

# Sensitive skin and stratum corneum reactivity to household cleaning products

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Products intended for individuals with sensitive skin are being increasingly developed by formulators of household cleaning products. However, there is currently no consensus about the definition and recognition of the biological basis of sensitive skin. We sought to determine the relation between the nature of environmental threat perceived as aggressive by panelists, and the stratum corneum reactivity to household cleaning products as measured by the corneorosurfametry test. Results indicate substantial differences in irritancy potential between proprietary products. Corneorosurfametry data show significant differences in stratum corneum reactivity between, on the one hand, individuals with either non-sensitive skin or skin sensitive to climate/fabrics, and, on the other hand, individuals with detergent-sensitive skin. It is concluded that sensitive skin is not one single condition. Sound information in rating detergent-sensitive skin may be gained by corneorosurfametry.

**Key words:** corneorosurfametry; fabrics; irritation; sensitive skin; surfactant; stratum corneum; bi-engineering methods. © Munksgaard, 1996.

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Sensitive skin is a common and puzzling problem that is notoriously difficult to define. It is likely a multifactorial process that encompasses distinct conditions (1). In a broad sense, sensitive skin means that the skin readily experiences either reduced tolerance or heightened response to external irritant factors. Adverse reactions may be immediate or delayed, and begin as purely sensory phenomenon with no clinical expression (2-4). These discomforts include tightness, stinging and burning sensations. Such subjective signs of irritation may be followed by visible effects, including rough and dry skin, and erythema (4). Several targets in the skin could be responsible for the abnormal self-perceived sensory response to irritants. In this study, we hypothesized that the response of the stratum corneum to environmental threat might be impaired in a subset of individuals complaining of sensitive skin. We tested such a hypothesis by using the corneorosurfametry test (5-8), in subjects with sensitive skin to household cleaning products, including dishwashing liquids.

## Materials and Methods

3 groups of 15 subjects were selected in January 1994, after answering questionnaire using a 3-point

scale for rating sensitive skin (Table 1). They were of both sexes, with ages ranging from 23 to 51 years ( $33 \pm 7$  years). The criteria for non-inclusion were the presence of dermatitis, the use of emollients, and values of transepidermal water loss (TEWL) exceeding  $8 \text{ g/m}^2/\text{h}$ . Subjects with normal non-sensitive skin formed a control panel. Panelists who claimed to have skin sensitive to skin care products and household cleaning products predominantly, were allocated to a 2nd group. Panelists who reported having skin sensitive to some specific environmental threat other than detergents were allocated to the 3rd group. Each of the panelists with sensitive skin selected in the 2 latter groups had to reach a minimum cumulative score of 4 in the rating scale.

Table 1. Criteria of selection of volunteers according to their self-perceived body sensitivity; rating scale: 0: not sensitive; 1: occasionally sensitive; 2: sensitive

| Skin reactive to            | Score   |         |         |
|-----------------------------|---------|---------|---------|
|                             | Panel 1 | Panel 2 | Panel 3 |
| climate (dry and cold)      | 0       | 0 or 1  | 2       |
| skin care products          | 0       | 1 or 2  | 0       |
| household cleaning products | 0       | 2       | 0       |
| microtrauma (rough object)  | 0       | 0 or 1  | 0 or 1  |
| fabrics (wool)              | 0       | 0       | 1 or 2  |

Informed consent was obtained from each subject after the study protocol had been fully explained. 5 cyanoacrylate skin surface strippings (CSSS,  $3 \times 1.5$  cm) were harvested from the volar aspect of both forearms. They were used for the corneorosurfametry technique, which has previously been described in detail (5–8). In short, diluted surfactants are sprayed over the CSSS. The investigator is blinded as to the product allocated to each CSSS. Samples are kept at room temperature in a humid environment for 2 h. They are then thoroughly rinsed with tap water, dried and stained for 3 min with a toluidine blue-basic fuchsin solution (Polychrome Multiple Stain, PMS, Delasco, Council Bluff, USA). Their color is measured by reflectance colorimetry using the  $L^*a^*b^*$  system (Chroma Meter<sup>®</sup> CR200 Minolta, Osaka, Japan).

It has previously been shown that harsh surfactants considerably increase the intensity of staining of the CSSS (5–8). In this study, 1 CSSS of each subject was sprayed with water alone, and served as negative control. Another CSSS was sprayed with a 1% aqueous solution of sodium lauryl sulfate (SLS) to serve as an internal positive standard. Each of the 8 other CSSS were sprayed with a 1% aqueous solution of 1 of the test products, including 4 dishwashing liquids and 4 other household cleaning products.

After inclusion in the study and collection of the CSSS, volunteers allocated to the detergent-sensitive skin panel received, at random, 1 of 2 commercial liquid cleansers marketed for sensitive skin. The product had to be used on a regular basis to the exclusion of any other skin care product, to

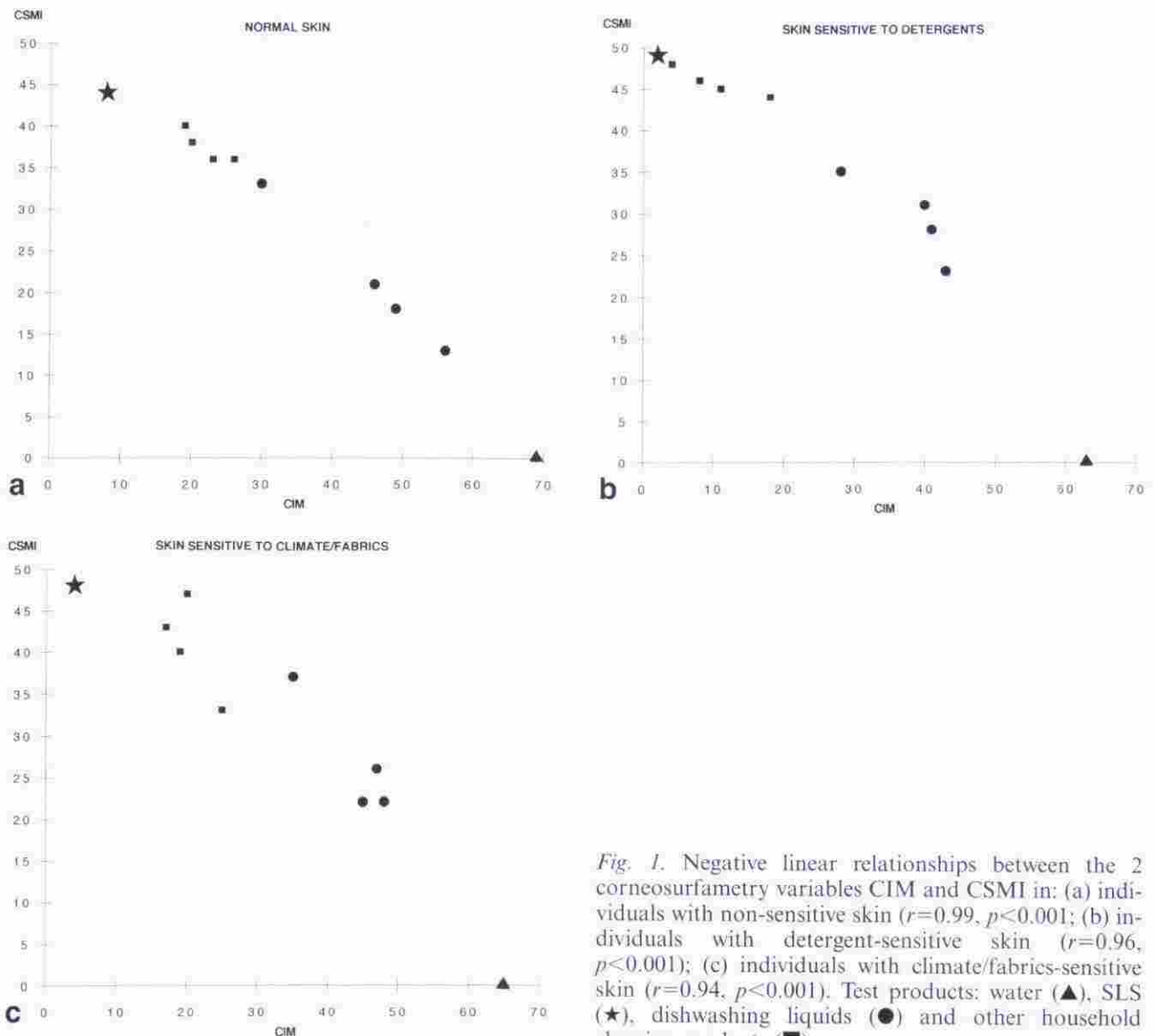


Fig. 1. Negative linear relationships between the 2 corneorosurfametry variables CIM and CSMI in: (a) individuals with non-sensitive skin ( $r=0.99$ ,  $p<0.001$ ); (b) individuals with detergent-sensitive skin ( $r=0.96$ ,  $p<0.001$ ); (c) individuals with climate/fabrics-sensitive skin ( $r=0.94$ ,  $p<0.001$ ). Test products: water (▲), SLS (★), dishwashing liquids (●) and other household cleaning products (■).

wash the forearms. These panelists were asked to take part to a control experiment 1 month later, when a corneorosurfametry test was performed in a similar way as at entry to the study.

Data of the corneorosurfametry assays were expressed by 2 variables, namely the corneorosurfametry index (CSMI) and the colorimetric index of mildness (CIM) (5–8). CSMI corresponds to the color differential  $\Delta E^*ab$ , calculated between the colorimetric values of each test product-CSSS sample and the water-treated CSSS. CIM corresponds to the difference between the  $L^*$  and Chroma  $C^*$  values of each CSSS test sample.

Means (M), standard deviations (SD) and coefficients of variation ( $V=10^2/SD \cdot M^{-1}$ ) of CSMI and CIM were calculated for each product in each panel of volunteers. A relationship between CSMI and CIM values was searched for by calculating the coefficient of correlation  $r$ . The overall difference in corneorosurfametry (ODC) values between 2 test products was calculated from the differences in mean CSMI ( $\Delta CSMI$ ) and mean CIM ( $\Delta CIM$ ), following:  $ODC=[(\Delta CSMI)^2 + (\Delta CIM)^2]^{0.5}$ . Bivariate analysis combining both CSMI and CIM was used to compare products within each panel. The overall reactivity of the stratum corneum to detergents was evaluated in each panel by calculating the average values of CSMI and CIM of all test products combined. Bivariate analysis was then used to compare these average values in the 3 groups of volunteers. A  $p$ -value lower than 0.05 was considered as reaching statistical difference.

## Results

A significant negative linear relationship was found between the means of CSMI and CIM in each panel (Figs. 1a, c). They corresponded to a scale of irritancy bordered by water, as a non-irritant, and SLS as the most aggressive product.

Data of the corneorosurfametry assay performed on non-sensitive skin are presented in Fig 1a. The coefficients of variation for CSMI and CIM were in the range 10–27%. In the scale of irritancy going from water to SLS, dishwashing liquids were milder than the other household cleaning products. Bivariate analysis showed, however, that the most irritant dishwashing liquid was not significantly different from the 4 household cleaning products.

Data of the corneorosurfametry assays performed on skin sensitive to detergents or to climate/fabrics are presented in Figs. 1 b and c, respectively. The coefficients of variation for CSMI and CIM were in the range 16–34%. In both groups, dishwashing liquids were less aggressive than the other household cleaning products. The rank orders of the test products in the scale of irritancy were not always

similar to that found in the assay on non-sensitive skin (Fig.2).

The overall stratum corneum reactivity, as calculated by the average values of CSMI and CIM of

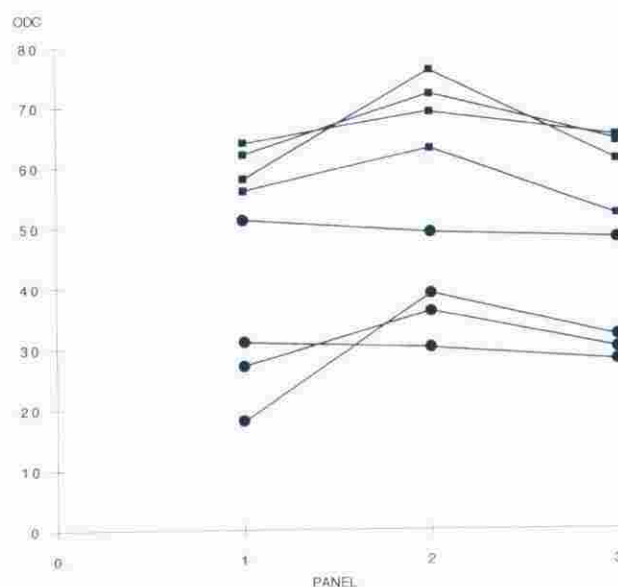


Fig. 2. Overall difference in corneorosurfametry (ODC) values of test products by combining both CIM and CSMI variables. The 3 panels of 15 subjects each concern non-sensitive skin (group 1), skin sensitive to detergents (group 2) and skin sensitive to climate/fabrics (groups 3). The ranking of the irritancy potential of the test products (dishwashing liquids (●), other household cleaning products (■)) shows some differences according to the panel.

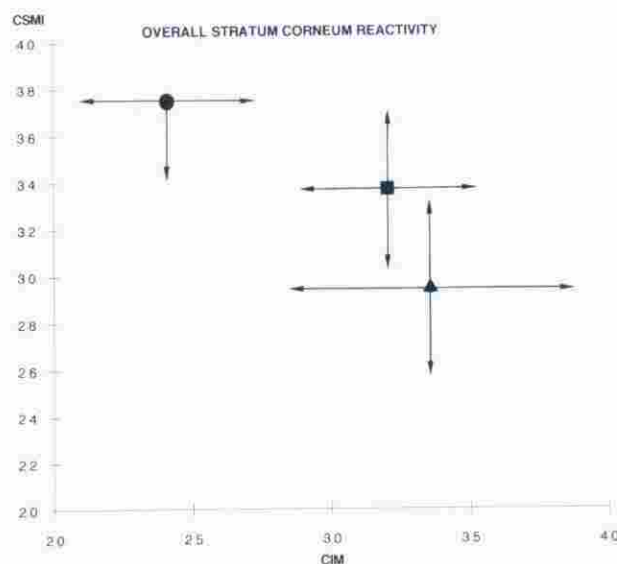


Fig. 3. Mean  $\pm$  SEM of the overall stratum corneum reactivity, representing the mean of the corneorosurfametry variables CIM and CSMI, combining the 8 tested household cleansing products. The 3 panels group subjects with non-sensitive skin (▲), detergent-sensitive skin (●) and climate/fabrics-sensitive skin (■).

all test products combined in each of the 3 panels, is presented in Fig. 3. A significant ( $p < 0.01$ ) difference was found between detergent-sensitive skin and both non-sensitive skin and climate/fabrics-sensitive skin. No difference was shown between the 2 latter groups.

12 of the 15 volunteers with detergent-sensitive skin returned for the 2nd corneosurfametry test after a 1-month normal use of a selected liquid skin cleanser. None reported modifications in their self-perception of sensitive skin. Changes in corneosurfametry values were arbitrarily considered as beneficial or deleterious only when they showed variations over 5% of the initial values. With one of the skin cleansers, no modification was shown in 3 subjects, but worse corneosurfametry data were present in the other 2 subjects. In contrast, 3 subjects of the panel using the other product experienced an improvement in these measures, 4 showed no modification, and none worsened.

### Discussion

This study was conducted during the winter season because discomforts linked to the use of detergents are greater at that time of the year, particularly in persons with sensitive skin (9). There are many methods for comparing the irritancy potential of detergents, and there is a risk of finding contradictory results concerning product mildness (10). Several different methodologies focusing on specific biological responses to irritation should be used before drawing definite conclusions on the mildness/irritancy of a product. In this study, corneosurfametry was used to avoid the hazards of unnecessary in vivo exaggerated exposures to detergents. This technique has the advantage of testing exclusively the action of surfactants on the stratum corneum. It has been shown that corneosurfametry data correlate with in vivo susceptibility tests (8). This allows the comparison of multiple products, in contrast with exaggerated wash tests, which can be used only for pair-wise comparisons.

The present study confirms previous results (6) where a linear correlation was found between CSMI and CIM. Such dual evaluation increases the sensitivity of the corneosurfametry test in ranking products according to their mildness/irritancy properties. The calculation of the ODC for each product versus water shows substantial and even significant differences in stratum corneum aggressiveness among dishwashing liquids. As expected, the other household cleaning products proved to be more harsh than dishwashing liquids.

The overall responsiveness of the stratum corneum to the test products was significantly higher in the detergent-sensitive skin panel than in the 2

other panels of volunteers. This suggests the existence of distinct and specific types of sensitive skin. The detergent-sensitive subjects could have a weakened resistance of their stratum corneum to surfactants. Other types of sensitive skin could depend on other biological factors not explored by corneosurfametry.

The ranking of cleaning products according to their irritancy properties, as determined by their ODC versus water, was not always the same in the 3 panels of volunteers. Some products showed an increased relative irritancy while others improved their ranking in sensitive skin subjects.

Many recent studies have shown that surfactants alter some structures and functions of the skin. Even persons without appreciable skin signs may have substantial subclinical alteration in the structure and barrier function of the stratum corneum (3, 6, 11). It had been suggested that surfactants lead to an increased stratum corneum turnover (12, 13). These observations suffered from a flaw in the methodological design (14) and therefore may not be interpreted as an attempt at biological repair of the damage.

The corneosurfametry data obtained after a 1-month normal use of liquid skin cleansers are consistent with the Malten theory of traumatic irritation (15). One of the skin cleansers did not improve and even weakened the stratum corneum to the corneosurfametry test. Regular exposure to this skin cleanser therefore has a negative influence on the stratum corneum resistance to further aggression by household detergents. In contrast, the other skin cleanser led to a trend in improved resistance of the stratum corneum to household detergents. It could therefore likely participate in decreasing in time the severity of the sensitive skin symptoms. These 2 examples concerning skin cleansers show the differences in biological effects of commercial products designed and marketed to have a minimum likelihood of causing irritation to the skin.

In conclusion, the corneosurfametry test seems to indicate that sensitive skin is not one single condition. It probably encompasses different categories of subjects, having different weak points in their defences to environmental threat. The range of variation in stratum corneum alteration following contact with household cleaning products is wide. Sound information may be gained by corneosurfametry. The nature of the skin-care cleansing product may modulate the severity of skin sensitive to detergents.

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