Adequate laundering to reduce bacterial counts in linens is not only possible but desirable. Laundering that destroys heat-resistant spore formers makes impossible survival of any bacterial pathogens.

BACTERIA IN LAUNDERED FABRICS

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THROUGHOUT the years, it has been tacitly accepted that laundering of fabrics has not only removed soil, but that laundered items have been rendered "bacteriologically clean" as well. Recent experimental evidence has dispelled this illusion, as citations from articles in the open literature will testify. Two of these are briefly reviewed below.

Arnold[1] published the results of some of his experiments under the title, "A Sanitary Study of Commercial Laundry Practices." He examined the wash suds waters and rinse waters of both high-temperature and low-temperature laundering techniques. Averaging the data from 120 experiments, he found that under the conditions of high-temperature laundering—which included first a flush, then four suds applications, four rinsings, and two final "sour" and "blue" applications—that the average number of bacteria were reduced from 200,000 organisms per ml in the first flush to 0 at the sour and blue flush of the cycle.

His experience with low-temperature laundering of dyed materials, and of materials for which high temperatures were inimical to fabric life, presented a different picture. Again, averaging the data from 120 experiments, he found 3,600,000 bacteria per ml in the first flush water and 158 bacteria per ml in the final souring and bluing part of the cycle. The implication is, of course, that the high-temperature laundering procedure adequately sterilizes fabrics.

The author did not indicate that he utilized any type of pH neutralization, or that he added anything to neutralize the antibacterial activities of bleaching compounds. Had he done so, his bacterial counts might have been higher. Also, Arnold did not test the final laundered product. Only the wash and rinse waters were examined microbiologically. He presented no indication of the number of microorganisms which might have remained in the fabric after completion of the laundering process.

Data presented by McNeil & Choper,[2] in a paper read before the 48th mid-year meeting of the Chemical Specialties Manufacturers Association, indicated that the use of sanitizing agents in either the wash or the rinse cycle of home laundries lowered the bacteria count a great deal but, more often than not, did not destroy all the bacteria. Their control washes, where no disinfecting agents were used, were of the greatest interest in that the bacterial numbers in the wash water, in the rinse water, and in macerated samples of fabric, were affected very little by the laundering procedure which used anionic or nonionic detergents as cleansing agents.

Other work could be cited but, after a thorough study of the literature, one is left with the impression that, if ade-

quate testing methods for the detection of bacteria in laundered and ironed fabrics are used, ordinary laundry procedures fall short of producing bacteria-free items.

It is to be noted that studies described in all of the literature covered indicated that a high-temperature laundering procedure is much more efficient at removing viable bacteria from fabrics than is a low-temperature procedure. With the advent of the nonwrinkle, no-iron fabrics which require low-temperature laundering techniques to maintain the longevity of the "no-iron," "no-wrinkle" features, one wonders about the adequacy of bacterial removal from these materials. This new fabric treatment opens up a whole new area of microbiological study of the laundry practices for such fabrics.

In the laboratories of the University of Utah's Department of Microbiology, time has been allotted over the past year and a half for the microbiological monitoring of the laundering processes in the laundering plants associated with the Steiner American Corporation. Laundered items from these commercial operations from all over the world, including Australia and Germany, have been examined bacteriologically. Some of the data from these studies are reported here with the main object of showing that, with adequate laundry procedures, the bacteria counts of laundered items can be reduced to nearly zero.

Methods and Procedures

Samples of fabrics sent to us for examination were usually cut from laundered and ironed continuous towels, but other items were also studied and included uniforms, napkins, dish towels, and barber towels.

Samples were collected according to specific directions and folded carefully, avoiding as much as possible extraneous contamination from the hands of the sampler or from the dust and debris in the environment. Those who took samples were also instructed to fold them so that technicians in the laboratory would be presented with folded fabric and a sample through eight layers of material could be obtained. The folded sample was slipped into a clear plastic bag which was sealed and then mailed to the laboratory.

In the laboratory, the seal on the bag was broken, the bag carefully opened, and the sample removed and placed on a sterile surface. For a period of time, a Rodac plate filled with trypticase soy agar containing lecethin and polysorbate—a medium prepared from the dehydrated material purchased from Baltimore Biological Company—was used to culture the surface of the fabric in an attempt to enumerate the number of viable organisms to be found on the surface of the laundered product. Since it was found that this count was unreliable and usually bore no relationship to the actual number of microorganisms in and on the fabric, the procedure was soon abandoned.

The folded sample of cloth was then aseptically transferred to a sterile cutting apparatus, and a circular cut one inch in diameter was made through the eight layers of fabric. Thus a good sample of eight different areas on the fabric was obtained. These circular pieces were aseptically transferred to a sterile, stainless steel Waring blendor canister containing 200 ml of sterile water. The fabric samples were then macerated by the blendor action at high speed for a period of three minutes.

The fabric shreds were allowed to settle and the water menstrum containing the bacteria was diluted in water blanks through a series of tenfold dilutions to 10^{-4}. One ml of each of the dilutions including the water in the canister was put into each of five 100 x 15 mm sterile plastic petri dishes, and the latter poured with cooled trypticase soy agar containing

lecethin and polysorbate. The lecethin and polysorbate ingredients were utilized as neutralizers for any antibacterial or antifungal agents which might have been used in the final rinse to control the growth of bacteria or fungi in the finished laundered items.

The later were incubated for a period of 48 hours, then read and the counts reported as the number of bacteria per square inch of cloth. Our dilution series was so arranged that one colony on the plate containing undiluted sample represented at least 32 microrganisms per square inch of fabric. Therefore, if no colonies appeared on this plate, the count was reported as less than 32 organisms.

To control the procedures, samples of fabric were sterilized in the autoclave and run with the test samples. If these showed growth at any dilution, the test data were considered unreliable.

Results

Tables 1 and 2 demonstrate the inadequacy of the Rodac plate technique for use as an analytical method for the enumeration of bacteria associated with fabrics, and also show the large number of bacteria which may be associated with articles even though they have been supposedly well laundered and ironed.

Table 1 presents data obtained from samples of barber towels, and demonstrates the false impression one would receive of the numbers of bacteria associated with barber towels, should the Rodac plates be used as the criterion for judgment. The macerate counts give a much more accurate indication of the true state of the bacterial population. Obviously the bacteria are imbedded in the depths of the fabric associated with the woven fibers used in the towels. It should be emphasized that these towels represented very random samples. We have postulated that fabrics, laundered in a manner which does not completely destroy the microflora of fabrics, tend to allow buildup of numbers over a period of time. Thus the large variations in the numbers of microorganisms exhibited in Table 1 represent accumulation of bacteria over a period of several launderings.

Table 2 demonstrates the state of bacterial contamination of a group of laundered colored napkins. Most of the Rodac plate counts showed bacterial colonies too numerous to count, and the macerate plate counts showed bacteria counts varying from 5,000 to over 2 million. Again, it should be emphasized that these articles were laundered

Table 1—Enumeration of bacteria associated with barber towels

Towel no.	Rodac plate count bact./sq. in.	Macerate plate count bact./sq. in.
T–1	0	44,600,000
T–2	24	640
T–3	2	134
T–4	1	31,900,000
T–5	1	2,020,000
T–6	1	118,000
T–7	3	5,420,000
T–8	1	640,000
T–9	3	1,910
T–10	2	5,420,000

Table 2—Enumeration of bacteria associated with colored napkins

Towel no.	Rodac plate count bact./sq. in.	Macerate plate count bact./sq. in.
1	TNC	1,600,000
2	TNC	96,500
3	TNC	407,000
4	TNC	185,000
5	TNC	34,400
6	TNC	5,200
7	TNC	33,300
8	TNC	21,000
9	189	3,740,000
10	TNC	259,000

Table 3—Bacteria counts on white continuous towels demonstration of improvement with change in laundering practice

	Sample no.	Bact./sq. in. of cloth	Average
September, 1968	T-1	35,100	41,960
	T-2	17,200	
	T-3	89,500	
	T-4	60,700	
	T-5	7,350	
February, 1969	T-1	<32*	<32
	T-2	<32	
	T-3	32	
	T-4	<32	
	T-5	<32	

* <32 indicates no colonies at 10° dilution of the macerate menstrum.

and ironed. The Rodac plate counts indicate that the articles had probably been exposed to further surface contamination before reaching the laboratory. There is little correlation between the Rodac counts and those obtained by the macerate technique.

With a change in laundering practice, with emphasis on the utilization of either oxygen-type bleach in place of chlorine, and with other necessary adjustments in chemical formulation of laundering aids, processing time. and higher temperatures, a great decrease in bacterial contamination of continuous towels was accomplished.

Table 3 presents data obtained in tests from Plant No. 6, demonstrating improvement resulting from the suggested changes in processing. The first group of samples was tested in September of 1968, and the second, showing the great improvement, was tested in February, 1969. Counts were reduced from an average approximating 42,000 organisms per square inch of cloth to less than 32 per square inch.

Data from tests made on continuous towels from Plant No. 24 demonstrated the effectiveness of the oxygen bleaches as compared to chlorine. Table 4 presents data from one set of samples where five samples of toweling, T-1 through T-5, had been chlorine-bleached and from a second set, T-6 through T-10; the latter was bleached with an oxygen-type bleach on the occasion when this bleach was used in the plant for the first time. As no other changes in the process had been initiated, it was obvious that the improvement was due to the oxidizing bleach. It is expected that further regulation of the laundering formula will render the bacteria counts in continuous towels at this plant comparable to those of Plant No. 6.

Plant No. 35 is an establishment in West Germany. An oxidizing (oxygen) bleach has been used as a bleaching agent on white continuous towels in this plant for the past ten years, but no bleach of any kind has been utilized on blue continuous towels. Table 5 demonstrates the difference in the effectiveness of the laundering process in controlling the bacteria count where an oxygen bleaching compound is used.

Table 4—Improved bacterial counts by change of bleaching compound

Sample no.	Treatment	Bact. count per sq. in. of fabric	Average
T-1	Chlorine bleach	1,590,000	3,127,000
T-2	" "	1,590,000	
T-3	" "	9,250,000	
T-4	" "	3,190,000	
T-5	" "	15,900	
T-6	Oxygen bleach	95,500	160,000
T-7	" "	191,000	
T-8	" "	60,800	
T-9	" "	67,000	
T-10	" "	389,000	
	Counts reduced 20-fold		

Table 5—Effectiveness of the continuous use of an oxygen-type bleach

Sample no.	Identification	Bact. per sq. in. of fabric
	White continuous	
T-1	towel	<32
T-2	"	<32
T-3	"	<32
T-4	"	<32
T-5	"	32
	Blue continuous	
T-11	towel	TNC*
T-12	"	32,600
T-13	"	242,000
T-14	"	83,000
T-15	"	115,000

* TNC = too numerous to count.

Other factors should also be considered in analysis of Table 5. For one thing, the blue towels are used in dirtier circumstances than the white, and thus it is possible that they receive a greater bacterial contamination. It is also possible that, because of their color, they undergo a less rigorous laundering process. Even so, a great deal of the success of the processing of white towels is attributed to the continuous use of the oxygen-type bleach.

It must be emphasized that oxygen-type (oxidizing) bleaches must be applied properly within the laundering cycle. An oxygen bleach is readily destroyed by the soil which laundering intends to remove, and therefore application methodology is critical.

Also, it should be further emphasized that not all oxygen-type bleaches act satisfactorily. As an example, potassium monopersulfate would not be feasible for use under the circumstances extant in the laundry process and at the same time be capable of maintaining the longevity of fabrics. This compound, used at a pH which would actively bleach and concomitantly destroy bacteria, would rapidly destroy the tensile strength of most fabrics.

What is the significance of high bacteria counts in laundered articles? We feel that these organisms—which, upon examination, proved to be mostly Gram-positive, spore-bearing organisms—do not present a great public health menace. A rather thorough search of the archival literature indicates this to be the case.

The *British Medical Journal*[3] (February 10, 1951) discusses, editorially three recent epidemics of smallpox brought into Great Britain by vaccinated, returning travelers. These patients did not demonstrate typical symptoms and the disease was misdiagnosed; therefore no special precautionary measures were instituted. As a result, several unvaccinated laundry workers were infected from handling the soiled linen used by these patients. There was no incidental disease traced to those who later utilized the laundered items.

Gonzaga[4] reported experiments wherein, under well-controlled conditions, he exposed newborn infants to blankets, shirts, and diapers which had been contaminated by known S. aureus carriers. Colonization of the newborns occurred only if the fomites were heavily contaminated. Storage of the contaminated articles had no effect on the transmission rate. It was emphasized that laundering effectively broke the transmission chain.

Payne[5] described an epidemic of staphylococcal cystitis on a gynecological hospital ward. The source of the causal agent was traced to organisms harbored in blankets and dust. Laundering of the blankets and adequate control of dust on the ward contributed to successful control of the outbreak.

Other articles in the literature could be cited, but these mentioned will serve to make the point. In all of the literature reviewed, there has been no indication of transfer of disease by laundered fabrics. This precludes the possibility of postlaundering contamination.

From two very important points of view, it is suggested that adequate laundering to reduce bacterial counts in linens is not only possible but desirable. First, it is well known that, if the heat-resistant spore formers are destroyed by the laundering process, there will certainly be no possibility of the survival of any bacterial pathogens. And second, it is esthetically desirable to service the public with linens to be utilized in close association with body surfaces and orifices which, though not sterile, are relatively free of bacteria. This knowledge should certainly give the public confidence in the utilization of those articles offered them as a public service.

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Caribbean Conference

"The People's Health" is the title of a postgraduate seminar to be held in Haiti the week of January 18 to 25, 1971, and again from January 25 to February 1. The theme will be public health and preventive medicine, and Dr. Christiaan N. Barnard, cardio-thoracic surgeon from Cape Town, South Africa, is to be the featured speaker. Following the seminar will be opportunities to visit Jamaica, Puerto Rico, Martinique, and other islands. For further information, contact: Caribbean Medical Institute, Incorporated, 3385 South Newport Street, Denver, Colo. 80222.