

# The Irritancy of Hand Dishwashing Liquids on the Skin

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**Background :** The regular use of soaps and synthetic detergents has been associated with skin dryness and aggravation of dermatological conditions.

**Objective :** Our purpose was to investigate the irritancy of 10 hand dishwashing liquids on normal skin.

**Methods :** The skin changes, responding to repeat patch testing with 10 hand dishwashing liquids, were measured by visual scoring.

**Results :** The results are summarized as follows;

1. Of the 16 healthy volunteers 8 had reactions. 5 women and 3 men, but there was no significant difference in irritancy between men and women.

2. The mean irritancy scores of the 10 hand dishwashing liquids ranged from 0.06 to 0.88

3. A prominent increase in the degree of erythema in the first 24 hour patch test did not persist beyond exposure day 5, but after day 5, augmented responses of the erythema and scales, even fissuring occurred.

4. The pH of the test solutions of the hand dishwashing liquids ranged from 5.0 to 6.0, but there appeared to be no correlation between pH and irritancy in the dishwashing liquids tested.

**Conclusion :** Our data suggests that regular exposure to hand dishwashing liquids may cause disturbances of the skin in a substantial proportion of individuals, and workers should use hand dishwashing liquids in lower concentrations than recommended and only for short periods with protective measures. (Ann Dermatol 11(1) 13~18, 1999).

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*Key Words :* Hand dishwashing liquid, Irritancy

Irritant contact dermatitis is a common clinical problem, and is far more common than allergic contact dermatitis. Unlike allergic contact dermatitis, however, its mechanism is poorly understood and management can be very difficult.

The integrity of the skin's barrier function is essential in maintaining skin hydration. If the barrier function is impaired, there will be an increase in the rate of water vapor lost through the stratum corneum. Irritant contact dermatitis often affects the stratum corneum first; thus an increase in dryness, scaling, or erythema is a common sign of

skin irritation. The use of soaps and synthetic detergents has been associated with skin dryness and aggravation of dermatological conditions.

The irritancy potential of soaps and detergents has been shown by numerous investigators. Frosh and Kligman<sup>1</sup> compared 18 commercially available toilet bars using a repeat insult patch test, which showed significant differences among the various bars. Hand dishwashing liquids are designed to be diluted in water and recommended usage is that they should be in contact with the skin only for short periods with protective measures. In real-life situations, however, a number of persons do not use rubber gloves or use them infrequently. .

The aim of this study is to evaluate and compare the irritancy of ten common brand name hand dishwashing liquids in Korea on normal skin, using repeat patch tests with visual scoring.

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**Table 1.** Irritancy scale

	Scale
Erythema	1 (slight redness, spotty or diffuse) 2 (moderate, uniform redness) 3 (intense redness) 4 (fiery red with edema)
Scaling	1 (fine) 2 (moderate) 3 (severe with large flakes)
Fissure	1 (fine cracks) 2 (single or multiple broader fissures) 3 (wide cracks with hemorrhage or exudation)

### Experimental Design

Ten common brand name hand dishwashing liquids were used in this study, along with glycerol as a negative control, and 1% sodium lauryl sulfate for a positive control. Modified patch testing was carried out using the method of Frosch and Kligman<sup>1</sup>. Finn chambers with filter paper disks on Scanpor tape were applied to the subject's backs. The solutions placed in the 10 chambers were the hand dishwashing liquids, diluted to a concentration of 3%, similar to the concentration used in manufacturer testing. In addition, two extra chambers were placed with 3% glycerol and 1% sodium lauryl sulfate. 15  $\mu$ l of each solution was applied to a filter paper disk in each chamber; a different sterile pipette was used for each solution and each application. The exposure encompassed five weekdays.

**Table 2.** Summary of data and results(I)

No.	Sex /Age	Prior use of detergent	1% SLS*	Mean irritancy score
1	M / 27	Never	-	0.1
2	M / 30	Never	-	0.7
3	M / 26	Never	+	1.1
4	M / 24	Never	+	-
5	M / 28	Never	+	-
6	M / 25	Never	+	-
7	M / 28	Never	-	-
8	M / 25	Never	-	-
9	F / 25	Never	-	0.1
10	F / 24	Regular	+	0.2
11	F / 24	Never	+	0.8
12	F / 24	Regular	+	1.0
13	F / 24	Regular	+	1.2
14	F / 24	Occasional	-	-
15	F / 24	Regular	-	-
16	F / 25	Occasional	-	-

SLS\* : sodium lauryl sulfate

## MATERIALS AND METHODS

### Study Population

Sixteen healthy volunteers (eight men and eight women), between 24 and 30 years of age, participated in the study, after having given their written informed consent. None had a history of atopy or other allergic dermatitis.

The initial patches were left in place for 24 hours. After 24 hours the patches were removed and fresh solutions were applied to the same sites for 6 hours daily for the next four days, except for 1% sodium lauryl sulfate. The skin was not protected during the off-periods. The first exposure was four times longer than the rest in order to damage the horny layer barrier quickly and render it highly permeable. The off-periods accentuated the differences among the hand dishwashing liquids by bringing

**Table 3.** Summary of data and results(II)

Detergent	pH	Mean irritancy*			Components
		E	S	F	
A	5.0	0.38	0.38	0.12	surfactant(20%), solubilizer
B	5.0	0.38	0.13	0.18	surfactant(20%), solubilizer
C	5.5	0.31	0.06	-	surfactant(21%), alcohol, fatty acid, $\alpha$ -olefin
D	6.0	0.25	0.06	-	surfactant(25%), alcohol, fatty acid, $\alpha$ -olefin, aminoxide
E	5.5	0.12	0.13	-	surfactant(21%), alcohol, fatty acid, $\alpha$ -olefin
F	6.0	0.13	0.06	-	surfactant(20%), solubilizer, fatty acid, citrate, aminoxide
G	6.0	0.12	0.07	-	surfactant(20%), alcohol, fatty acid
H	5.0	0.06	0.07	-	surfactant(21%), alcohol, fatty acid, citrate
I	5.0	0.07	0.06	-	surfactant(20%), alcohol, fatty acid
J	6.0	0.06	-	-	surfactant(24%), alcohol, fatty acid

\* : Total irritancy score/ subjects's numbers, E: erythema, S: scaling, F: fissure

**Fig. 1.** Combined scores of erythema, scaling and fissuring ranked from most to least irritating.

**Fig. 2.** Sum curves for visual scores after cumulative application of detergent.

forth subtle morphological changes which were blurred by continuous exposures. The final reading of the sites was done approximately 48 hours later.

#### Evaluation of Irritancy

The skin responses to the patch tests with the 10 hand dishwashing liquids were measured by visual scoring, according to Frosch and Kligman (Table 1)<sup>1</sup>. Total irritancy scores of each hand dishwashing liquid were made by a total assessment scaled score of erythema, scaling and fissuring at the final reading. The mean irritancy score of each hand dishwashing liquid was measured by the total irritancy score di-

vided by the subject's numbers.

#### Statistical Analysis

Scores for erythema, scaling, and fissuring were ranked and analysis was performed on the ranks by means of one-way analysis of variance followed by the modified least significant difference procedure to control for multiple comparisons.

elevated persistently beyond exposure day 5. After day 5, augmented responses of the erythema and scale, even fissuring occurred, which suggest irreversible damage to the skin's barrier function due to cumulative irritation (Fig. 2).

## DISCUSSION

Numerous factors contribute to the irritancy potential of detergents, including its chemical structure<sup>2</sup>, purity<sup>3,4</sup> and concentration of surfactants<sup>5-7</sup>, pH<sup>2</sup>, type of application (open/under occlusion)<sup>8</sup>, and frequency and duration of exposure<sup>8,9</sup>. Although the importance of these factors differs depending on the investigator, there is general agreement that the chemical nature of surfactants, specifically the carbon chain length, is the factor that contributes the most to a detergent's irritancy<sup>10</sup>. Detergents with higher molecular-weight are less irritating than those with lower molecular-weights because low molecular weight carbon chain containing detergents are more soluble in water and therefore penetrate the stratum corneum more readily. Most of the hand dishwashing liquids used in our study were formulated with a combination of short-chain and long-chain carbon components.

Among the types of surfactants, anionic surfactants attack the horny layer and increase its permeability. Sodium lauryl sulfate, one of the anionic surfactants, is known as very potent irritant substance. It increases transepidermal water loss, skin blood flow, stratum corneum turnover time, skin pH, and water-holding capacity and the water content of the stratum corneum<sup>11-13</sup>. In this study, among the 8 reactors to 1% sodium lauryl sulfate after the induction of acute irritant dermatitis with a single 24-hour patch application, only 5 subjects responded to the commercial hand dishwashing liquids. This result suggests that additional compounds are present in dishwashing liquids, but what kind of substances contribute in what fashion is not clear. Most hand dishwashing liquids currently on the market are mixed anionic, cationic and non-ionic components.

No influence of pH of the different soaps or detergent solutions on their irritant potential was noted in the ranges of pH 4.0 to 10.5<sup>14,15</sup>. Cleansing with a high pH detergent stresses the skin's buffering capacity. The length of time necessary to re-establish normal skin pH varies from minutes to hours<sup>16,17</sup>.

Fig. 3. Cutaneous changes to cumulative irritation.

## RESULTS

Eight (five women and three men) of the 16 subjects had reactions on the patch test with hand dishwashing liquids. Women having reactions with hand dishwashing liquids are more common than men, but there was no significant difference of individual mean irritancy scores between the men and women. Eight (four women and four men) showed reactions with 1% sodium lauryl sulfate, and among these, 5 subjects responded to hand dishwashing liquids. The female subjects with a history of regular use of detergents had more intense reactions than those who did not, but not to a degree that reached statistical significance (Table 2).

The mean irritancy score of the 10 hand dishwashing liquids ranged from 0.06 to 0.88 (Fig. 1). J hand dishwashing liquid was the least irritating ( $p \leq 0.05$ ) and was the only one that did not cause scaling in any subjects. The pH of the test solutions of hand dishwashing liquids ranged from 5.0 to 6.0, and there was no correlation between pH and irritancy in the dishwashing liquids tested. The composition of surfactant in 10 hand dishwashing liquids ranged from 20 to 25%, J liquid was 24 in contrast to 20 in A liquid and this was the most irritating (Table 3).

A prominent increase in the degree of erythema after the first 24 hours of the patch test did not remain

The pH of the test solutions of the 10 hand dishwashing liquids ranged from 5.0 to 6.0, similar to normal skin pH, and there appeared to be no correlation between pH and irritancy in the dishwashing liquids tested (Table 3).

Excessive removal of skin lipids has also been implicated in the irritancy potential of detergents<sup>10</sup>. Products such as dishwashing liquids, which are formulated to remove grease and oils, tend to be especially irritating to the skin.

Irritant patch tests are often not reproducible, whereas true allergic patch tests are almost always constant<sup>18</sup>. Conventional 24- to 48-hour occlusive patch tests cannot accurately discriminate among irritants because all produce a monotonous erythema which varies only slightly in intensity. This confirms earlier studies from other laboratories<sup>19,20</sup>. In this study, we used the repeat patch test technique to achieve reproducibility. As a result, subjects exhibited erythema scores varying from 0 to 2 (moderate erythema) after both the first and the repeat patch test. Thus 3% diluted hand dishwashing liquids proved to be a useful concentration for studying mild cumulative irritation. However, the degree of erythema produced by both the first and the repeat patch test varied greatly from subject to subject. Sometimes the reaction was more pronounced after the first patch test, and sometimes the reverse occurred. A prominent increase in the degree of erythema after the first 24 hour patch test did not persist beyond exposure in day 5. This result suggests that in the presence of the spotty erythema seen so commonly in early irritant contact dermatitis, there are widely fluctuating readings and partial recovery of the skin's barrier function. However, after day 5, augmented responses of the erythema, scale and fissures suggest irreversible damage to the skin's barrier function, due to cumulative irritation (Fig. 2). Fig. 3 shows normal skin changes to cumulative irritation during the exposure period.

It is interesting to examine the inter-relationships between erythema, scaling, and fissuring in the patch tests. While scaling and erythema tended to parallel each other, the correlation was actually weak. Fissuring may signify intense damage and is usually preceded by a dermatitis with exudation and crusting. It must be emphasized that the hallmark of hand dishwashing liquid damage is a rough, dry, cracked, ruddy surface on the hands. Patients with this condition may need protection for

longer than what seems to be necessary from a simple inspection of the skin because healed contact irritant dermatitis may flare again after exposure to mild irritation such as hand washing.

Hand dishwashing liquids comprise surfactants, solubilizers, fragrances, dyes, foam-sustaining components, preservatives, and multiple other ingredients. Recently, many manufacturers add agents designed to counter-act the effects of cleansing by moisturizing the skin, but they may help only to a limited extent. Even the mildest of products, if overused, might cause minor or moderate adverse reactions. In this study, whether dry, flaky skin changes caused by repeat patch tests were due to the irritant effect of the surfactant or due to additional irritating compounds present in the hand dishwashing liquid could not be completely answered by our results. Further study would be required to ascertain which components cause irritation.

In conclusion, our main finding was that repeat patch tests with 3% diluted hand dishwashing liquids (standard usage concentration) at the same site after 5 days produced disturbances of normal skin even though the skin had looked normal for 3 to 4 days. Therefore, our results suggest that workers should use hand dishwashing liquids in lower concentrations than recommended and only for short periods with protective measures.

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