuous, 45.76 (that is 8 per cent. more) of the unmixed milks showed the same quality. If it be remembered that 23 out of the 24 of the latter had been taken from tuberculous cows, and that more than one-half of these cows had diseased udders, it will be evident that to get a proper idea of the relative noxiousness of mixed and unmixed milks on the basis of the results quoted above, the tuberculous milks should be excluded.

If this be done there remain 42 specimens of non-tuberculous mixed milks, and 18 of non-tuberculous unmixed milks. The pathogenic properties of which were as follows:

	Not Irritating.	Irritating Locally.	Highly Virulent.
	Per cent.	Per cent.	Per cent.
Mixed milks ...	40.8	40.8	19.2
Unmixed milks ...	60.5	38.5	—

The following tables show the influence of keeping and of temperature:

I.—*Mixed Milks coming from a Distance of generally over Forty Miles, and generally kept for from Twenty-four to Sixty Hours, and even more in a few Cases.* (*Tuberculous Samples excluded.*)

Mean Temperature in the Shade (Manchester) during Time the Specimens were kept.	Specimens producing no Noxious Effects.	Noxious Specimens.	Totals.	Percentage of Good Specimens.
30° to 35°	7	5	12	58.0
35° to 40°	7	11	18	38.5
40° to 45°	2	3	5	40.0
45° to 50°	1	4	5	20.0
50° to 55°	—	—	—	—
55° to 60°	0	2	2	0.0
	17	25	42	39.0

II.—*Mixed Milks coming from a short Distance (generally under Twenty Miles), most of them kept for less than Ten Hours (with the exception of Five out of the Seven bad Specimens, and Four out of the Twenty-Two good Specimens, Tuberculous Samples excluded.)*

Mean Temperature in the Shade (Manchester) during Time the Specimens were kept.	Specimens producing no Noxious Effects.	Noxious Specimens.	Totals.	Percentage of Good Specimens.
50° to 55°	1	0	1	100.0
55° to 60°	8	1	9	88.8
60° to 65°	11	4	15	73.2
65° to 70°	—	—	—	—
70° to 75°	2	2	4	50 0
	22	7	29	75.68

III.—*Unmixed Milks kept for various Lengths of Time, but Collected from the Udder in Sterilised Vessels. (Tuberculous Samples excluded.)*

Mean Temperature in the Shade (Manchester) during Time the Specimens were kept.	Specimens producing no Noxious Effects.	Noxious Specimens.	Totals.	Percentage of Good Specimens.
35° to 40°	6	0	6	100.0
40° to 45°	3	2	5	60.0
45° to 50°	5	2	7	71.5
50° to 55°	—	—	—	—
55° to 60°	—	—	—	—
60° to 65°	0	3	3	0.0
	14	7	21	67.2

The influence of time is well shown by the number of specimens remaining good even at high temperature when the milk had been kept only half a day.

On the other hand, the influence of temperature is still more evident, for in every category the number of good specimens is almost inversely proportional to the height of the temperature.

When the clear relation existing between time of keeping *plus* temperature and the noxious properties of a certain number of samples of milk is contrasted with the ambiguous results obtained when an attempt is made to connect these noxious properties with disease of the udder (tuberculosis being excluded), it is difficult not to feel convinced that infection of the milk outside the udder, and the conditions under which it is kept, are the most important factors causing it to acquire irritating properties.

I have been able to collect some facts during the last few years in connection with outbreaks of epidemic diarrhœa due to the consumption of milk. I have found a close resemblance between the infection produced in guinea-pigs by the inoculation of milk which had given rise to one of these outbreaks, and that produced in guinea-pigs by the injection of several samples of mixed milks obtained on the market. This has led me to suspect that milk must be one of the most potent causes of the summer diarrhœa of children, an opinion which is also held by several well-known authorities. My belief has been strengthened by the fact that from all the cases of fatal septicæmia due to milk injections I have been able to isolate a bacillus identical with that obtained twice from milk causing intense diarrhœa in children and adults. Other organisms have been present in a few specimens, but the only organism constantly present has been this bacillus. This microbe retains its virulent properties even after being cultivated for several generations outside the body. It resembles closely the bacillus coli communis in its pathogenic action, its mode of growth on gelatine, agar, potato, milk, lactose agar, glucose gelatine, its size and shape, its motility. The differences are

so much within the limits of variations observable in that organism that I am still doubtful whether the differences observed are enough to allow of this milk bacillus being considered a different species. It does not either correspond exactly to any of the other known bacilli resembling the bacillus coli. It is possibly only a pathogenic variety, but for the present it will be enough to say that it is a bacillus found in pathogenic milk.