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Soap and detergent bar rinsability

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Synopsis

Studies on the role of cleansing bars in skin irritancy have focused on pH and composition. The rinsability factor is ignored by chamber style tests but seems to be significant in usage experience. In order to understand the differences seen in chamber and use testing, 18 common soap, combars, and syndet bars were studied for their rinsing characteristics, which were compared to their irritancy potential. The relative rinsabilities of the products were determined photographically and spectrophotometrically using soap solutions spiked with fluorescein dye. The dye-containing soap solutions were applied to the forearms of volunteers, worked into a lather, and rinsed uniformly. The residues were then either photographed or extracted from the skin and quantified spectrophotometrically. Both photographic aand spectroscopic methods demonstrated that there are significant differences in rinsabilities among the products tested. Deodorant bars, regardless of composition, rinsed poorly. Facial bars and "mild bars" tend to have superior rinsabilities.

INTRODUCTION

The effects of soap products on skin have been the subject of continuous controversy and debate (1,5). The most popular form of personal soap product remains the original bar. Bar soap products can be divided into three types: Soap bars are mainly composed of the alkali salts of long chain fatty acids and have a pH between 9.0 and 10.0. Combars are composed primarily of alkaline soaps (pH 9.0 to 10.0) to which various surface active agents are added to act as lime soap dispersants (2). Syndet bars consist primarily of synthetic detergents and fillers which contain less the 10% soap and generally have an adjusted pH between 5.5 and 7.0 (2). A major point of differentiation between these three types has been their potential for skin irritation or mildness as it is commonly referred to.

Until recently, the prevalent dermatologic thinking was split over the importance of the alkaline nature of soaps in cutaneous irritancy (4). The soap chamber test, developed by Kligman and Frosch, clearly demonstrated that pH in the range of 5.5 to 10.0 has little or no effect on the irritancy of soap or detergents (5). This result is probably due to the high buffering capacity of the skin. However, more recent work by Frosch in

evaluating wash tests of the face and antecubital areas produced several changes in results compared to the earlier soap chamber test (6).

One possible explanation of the difference in results between these methods may be the nature of the test procedures used. The soap chamber test is basically a repeated occluded patch test which does not allow for rinsing of the soap from the skin, an integral part of the use of any cleansing product such as soap. Wash testing, which includes rinsing, more closely approximates actual consumer use. This raises the question of the importance of rinsability as an attribute affecting the mildness of soap products. Assuming that the longer a soap remains on the skin, the greater the potential for irritation, a number of cleansing bar products were investigated solely for their rinsabilities.

MATERIALS

Eighteen common soaps, combars, and syndet bars were obtained from local retail stores (List 1). The bars were cut into fine shavings and dissolved in tap water to a final concentration of 10% (w/v). Tap water (260 ppm hardness) was selected for these experiments since it most closely simulates actual consumer water hardness levels. Fluorescein dye (Sigma, St. Louis, MO) was added to obtain a dye concentration of 0.005% (w/v) and the mixture thoroughly stirred. Similarly, a 10% reference solution of each bar was prepared in the same manner without fluorescein dye.

INITIAL EXPERIMENTS

Fluorescein dye was initially evaluated by placing a 1.0% dye solution on the forearms of volunteers and allowing this to stand for 15 minutes. The arms were then rinsed and examined under ultraviolet light to determine if the dye was in any way substantive or absorbed into the skin. It was found that a 1.0% fluorescein dye solution left no detectable residue on the skin after 15 minutes. Further studies indicated that only after 45–60 minutes were detectable amounts of fluorescein dye adsorbed into the skin.

To demonstrate the proportionality of the fluorescein dye to the amount of soap residue, 5.0 ml of a 10% soap/fluorescein dye solution was applied to each of 10 tared etched glass plates (8 cm × 8 cm). The solutions were then worked into a lather and rinsed gently with 100 ml of tap water. The plates were then allowed to dry at 50°C to a constant weight, and the amount of soap residue was then calculated. Each plate was then extracted with 50 ml of methanol:water (80:20) and the amount of fluorescein dye quantified spectrophotometrically at 280 nm. The ratio of the initial soap-to-dye concentration was then compared to the ratio of the soap residue (weight) to the residue dye concentration and were found to be equivalent. (Table I). This experiment was repeated with three other soaps of varying rinsabilities, with the same results. (Table I). From this, we determined that the amount of fluorescein dye deposited with the soap residue is proportional to the amount of soap left on the skin.

PHOTOGRAPHIC METHOD

A small cloth was saturated with a fluorescein-containing soap solution. The solution was applied to a randomly chosen site (approximately 5 cm in diameter) on the ventral aspect of the forearm of a volunteer, using up to three different soap solutions per

List 1

Product Code by Ingredient Predominance

A:	Non-detergent, mineral oil, lanolin, PEG-4 dilaurate
B:	Collodial oatmeal, lanolin derivative, mild surfactant
C:	Sodium tallowate, sodium cocoate, stearic acid
D:	Sodium tallowate, sodium cocoate, water, glycerin (active ingredient: triclocarban)
E:	Sodium cocoyl isethionate, stearic acid, sodium tallowate, water, sodium isethionate
F:	Sodium tallowate, sodium cocoate, stearic acid
G:	Triethanolamine, sodium tallowate, stearic acid, glycerin
H:	Sodium and potassium fatty acids, glycerin
I:	Sodium tallowate, sodium cocoate, water coconut acid (active ingredient: triclocarban)
J:	Sodium tallowate, potassium lauryl sulfate, magnesium tallowate (active ingredient: triclocarban)
K:	Sodium cocoyl isethionate, stearic acid, dextrin, water, sodium isostearoyl-2-lactylate.
L:	Sodium cocoate, sodium tallowate, coconut acid, water
M:	Sodium cocyl isethionate, stearic acid, sodium tallowate, water, sodium isethionate
N:	Sodium tallowate, sodium cocoate, coconut acid, water
O:	Sodium cocoyl isethionate, stearic acid, dextrin, water, sodium isostearoyl-2-lactylate
P:	Sodium tallowate, sodium cocoate, water, coconut acid
Q:	Stearic acid, rosin, coconut oil, water, glycerine
R:	Sodium tallowate, sodium cocoate, water, glycerin, cocoa butter
Z:	Sodium tallowate, potassium lauryl sulfate, magnesium tallowate, sodium lauryl glyceryl sulfate, water (active ingredient: triclocarban)

forearm. The soap solution was worked into a lather for approximately 15 seconds with a circular motion using the applicator cloth. After the application was completed, each site was rinsed with 250 ml of room temperature tap water, and either air-dried or gently blotted dry. The soap/fluorescein residues were photographed using Ektachrome 400 film with an aperature setting of f8. The arms were illuminated using a Novatron strobe equipped with a 18A ultraviolet filter.

A total of ten soaps were analyzed using the photographic method. The relative rinsability was then determined by a comparison of the photographic intensities of the fluorescein dye residue as ranked from 1 to 10, 10 being the greatest residue, as rated by three independent judges. These ratings were averaged to form an overall ranking.

Table I
Comparison of Soap/Fluorescein Ratios in Soap Residues

Soap	Initial Soap/Dye Ratio w/w	Residue Soap/Dye Ratio w/w
G	2000	2350 ± 195
E	2000	1920 ± 285
J	2000	1905 ± 143
H	2000	2141 ± 137
		Average: 2079 ± 210

SPECTROSCOPIC METHOD

A glass extraction ring (3.5 cm ID × 3.5 cm) was randomly placed on the ventral aspect of the forearm of a volunteer. After the ring was secured, the site was clearly marked. A soap/dye solution (0.5 ml) was then applied to the skin inside the ring and worked into a lather for approximately 15 seconds, using an L-shaped glass rod. This was considered to be an appropriate length of lathering time from prior consumer studies. The extraction ring was then removed and the application site gently rinsed with 100 ml of room temperature tap water. The volume of water selected was the minimum required to rinse the soap from the skin without leaving a visible residue. The rinsing was performed without rubbing, since this would add a major variable and would not actually add any information as to the product's rinsability but only as to its ability to be physically removed or abraded from the skin. A clean extraction ring was then placed exactly over the original site. The soap/dye residue remaining on the skin inside the ring was extracted by the addition of 10 ml of methanol (UV grade, Fisher, Fairlawn, NJ):water (80:20). The skin inside the ring was agitated with a clean L-shaped rod, and the methanolic extract was pipetted from the ring into a 25-ml volumetric flask. The extraction was then repeated with an additional 10 ml of 80% methanol. After the extraction was completed, each subject's arm was examined under ultraviolet light (280 nm) to confirm the complete removal of the fluorescein dye from the skin. The combined extracts were diluted to a total volume of 25 ml with fresh 80% methanol. This process was then repeated on the same volunteer using each of the soap/dye solutions and with the soap solutions not containing fluorescein dye. The dye/soap residue solutions were analyzed using a Beckman 35-UV visible spectrophotometer at 280 nm, with the appropriate soap only extract solution as the reference blank.

STATISTICAL ANALYSIS

To determine the statistical significance between samples, the results were analyzed using a standard paired T-test. The p values reported in Tables II and III were determined by comparing each of the samples, arranged in order of decreasing rinsability, with that of the next sample of lower rinsability.

RESULTS

Table II lists the residue ranking of 10 soap samples using the photographic technique. Photographically, soaps G, B, and C rinsed above average, leaving the least residue.

Table II
Rinsing as Determined by the Photographic Method

Sample	Mean Rating	Ranking	p
G	1.22	1	.01
B	2.17	2	.05
C	2.84	3	.10
H	4.33	4	.50
A	4.66	5	.60
E	5.50	6	.90
D	7.49	7	.10
I	7.92	8	.10
F	8.40	9	.05
J	9.11	10	–

$\bar{X}$ = 5.36
Median = 5.50 sample E.
1 = Least residue.
10 = Most residue.
N = 28 trials/soap product.

Soaps H, A, and E demonstrated average rinsability, leaving a moderate residue, with E (5.50) being the median of the products tested (Figure 1). Soaps I, F, and J all left considerable residues, demonstrating less rinsability (Figure 2). The three deodorant soaps used in this study, samples D, I, and J, all showed average to below average rinsability as expected, due to the nature of these products.

The results of the spectroscopic methods are listed in Table III. With the more quantitative spectroscopic method, soap G clearly left the least residue of the products tested, followed by B, with both products demonstrating significantly above average rinsability. D, F, I, and J all showed below average rinsability, leaving significant residues.

Table III
Rinsability as Determined by the Spectroscopic Method

Sample	Absorbance	±SD	Type	pH	p
G	.143	.028	Soap	8.8	.001
B	.197	.013	Syndet	5.4	.800
Q	.215	.018	Soap	9.8	.550
A	.222	.016	Soap	9.4	.500
C	.228	.010	Soap	9.6	.500
H	.231	.015	Soap	9.8	.001
O	.296	.027	Syndet	5.7	.050
K	.330	.032	Syndet	5.5	.500
R	.333	.019	Soap	9.6	.100
P	.351	.028	Soap	9.6	.600
N	.362	.027	Soap	9.7	.500
E	.388	.019	Syndet	7.2	.300
L	.405	.024	Soap	9.7	.600
M	.421	.031	Combar	9.7	.001
D	.526	.019	Soap	10.0	.500
F	.537	.024	Soap	9.6	.005
I	.602	.016	Soap	9.6	.800
J	.629	.010	Combar	9.4	–

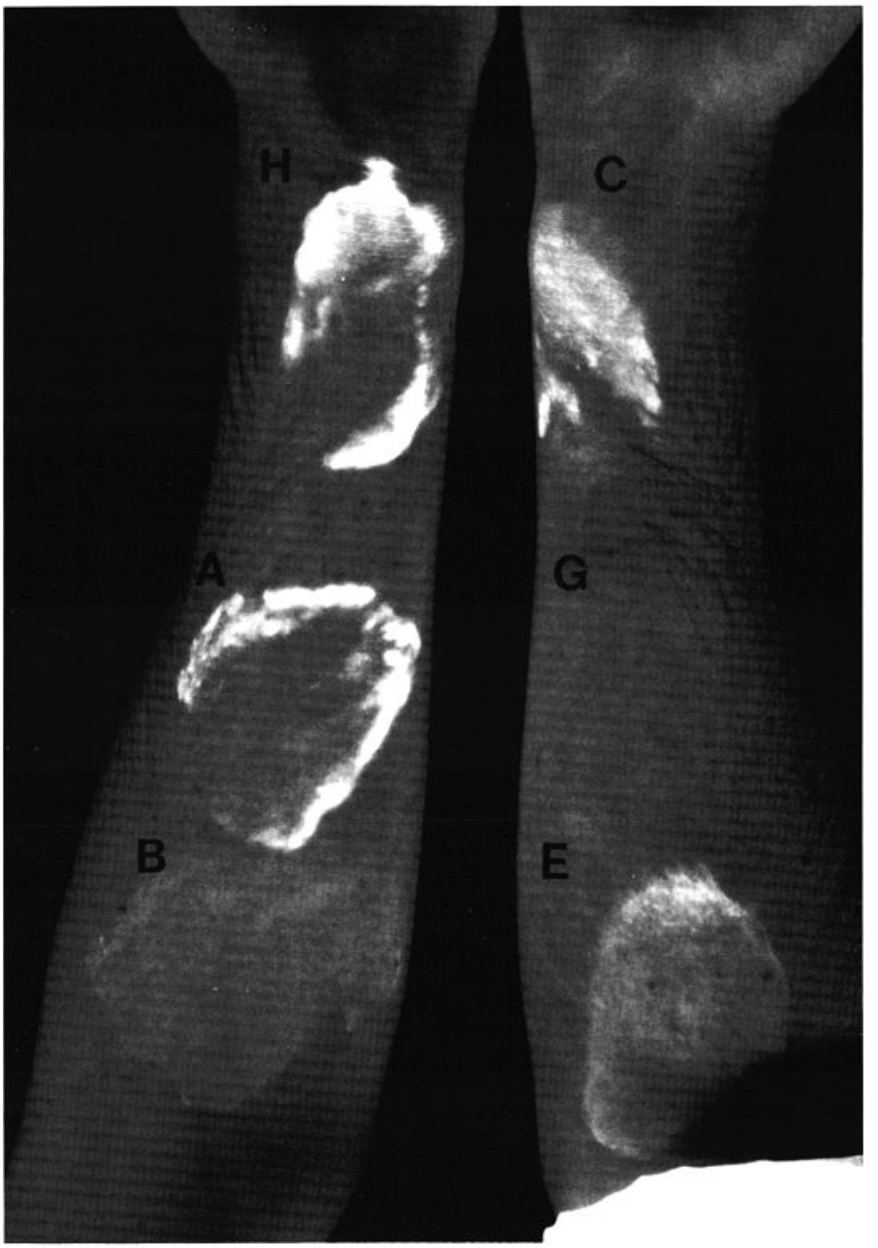

Figure 1. Soap residues after washing as revealed by fluorescein fluorescence.

Samples N and P demonstrated average rinsability, with all the other products tested showing slightly above or below average rinsability.

DISCUSSION

In comparing the two methods, the spectroscopic method is simpler, does not require special photographic equipment, and is substantially more quantitative than the photo-

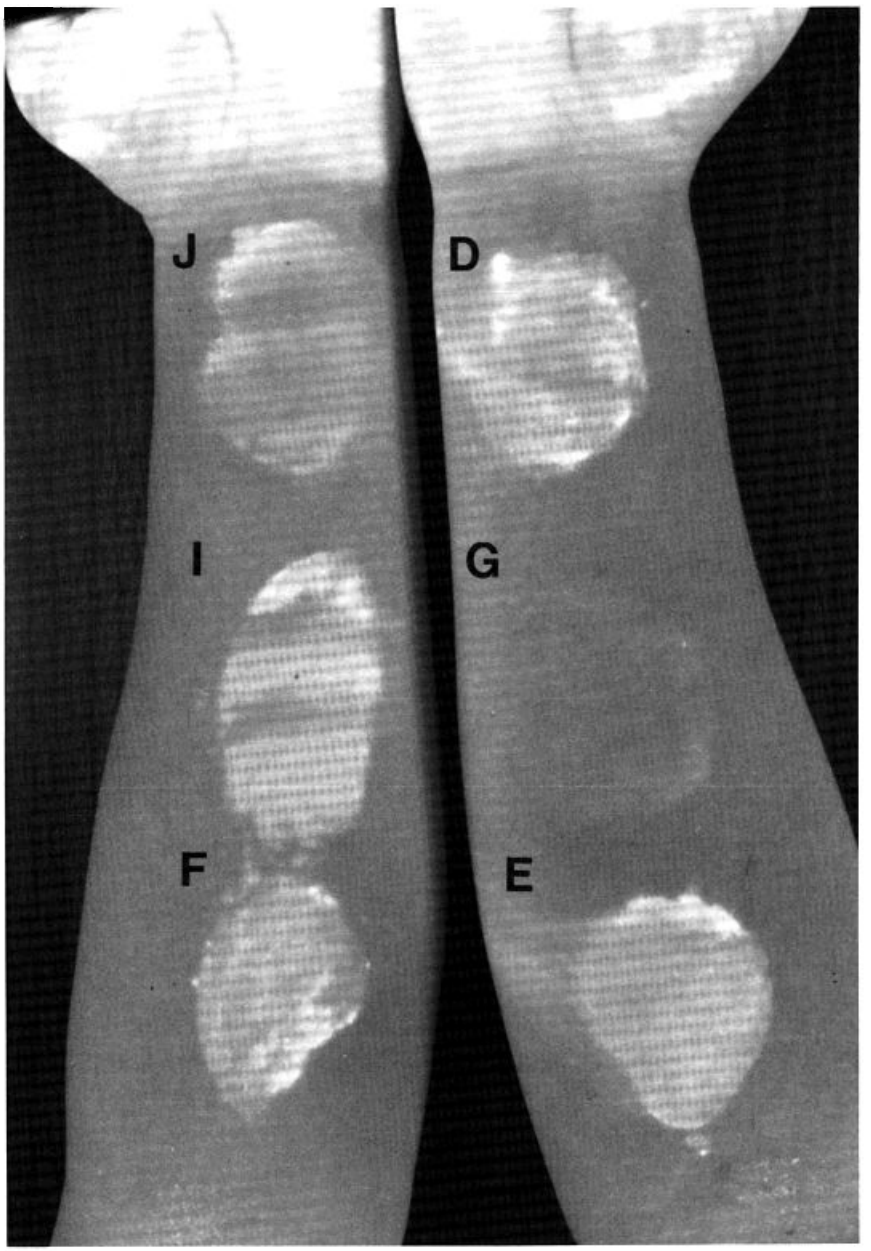

Figure 2. Soap residues after washing as revealed by fluorescein fluorescence.

graphic method. The photographic method exploits well the impact of direct visual comparison. The results of both methods are comparable as shown by a linear regression analysis of the two methods which yielded a correlation coefficient of 0.952, indicating an excellent correlation between the two methods.

The spectroscopic method was designed to quantify the dye residue rather than simply visually ranking it. Since many soap and detergent bars contain antioxidants, bright-

Table IV
Comparison of Soap Chamber Irritancy (5) With Rinsability Data

	Irritancy (5)				Rinsability[3]	
Product	Erythema[1]	Rank	Scaling[2]	Rank	Absorbance	Rank
E	.3	(1)	.2	(1)	.388	(5)
B	1.0	(2)	.5	(2)	.197	(2)
H	1.2	(5)	1.5	(7)	.231	(4)
D	1.2	(4)	1.1	(4)	.526	(7)
C	1.5	(7)	1.0	(3)	.228	(3)
G	1.0	(3)	1.3	(5)	.143	(1)
F	1.3	(6)	1.4	(6)	.537	(8)
J	3.0	(9)	1.8	(8)	.629	(9)
L	2.6	(8)	2.2	(9)	.405	(6)

1: Erythema (1) = diffuse; (2) = moderate; (3) = intense.
2: Scaling (1) = dryness; (2) = fine scales; (3) = moderate scaling.
3: Rinsability as determined by the spectroscopic method.

eners, and other UV-absorbing compounds, the soap solutions without fluorescein were used as a reference blank to eliminate any possible spectral interferences. Methanol:water (80:20) was used as the diluent, to minimize pH variations and to dissolve the fluorescein dye in a highly polar solvent, eliminating any significant variation in its extinction coefficient due to surfactants or other ingredients.

Soap G, a triethanolamine soap, was the product with the best rinsing characteristics using either method in this study. Soaps B, A, C, and H, all soaps promoted to dermatologists as mild, demonstrated slightly above average rinsability for the bars tested. Samples E, N, and P demonstrated average rinsability. Soaps D, F, I, and J showed significantly lower rinsability. Of these products, three (D, I, and J) are deodorant soaps, which may explain their performance, since these products are designed to leave some residue as part of the deodorant action. This may also explain the irritancy of these types of products, since they tend to leave a mixture of ingredients on the skin along with the active ingredient, leading to an increased irritancy potential (6). Conversely, the lack of rinsability may be due to the cutaneous damage induced by the cleansers. Damage to the horny layer results in increased stratum corneum permeability as determined by transepidermal water loss. This effect can be detected after a single wash (8). It is possible that this type of permeability, while in itself a subclinical reaction, may affect rinsability in this test.

In the discussion of mildness in soap products, two characteristics of importance appear. These are ingredient mildness and rinsability. Bar E is an example of a very mild syndet with only average rinsability. In comparison, L, a soap bar, has approximately the same rinsability as E, yet it exhibited substantially greater irritancy in the soap chamber test (Table IV). G, a soap bar with exceptional rinsability, demonstrated a moderate irritance potential in the soap chamber test and yet demonstated equivalent mildness to E in the wash testing which included rinsing (5). These observations lead to the conclusion that while all soaps and detergents are to some degree irritating, those products that remain in contact with the skin for the longest time have the greatest potential for irritancy. The changes in the results of the soap chamber and wash tests are understandable in light of the results reported here. A comparison of the rankings between the

chamber and exaggerated wash testing illustrates the difficulty in correlating such predictive assays as the soap chamber test with product use data. In an effort to screen for potentially mild formulations, a combination of chamber, rinsability, and final product use tests should be employed.

REFERENCES

(1) J. W. Jordan, F. A. Dolce, and E. D. Osborne, Dermatitis of the hands in housewives: Role of soap in its etiology, methods and prevention, *JAMA,* **115,** 1001–1006 (1940).
(2) E. Jungermann, New trends in bar soap technology and liquid soaps, *Soap/Cosmetics/Chemical Specialties,* 30–34 (January 1982).
(3) E. Jungermann, "Soap" in *Bailey's Industrial Oil and Fat Products,* 4th ed. O. Swerm, Ed. (John Wiley and Sons, New York, 1979), Vol. 1, pp 579–580.
(4) K. D. Crow, Barrier creams, *Practitioner,* **202,** 127 (1967).
(5) P. J. Frosch and A. M. Kligman, The soap chamber test. A new method for assessing the irritancy of soaps, *J. American Academy Dermatology,* **1,** 35–41 (1979).
(6) P. J. Frosch, "Irritancy of Soap and Detergent Bars," in *Principles of Cosmetics for the Dermatologist,* P. Frost and S. N. Howitz, Eds. (C. V. Mosby Co., St. Louis, 1982), pp 5–12.
(7) J. T. McClave and F. H. Dietrich, *Statistics,* 2nd ed. (Dellen Publishing, San Francisco, CA, 1982), pp 404–414.
(8) A. M. Kligman, Personal communication (1983).