Comparative Evaluation of Antibacterial Soaps[1]

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Abstract

Two antibacterial soaps and an antibacterial detergent were examined for their effectiveness in inhibiting the growth of a large number of bacteria. All products were markedly superior in this regard to a nonmedicated soap. A soap containing equal parts by weight of hexachlorophene and 3,4,4′-trichlorocarbanilide was more effective than a detergent containing hexachlorophene only and a soap containing a mixture of equal parts by weight of 3,4′,5-tribromosalicylanilide, 3,4,4′-trichlorocarbanilide, and 4,4′-dichloro-3-(trifluoromethyl) carbanilide. A total of 27 bacteria, including 12 pathogens, was used.

Introduction

DEODORANT SOAPS represent the most rapidly growing segment of the bar soap market. Today's US toilet soap market is in excess of three hundred million dollars per year; more than 50% is now dominated by deodorant (antibacterial) soaps. This is a phenomenonal growth from the 10% share of the market enjoyed by these products 15 years ago and reflects the consumer's increasing concern with personal hygiene. In great measure this development is attributable to the fact that use of an antibacterial soap reduces the intensity of body odor by interfering with the growth of bacteria which decompose constituents of apocrine sweat. Although the antibacterial soaps are of considerable hygienic and economic importance, little has been published about their relative efficacies against bacteria. It is the purpose of this paper to define these values for 2 bar soaps and for an antibacterial liquid detergent, using a large number of bacterial cultures for making the comparisons.

Experimental

Cultures were transferred for three consecutive days using Bacto-AC Medium for streptococci and Bacto-AATCC Bacteriostasis Broth for all other cultures. Soap dilutions were made at 60C with sterile, distilled water. In preparing pour-plates, 0.1 ml of streptococci, diluted or undiluted, was added to 50 ml of Bacto-AC Medium containing 1.5% of agar and a known concentration of soap. A similar procedure was followed for all other micro-organisms except that Bacto-Nutrient Agar was used. The inoculated agar was poured into petri dishes, allowed to harden, and incubated for 24 hours at 37C. Duplicate plates were used in each instance.

Results and Discussion

With the exception of the nonmedicated soap (Ivory) used as a control, the products tested contained one or more of the compounds shown in Figure 1. The materials used were the following: a) Dial soap, containing a combination of 0.75% hexachlorophene and 0.75% 3,4,4′-trichlorocarbanilide; b) Safeguard, containing a mixture of 0.67% 3,4,4′-trichlorocarbanilide, 0.67% 4,4′-dichloro-3-(trifluoromethyl) carbanilide, and 0.67% of a mixture consisting mostly of 3,4′,5-tribromosalicylanilide with some 3,5-dibromosalicylanilide; and c) pHisoHex, a liquid detergent containing 3% hexachlorophene.

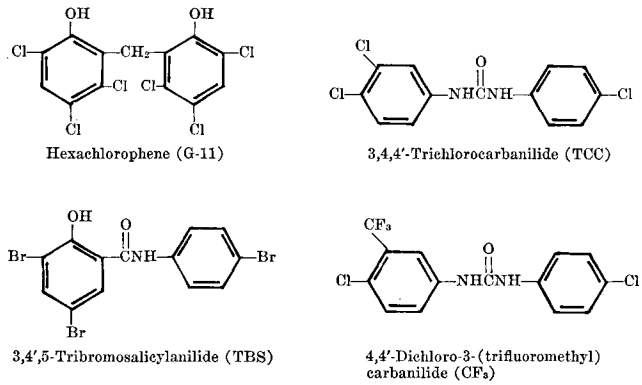

FIG. 1. Soap germicides.

The minimum inhibitory concentrations (MIC's) of the above mixtures are presented in Table I. The MIC is a measure of inherent effectiveness and, as such, has considerable predictive value since materials of quite different degrees of effectiveness will generally perform in vivo according to the order of their MIC's. To be sure, the property of substantivity contributes importantly to the over-all effect under conditions of practical use, but this feature cannot make up for an otherwise inferior level of efficacy.

It is of interest to consider that the MIC's based on contained germicide rather than on soap are 1/100th of the values shown, meaning that commercial bacteriostats intended to be used in soap have activities as good as or better than some antibiotics. (For example, the MIC of neomycin undecylenate for *Staphylococcus aureus* ATCC 6538 is 0.2 ppm whereas the MIC for the mixture of hexachlorophene and 3,4,4′-trichlorocarbanilide, No. 2 in Table I, is 0.07 ppm.)

As expected, the effectiveness of a bacteriostatic system increases with concentration. The decreasing contribution of incremental additions of bacteriostat beyond a point may reflect the relatively rapid attainment of maximum solubility of bacteriostat in the vehicle, a property intimately related to antibacterial performance (1).

The increased attention which pathogenic staphylococci have received of late, largely because of the

TABLE I

Minimum Inhibitory Concentrations of Soaps Against *Staphylococcus aureus* ATCC 6538

No.	Material	Concentration of germicide %	M.I.C. ppm basis soap
1	Hexachlorophene	1.0	30–40
2	Mixture of one part G-11 and one part TCC	1.0	7
3	As for 2	1.5	4
4	As for 2	2.1	3
5	Mixture of equal parts of TCC, TBS, and CF_3	1.0	10
6	As for 5	1.5	8
7	As for 5	2.0	4
8	As for 5	2.5	3
9	As for 5	2.8	3

[1] Presented at the AOCS Meeting in Los Angeles, April 1966.

TABLE II

Minimum Inhibitory Concentrations of Soaps Against Pathogenic Staphylococci and Streptococci

Organism[a]	M.I.C. (ppm) basis total product		
	A	B	C
Staphylococcus PS 187	4	5	>2000
Staphylococcus S A 9 Smith (diffuse)	3	>4	>2000
Staphylococcus PS 42D	3	5	>2000
Staphylococcus Cowan I NCTC 8530	3	5	2000
Staphylococcus Cowan II NCTC 8531	2–3	4	>2000
Staphylococcus Wood 46	2–3	4	2000
Streptococcus Group A GS 208–4	2	4	2000
Streptococcus Group A SS 510	3	6	2000
Streptococcus Group B B1	3	5	2000
Streptococcus Group B B5	6	10	2000
Streptococcus Alpha Group D DS 1455–65	9	>12	2000
Streptococcus Group G DS 1426–65	2	5	1500

[a] Dilution of culture, 1×10^{-2}.

emergence of resistant strains in hospitals, has occasioned a search for disinfecting agents active against them. Particularly important for personal hygiene are the antibacterial soaps, which function by leaving a residue of antibacterial materials on the skin.

Although there exists some disagreement as to the characteristics which pathogenic staphylococci share, there seems to be universal agreement that the production of the enzyme coagulase should be taken as indicating potential pathogenicity. For purposes of identification, this convenient classification, which follows the scheme employed in Bergey's "Manual of Determinative Bacteriology" (2), has been accepted. The ability of different soaps to inhibit the growth of several pathogenic staphylococci is displayed in Table II.[2] Two conclusions may be drawn from the data: a) antibacterial soaps (A and B) are very much more effective than a nonmedicated soap (C) in inhibiting the growth of the bacteria shown; b) although the differences in MIC's between the antibacterial soaps are small, the product containing the mixture of hexachlorophene and 3,4,4′-trichlorocarbanilide (Soap A) consistently gives lower values than are exhibited by the three-component system (Soap B). To workers experienced in this area it is well known that, with the chemicals now available to the formulator of antibacterial products, it is considerably easier to drop from an MIC of 100 ppm to about 10 ppm than to achieve changes of 1 or 2 ppm in the region below 10 ppm. When it is considered that Soap A contains less total bacteriostat than B, the innate differences between the products become even more pronounced.

[2] Dilutions of the cultures in this and subsequent tables are based upon a 24-hr culture. Unless stated otherwise, the cultures mentioned in Tables II-V were obtained from the Communicable Disease Center, Atlanta, Ga.

TABLE III

Minimum Inhibitory Concentrations of Antibacterial Systems Against Pathogenic Staphylococci and Streptococci

Organism[a]	M.I.C. (ppm) basis total product	
	A	D
Staphylococcus PS 42D	4	>6
Staphylococcus S A 9 Smith (diffuse)	3	3
Staphylococcus PS 187	3	>7
Staphylococcus Cowan I NCTC 8530	4	8
Staphylococcus Cowan II NCTC 8531	3	6
Staphylococcus Wood 46	3	6
Staphylococcus aureus[b] ATCC 6538	5	10
Streptococcus Group A GS 208–4	3	5
Streptococcus Group A SS 510	3	5
Streptococcus Group B B1	5	8
Streptococcus Group B B5	6	11
Streptococcus Group G DS 1426–65	4	7

[a] Dilution of culture, 1×10^{-2}.
[b] Obtained from American-Type Culture Collection.

TABLE IV

Minimum Inhibitory Concentrations of Soaps Against Types of Bacteria Responsible for Human Body Odor[a]

Organism[b]	M.I.C. (ppm) basis total product	
	A	B
Staphylococcus epidermidis ATCC 155	4	6
Corynebacterium pseudodiphtheriticum ATCC 10700	3	5

[a] Cf. J. Meyer-Rohn, *Fette Seifen Anstrichmittel*, 67, 353 (1965).
[b] Dilution of culture, 1×10^{-2}.

A comparison of inhibitory concentrations of Soap A with a detergent preparation containing 3% hexachlorophene (D) is presented in Table III for several pathogenic staphylococci. It is apparent that the former is the more effective of the two.

Tables II and III also show data on the effect of various products against six pathogenic streptococci. The two streptococci termed Group A and Group B B5 are beta hemolytic. The others were isolated from children with diarrhea or impetigo. The conclusions are the same as were drawn from the experiments with pathogenic staphylococci, namely, greater efficacy of antimicrobial over nonmedicated soaps and significantly improved performance of Soap A over Products B and D.

When used for purposes of deodorancy, the function of antibacterial soaps is to interfere with the bacterial decomposition of apocrine sweat by inhibiting the growth of the bacteria responsible for this effect. It has been known for some time that sterile sweat is free of offensive odor (3); subsequent work proved that the odor is caused by the decomposition of apocrine sweat by diphtheroids and coagulase negative staphylococci (4–6). More recently Meyer-Rohn (7) has isolated from human axillae two microorganisms, *Staphylococcus epidermidis* and *Corynebacterium pseudodiphtheriticum,* which seemed to elicit typical body odor from sterile sweat to a greater extent than others which were recovered. A comparison of Soaps A and B against a strain of each of these organisms is shown in Table IV. Here again, lower values were obtained with Soap A.

In addition to pathogens and odor-causing bacteria it was of interest to determine the effect of antimicrobial soaps against a heterogeneous sampling of cultures. Results against 12 types of organisms are displayed in Table V. Included are five staphylococci, two sarcinae, three bacilli, a brevibacterium, and a diphtheroid. Lower values were consistently obtained with Soap A.

In evaluating the significance of comparative data of the type presented, it is exceedingly important to

TABLE V

Minimum Inhibitory Concentrations of Soaps Against Miscellaneous Bacteria

Organism	Dilution of culture	M.I.C. (ppm) basis total product	
		A	B
Sarcina lutea ATCC 9341	1×10^{0}	5	7
Sarcina lutea ATCC 9341A (Streptomycin-resistant)	1×10^{0}	6	10
Corynebacterium hoagii F-17[a]	1×10^{-3}	7	10–20
Staphylococcus citreus W-10[a]	1×10^{0}	3	>5
Staphylococcus lysodeikticus W-13[a]	1×10^{-2}	3	>5
Staphylococcus W-5[a]	1×10^{-3}	5	6
Staphylococcus W-11[a]	1×10^{-1}	3	4
Staphylococcus W-14[a]	1×10^{0}	4	6
Bacillus subtilis ATCC 6460	1×10^{0}	5	7
Bacillus cereus ATCC 9592	1×10^{0}	5	7
Bacillus subtilis[b]	1×10^{0}	3	5
Brevibacterium ammoniagenes ATCC 6871	1×10^{0}	1	2

[a] Obtained from F. B. Engley, Department of Microbiology, University of Missouri.
[b] Obtained from Industrial Bio-Test Laboratories, Northbrook, Ill.

TABLE VI

Influence of Inoculum Size of *Staphylococcus* W-11 upon Bacteriostatic End-points

Dilution of inoculum	Soap concentration (ppm)	Soap bars[a]	
		A	B
1×10^{0}	3	−	+
1×10^{-1}	3	−	+
1×10^{-2}	3	−	+
1×10^{-3}	3	−	−

[a] + indicates growth; − indicates no growth.

determine whether the data have been obtained under sufficiently rigorous conditions. For example, are concentrations of materials and cells specified? The question may seem elementary, yet it is surprising to observe the frequency with which these very important numbers are omitted from published reports of inherent bacteriostatic effectiveness, a common practice of suppliers of germicides. The need for such precautions is shown in Tables VI and VII.

From Table VI it is apparent that, by using sufficiently low concentrations of microbes (in this case, a 10^{-3} dilution of a 24-hr culture), differences between bacteriostatic systems become obscured, but these differences are disclosed at higher concentrations. A somewhat different representation of this situation is shown in Table VII for 2 bacterial cultures.

TABLE VII

Influence of Inoculum Size upon Bacteriostatic End-points

Organism	Dilution of culture	M.I.C. (ppm) basis total product	
		A	B
Staphylococcus epidermidis ATCC 155	1×10^{0}	4	6
	1×10^{-1}	4	5
	1×10^{-2}	2	3
	1×10^{-3}	2	3
Corynebacterium pseudodiphtheriticum ATCC 10700	1×10^{0}	3	5
	1×10^{-1}	2	5
	1×10^{-2}	2–3	5
	1×10^{-3}	2	5

TABLE VIII

Influence of Inoculum Size of *Corynebacterium hoagii* F-17 Upon Bacteriostatic End-points

Dilution of inoculum	Soap concentration (ppm)	Soap bars	
		A	B
1×10^{-3}	7	−	+
	10	−	+
	20	−	−
1×10^{-4}	7	−	−

The interaction of inoculum size and concentration of bacteriostat can be seen in Table VIII. At a sufficiently high concentration of soap, if the inoculum size is held constant, both Soaps A and B are inhibiting but at lower concentrations, A is still bacteriostatic whereas growth occurs with B. Decreasing the inoculum size has the same qualitative effect as increasing the amount of antimicrobial.

These data show the obvious need for complete reporting of experimental conditions if reliable comparisons between bacteriostats are to be made.

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[Received November 7, 1966]