

THE CLEANABILITY OF MATERIALS IN CONTACT WITH DAIRY PRODUCTS¹

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The removal of air dried soil (dairy products contaminated with *E. coli*) from the surface of disks of several possible dairy equipment construction materials was determined by both radioactive tracer techniques and bacteriological methods. Both methods showed that cleaning the disks with any of the four types of cleaning compounds effected essentially complete removal of the contaminating soil from the surface of the molded plastics and various finishes of stainless steel which were tested.

An almost daily problem presented to sanitarians is the cleaning and sanitizing of surfaces which contact food and milk. Methods for determining the cleanability of eating surfaces and the results obtained by these methods have been reported by Hucker (1), Hucker, Emery and Winkler (2), Mallmann, Kahler and Butt (3) and Ridenour and Armbruster (4). Similarly, methods for assessing the cleanability of surfaces in contact with dairy products should be valuable aids in devising specifications for 3A Standards.

These methods also must be suitable for testing new materials such as plastics considered for use for molded parts, as well as stainless steel finishes other than 120 grit.

A plastic must possess certain general characteristics before it can even be considered for use in dairy equipment. In general, it must be (a) non-toxic, (b) readily cleanable, (c) relatively non-absorbent, (d) non-reactive to mild acids and alkalis, (e) of adequate strength and (f) able to resist distortion at temperatures as high as 212°F. Stainless steels with finishes other than 120 grit must be as cleanable as the present finish to be satisfactory for equipment parts. Data is needed, therefore, which compares the cleanability of suitable molded plastics and of various stainless steel finishes with that of the 120 grit finish 18-8 stainless steel which has long been the standard construction material.

Both radioactive tracer techniques and bacteriological methods have been employed in this study. The materials tested were:

1. Zytel No. 31, a polyamide

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2. Genetron HL and Genetron VK, polychlorotrifluorethylenes
3. 18-8 Stainless Steels with the following finishes
 - A. 120 grit
 - B. 100 grit
 - C. 80 grit
 - D. No. 7 mill finish
 - E. Vapo Blast (VB) method of producing a pebble-like finish
 - F. 2B or cold rolled finish

EXPERIMENTAL

For the purposes of these studies, disks approximately two inches in diameter were used as the test specimen of each material. The general experimental plan consisted of soiling these disks with dairy products which had previously been contaminated with *Escherichia coli*. The milk products used were cream,

buttermilk, homogenized milk, and chocolate milk. On each disk, 0.4 ml. of the product was spread evenly on one side only and allowed to air dry. The soiled disks were then cleaned by scrubbing with a test tube brush for about 15 seconds in one of the following cleaners:

1. 0.25 per cent solution of an alkaline cleaning compound.
2. 0.25 per cent solution of an anionic detergent.
3. 0.25 per cent solution of a nonionic detergent.
4. 6.7 per cent solution of an acid cleaning compound.

After being scrubbed, the disks were rinsed in tap water.

Radioactive Tracer Technique

The *E. coli* suspension used to inoculate the dairy products for the radioactive tracer procedure for determining cleanability was prepared by the method of Ridenour and Armbruster (4). Briefly, this consisted of growing *E. coli* in a broth medium containing 10 microcuries per ml. of radioactive phosphorus. After 24 hours incubation at 37°C. the cells were washed three times to eliminate any radioactive phosphorus not taken up by the cells. The colony count of the dairy products used to soil the disks after contamination with the radioactive *E. coli* suspension was 56×10^6 per ml.

After the disks were dry, the amount of radioactivity of each was determined by counting in an end

window "Sugarman" type proportional counter. The scrubbing procedure described above was then carried out, after which any residual radioactivity was recorded.

Bacteriological Technique

The *E. coli* suspensions used in the bacteriological phase of this study were centrifuged, washed cells of 24-hour nutrient broth cultures. The washed cells were suspended in sterile water and were kept refrigerated until used. Three ml. of suspension were added to each 25 ml. of dairy product to prepare the soiling medium. The initial coliform count was determined by plating dilutions of each of the inoculated milk products. These samples and all those described below were cultured in Brilliant Green Bile Agar to which 0.5 per cent agar had been added so that 5 ml. aliquots could be plated in a single petri dish.

Each variable of disks with dried milk product on them was then subjected to the procedures described below:

(1) Two disks were placed in 25 ml. of sterile water so that the recovery coliform count, or count at time of cleaning, could be determined. After the disks were soaked and swabbed clean of all visible soil, dilutions of the soak water were cultured.

(2) Eight disks (two for each of the four cleaner variables) were scrubbed and rinsed as described above, then placed in 25 ml. of sterile water for approximately 5 minutes. This water was then cultured

TABLE 1 — RECOVERABILITY OF *E. coli* FROM SOILED DISKS (ALL FIGURES $\times 10^6$)

Materials		Dairy products in which <i>E. coli</i> was suspended							
		Cream		Buttermilk		Homogenized milk		Chocolate milk	
		Initial ^a count	Recovery ^b count	Initial ^a count	Recovery ^b count	Initial ^a count	Recovery ^b count	Initial ^a count	Recovery ^b count
Zytel #31	Max.	230.0	22.0	120.0	2.0	170.0	92.0	160.0	31.0
	Min.	62.0	9.7	27.0	1.8	60.0	7.5	72.0	4.9
18-8 (120)	Max.	200.0	94.0	96.0	2.1	170.0	40.0	190.0	29.0
	Min.	62.0	8.2	49.0	0.069	60.0	7.7	72.0	5.1
18-8 (100)	Max.	230.0	22.0	128.0	1.2	170.0	19.0	260.0	21.0
	Min.	47.0	9.5	27.0	.019	33.0	4.7	59.0	17.0
18-8 (80)	Max.	130.0	39.7	68.0	3.1	176.0	7.8	88.0	20.0
	Min.	58.0	8.1	64.0	.35	40.0	2.6	65.6	12.0
18-8 (#7)	Max.	180.0	21.7	104.0	2.2	200.0	13.0	180.0	86.0
	Min.	43.2	5.0	49.0	.127	140.0	1.8	99.0	1.8
18-8 (VB)	Max.	180.0	25.6	124.0	1.6	172.0	56.0	120.0	37.0
	Min.	58.0	6.0	44.0	.27	33.0	6.1	80.0	5.5
18-8 (2B)	Max.	180.0	50.0	104.0	.987	172.0	10.6	192.0	26.0
	Min.	47.0	8.1	49.0	.102	40.0	2.6	84.0	9.37
Genetron HL	Max.	204.0	90.0	96.0	1.5	172.0	16.0	220.0	66.0
	Min.	47.0	13.0	44.0	.025	59.0	5.9	84.0	27.0
Genetron VK	Max.	64.0	30.2	66.8	9.1	176.0	27.5	192.0	23.5
	Min.	50.8	14.5	64.0	.036	34.0	7.5	59.0	11.7

^aInitial counts are the calculated number of *E. coli* added to each disk when the disks were soiled with the contaminated dairy products.

^bRecovery counts are the *E. coli* colony count obtained by soaking and swabbing the air dried disks in sterile distilled water.

TABLE 2 — PER CENT REMOVAL OF *E. coli* FROM VARIOUS SURFACES WITH AN ALKALINE CLEANER AT ROOM TEMPERATURE

Surface cleaned	Dairy products in which <i>E. coli</i> was suspended							
	Cream		Buttermilk		Homogenized milk		Chocolate milk	
	Radio. technic.	Bact. technic.	Radio. technic.	Bact. technic.	Bact. technic.	Radio. technic.	Bact. technic.	
Zytel #31	100.00	99.99	100.00	99.99	99.99	99.99	99.99	
18-8 (120)	100.00	99.99	99.99	100.00	99.99	99.98	99.99	
"		99.99		99.99	99.99		99.99	
18-8 (100)		99.99		100.00	99.99		99.99	
"		99.86		100.00	99.99		99.99	
18-8 (80)	99.99	99.99	100.00	100.00	99.99		100.00	
"		99.99		99.99	99.99		99.99	
18-8 (#7)		99.99		100.00	100.00		99.99	
"		99.99		99.99	99.99		99.99	
18-8 (VB)		100.00		99.99	99.99		99.99	
"		99.99		99.95	99.99		99.99	
18-8 (2B)		100.00		99.99	99.99		99.99	
"		99.99		99.99	99.99		99.99	
Genetron HL	100.00	99.99	100.00	100.00	100.00		99.99	
"		99.99		100.00	99.99		99.99	
Genetron VK	100.00	100.00	100.00	100.00	99.99		99.99	
"		99.99		99.99	99.99		99.99	

Note: Each value represents two test disks.

TABLE 3 — PER CENT REMOVAL OF *E. coli* FROM VARIOUS SURFACES WITH AN ANIONIC DETERGENT AT ROOM TEMPERATURE

Surface cleaned	Dairy products in which <i>E. coli</i> was suspended							
	Cream		Buttermilk		Homogenized milk		Chocolate milk	
	Radio. technic.	Bact. technic.	Radio. technic.	Bact. technic.	Bact. technic.	Radio. technic.	Bact. technic.	
Zytel #31	99.82	99.99	99.98	100.00	99.99	100.00	100.00	
18-8 (200)	99.88	99.99	99.96	100.00	99.99	99.99	99.99	
18-8 (100)		99.99		100.00	99.99	99.99	99.99	
18-8 (80)	99.86	100.00	99.95	100.00	100.00	99.99	99.99	
18-8 (#7)		99.99		100.00	99.99	99.99	99.99	
18-8 (VB)		99.99		99.99	99.99	99.99	99.99	
18-8 (2B)		99.99		100.00	99.99	99.99	99.99	
Genetron HL	99.80	100.00	99.99	100.00	99.99	99.99	99.99	
Genetron VK	99.81	99.99	99.97	100.00	99.99	99.99	99.99	

Note: Each value represents two test disks.

in 5 aliquots, and each disk was cultured by pouring agar over it in a petri dish with the previously soiled side up.

(3) Eighteen disks (six each for the alkaline, nonionic, and acid cleaning compounds) were scrubbed and rinsed as in (2). Then two disks of each cleaner variable were placed in 25 ml. each of the following germicidal solutions for one minute to sanitize them: (a) hypochlorite solution with 100 ppm available chlorine, (b) solution of an iodophor with 25 ppm iodine concentration, (c) solution of a quaternary ammonium compound containing 200 ppm active ingredients prepared in water with a natural hardness in the range of 200 to 250 ppm.

Germicidal tests also were run on disks cleaned with anionic detergent. However, only four disks, two each for germicides (a) and (b), were used, since this detergent is not compatible with a quaternary ammonium compound.

If any *E. coli* were found to survive the one minute sanitizing period, this test was repeated increasing

the exposure time in one minute steps. At the end of the exposure period, the germicidal solution was inactivated, and the entire amount was cultured in 5 aliquots of 5 ml. each. Each disk was also subjected to the culture technique as in (2). The disks were considered sanitized if no coliform colonies were observed in these cultures.

The inactivation of the hypochlorite and iodophor solutions was accomplished with sodium thiosulfate. The quaternary ammonium compound solution was inactivated with an anionic detergent. In a previous study, this anionic solution inactivated the quaternary while not materially depressing the coliform count. In that study the following colony counts were observed when 1 ml. aliquots of an *E. coli* suspension were added to 9 ml. portions of:

1. Distilled water8.7 x 10⁶ per ml.
2. Quaternary (200 ppm)0.0
3. Anionic solution (400 ppm)7.2 x 10⁶ per ml.
4. Anionic solution (400 ppm)
plus Quaternary (200 ppm)8.5 x 10⁶ per ml.

TABLE 4 — PER CENT REMOVAL OF *E. coli* FROM VARIOUS SURFACES WITH A NONIONIC DETERGENT AT ROOM TEMPERATURE

Surface cleaned	Dairy products in which <i>E. coli</i> was suspended					
	Cream		Buttermilk		Homogenized milk	Chocolate milk
	Radio. technic.	Bact. technic.	Radio. technic.	Bact. technic.	Bact. technic.	Bact. technic.
Zytel #31	99.95	99.99	100.00	100.00	99.99	99.99
"		99.99		99.00	99.99	99.99
18-8 (120)	99.92	99.99	99.99	100.00	99.99	99.99
"		99.99		96.86	99.99	99.99
18-8 (100)		99.99		99.99	99.99	99.99
"		99.99		99.99	99.99	99.99
18-8 (80)	99.97	100.00	100.00	100.00	99.99	99.99
"		99.99		99.99	99.99	99.99
18-8 (#7)		99.99		100.00	99.99	99.99
"		99.99		99.99	99.99	99.99
18-8 (VB)		99.99		99.99	99.99	99.99
"		99.99		99.99	99.99	99.99
18-8 (2B)		99.99		99.99	99.99	99.99
"		99.99		99.99	99.99	99.99
Genetron HL	99.97	99.99	99.99	99.99	100.00	99.99
"		99.99		100.00	99.99	100.00
Genetron VK	99.97	99.99	99.98	100.00	100.00	99.99
"		100.00		99.99	99.99	100.00

Note: Each value represents two test disks.

RESULTS

The results of this study are shown in the accompanying five tables. Table 1 gives the range of concentrations of *E. coli* encountered in the various runs needed to complete the bacteriological technique data.

Tables 2 through 5 show the percent removal of *E. coli* from the surface of the test materials as determined by both the radioactive tracer method and bacteriological culture techniques. Each table covers the results with one cleaning material on all surfaces with each of the soil carriers.

As noted in Tables 2, 3, 4 and 5 both residual radioactivity and the residual coliform counts indicated that 96.86 per cent or more of the contaminating soil was removed by scrubbing the disks in any of the detergents and cleaning compounds used.

With few exceptions, the cleaned disks were sanitized within one minute upon exposure to the germicidal solutions at room temperature. None of the cultures was positive for *E. coli* after the disks had been held in the germicidal solution for three minutes. These results are, therefore, not shown in detail.

DISCUSSION

During the course of this study numerous suspensions of *E. coli* were prepared. These suspensions were not standardized to a given colony count. Although a uniform quantity of inoculated dairy products was used to soil the disks, the number of coliform organisms placed on the disks varied from 2.7×10^7 to 23×10^7 (see Table 1). Even with the great reduction in the coliform count noted during drying, well over a million organisms were recovered from the disks soiled with all the dairy products except some soiled

with buttermilk. Colony counts as low as 1.9×10^4 were obtained from a number of the disks soiled with buttermilk. Apparently some of the buttermilk used contained a substance that was toxic for *E. coli* as there was no visual evidence that buttermilk was more difficult to remove from the disks than the other dairy products.

An *E. coli* colony count of less than 10 per disk was observed in approximately 80 per cent of the cultures of the cleaned disks. About 4 per cent had a colony count greater than 100 per disk. Perhaps the colony count of the cleaned disks would have been more uniform if the disks had been scrubbed mechanically rather than by hand.

SUMMARY AND CONCLUSIONS

Completeness of removal of soil from the surface of several possible dairy equipment construction materials was determined by both radioactive tracer techniques and bacteriological methods. Molded disks of the plastics Zytel, Genetron HL and Genetron VK, and similar disks of 18-8 stainless steel with six surface finishes, were soiled with milk products inoculated with *E. coli* suspensions. The disks were then cleaned with four different major types of dairy cleaning materials.

Residual radioactivity and the residual *E. coli* colony counts show that cleaning the disks with any of the types of cleaning compounds effected essentially complete removal of the contaminating soil from the surface of all materials tested.

In a further experiment, the cleaned disks were sanitized within one minute, with very few exceptions, by the hypochlorite, iodophor and quaternary ammonium compound solutions at the concentration

TABLE 5 — PER CENT REMOVAL OF *E. coli* FROM VARIOUS SURFACES WITH AN ACID CLEANER AT ROOM TEMPERATURE

Surface cleaned	Dairy products in which <i>E. coli</i> was suspended					
	Cream		Buttermilk		Homogenized milk	Chocolate milk
	Radio. technic.	Bact. technic.	Radio. technic.	Bact. technic.	Bact. technic.	Bact. technic.
Zytel #31	99.92	99.99	99.96	100.00	99.99	99.99
"		99.99		99.99	99.99	99.99
18-8 (120)	99.90	100.00	99.97	100.00	100.00	100.00
"		99.99		100.00	100.00	100.00
18-8 (100)		100.00		99.99	99.99	99.99
"		99.99		99.99	99.99	99.99
18-8 (80)	99.92	100.00	99.94	100.00	99.99	100.00
"		99.99		99.99	99.98	100.00
18-8 (#7)		100.00		100.00	99.99	99.99
"		99.99		99.99	100.00	99.99
18-8 (VB)		100.00		100.00	99.99	100.00
"		100.00		99.99	99.99	99.99
18-8 (2B)		100.00		100.00	99.99	100.00
"		99.99		99.99	99.99	100.00
Genetron HL	99.86	100.00	99.90	99.99	99.99	100.00
"		99.99		100.00	99.99	99.99
Genetron VK	99.80	100.00	99.95	100.00	99.99	100.00
"		99.99		99.99	99.99	99.99

Note: Each value represents two test disks.

used. All disks were sanitized within three minutes.

It may be concluded from these data that the plastics and the several finishes of the stainless steel tested are as readily cleanable as is 18-8 stainless steel with 120 grit finish.

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