The pH of commercially available rinse-off products in Sri Lanka and their effect on skin pH

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(Index words: Stratum corneum, permeability barrier function, skin pH)

Abstract

Introduction Initially linked to antimicrobial function, the acidic skin pH plays a key role in permeability barrier homeostasis and integrity of the stratum corneum. Barrier recovery is delayed when acutely perturbed skin sites are exposed to a neutral pH.

Objective To evaluate the pH of commercially available rinse-off products in Sri Lanka, and the effect of detergent rinses on skin pH and its recovery rate.

Methods The pH of 18 rinse-off products was determined using pH indicator paper and a pH meter. The effect of an alkaline (pH 9) and an acid (pH 5.5) rinse-off product on the hand skin pH was compared in 48 healthy volunteers after single and multiple applications. The skin pH of the dorsum of hands was measured in nurses before (n=131) and during (n=40) a duty shift that involved frequent hand washing using alkaline soap.

Results Soaps available in Sri Lanka have a pH of 9.1–10.5. The pH of syndets and cleansers range from 5.5–7.0. Five minutes after hand washing, the mean skin pH increased by $1.7 \pm \text{SD } 0.5$ pH units with alkaline soap, and by $0.8 \pm \text{SD } 0.4$ pH units with acidic cleanser ($p < 0.0001$). Recovery of pH was slower when alkaline soap was used. The increase in skin pH was significantly greater when hands were repetitively washed with alkaline soap ($p < 0.0001$). The mean skin pH values of nurses before ($4.9 \pm \text{SD } 0.4$) and during ($5.7 \pm \text{SD } 0.7$) the work shift were significantly different ($p < 0.0001$).

Conclusions Alkalinisation with rinse-off products increases the skin pH with potential functional and clinical implications.

main contributors to SC acidity) alters SC permeability barrier homeostasis [5,6]. The negative consequences of SC neutralisation in all these examples have been further linked to activation of serine proteases, the key enzymes that mediate desquamation, which have neutral to alkaline pH optima [7]. These observations could be clinically relevant, because inflammatory skin diseases display both permeability barrier and integrity-cohesion abnormalities, as well as an increased colonisation by pathogenic microbes [8]. Moreover, not only inflamed skin, but also both neonatal [9,10] and aged skin [11] show a higher SC pH, with potential functional and clinical consequences.

It has been suggested that repeated use of rinse-off products with alkaline or neutral pH may disrupt the acid pH of the skin [12]. Furthermore, alkaline soaps are notoriously irritating [13], and contact sensitisation is enhanced when topical allergens are presented at a neutral or alkaline versus an acidic pH. Maintenance of an acidic pH improves permeability barrier function.

Commercially available soaps, synthetic detergents and cleansing agents have different properties [14,15]. Little focus has been given to hands, most frequently affected by washing procedures, especially in wet work professions.

The aim of the present study was to evaluate the pH of rinse-off products in Sri Lanka, and to compare the effect on the skin pH of an alkaline and acid rinse-off product.

Introduction

The initial observation that the human skin has an acidic surface ("acid mantle") was made nearly 80 years ago [1]. However, its origin and the importance were unclear until recently [2,3]. Initially linked to antimicrobial function [2,4], the acidic pH of the stratum corneum (SC) regulates at least two other key functions: permeability barrier homeostasis and SC integrity-cohesion. Maintenance of an acid pH is critical for SC lipid processing enzymes such as glucosylceramide and acidic sphingomyelinase. Barrier recovery is delayed when acutely perturbed skin sites are exposed to a neutral pH buffer [3]. Blockade or knockout of either secretory phospholipase A2 or the sodium-proton exchanger (NHE₁) pathways (the

Objectives

To determine the pH of rinse-off products commonly used in Sri Lanka, and evaluate the effect of alkaline and acid rinses on the skin pH and its recovery in healthy volunteers

Setting

The study was done at the Department of Dermatology, National Hospital of Sri Lanka in March–September 2006. Approval for the study was obtained from the Sri Lanka Medical Association's Ethical Review Committee.

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Materials and methods

A sample of 18 commonly used rinse-off products (including soaps, synthetic detergents and cleansing lotions) were drawn from the Sri Lankan market in March 2006. Their pH was determined using pH indicator paper (Universalindikator Merck, Darmstadt, Germany) and a pH meter (PH 900; Courage and Khazaka, Cologne, Germany). Two rinse-off products from the same manufacturer with alkaline (Johnson & Johnson baby soap, pH 9.1) and acid pH (Johnson & Johnson face wash, pH 5.5) were selected for evaluation of their effect on skin pH.

Forty-eight healthy volunteers (30 females), aged 17-59 years (mean 32.7 ± 8.8), were enrolled in the study after obtaining informed consent. Volunteers refrained from washing hands and applying any skin care product for at least 4 hours before and during the study. Subjects with skin disease were excluded.

A flat glass electrode (Mettler-Toledo, Giessen, Germany), attached to a precision pH meter was used to measure skin surface pH. The readings were taken in an air-conditioned room with temperature set at 25°C. The centre of the dorsum of the hand was used as the test site.

To assess the effect of a single application, hand washing with the 2 products was done in 30 volunteers. In each volunteer the basal skin pH of the hands was recorded, and one hand (selected at random) was washed with alkaline soap, and the other with acidic cleanser, using tap water (pH 6.8). Skin pH was recorded at 5 minutes and 1 hour after hand washing. In the last 18 subjects additional readings were taken at 30 min, and hourly intervals until the skin pH returned to its basal value.

The effect of repeated hand washing using the 2 products was evaluated in another group of 18 volunteers. After reading the basal skin pH, hands were repetitively washed with soap or cleanser and tap water at 30 minute intervals for 2.5 hours (6 applications). Skin pH was measured before and 5 min after each washing, and at 3 hours.

Next, to evaluate the effect of alkaline rinses on skin Wilcoxon signed rank test was used for significance testing.

Results

The pH of commercially available rinse-off products in Sri Lanka

The pH of rinse-off products available in Sri Lanka ranged from 5.5-10.5. The soaps had a pH of 9.1-10.5. The pH of synthetic detergents (syndets) and cleansing lotions ranged from 5.5-7.0 (table 1).

Table 1. The pH of commonly used rinse-off products in Sri Lanka

Soaps	
Lux	10.0
Rexona	10.1
Juliet	10.0
Vendol venivel	10.1
Kohomba	10.1
Pears Baby	10.0
Johnson's baby	9.1
Lifebuoy herbal	10.5
Lifebuoy gold	10.0
Dettol	10.2
Sunlight	10.5
Polytar	10.4
Acneaid Bar	10.1
Oilatum Bar	10.0
Cleansers/synthetic detergents	
Dove	7.0
Johnson's facial wash	5.5
Physiogel cleanser	7.0
Cetaphil cleanser	6.0

Figure 1. Mean skin pH changes on the dorsum of hands of 30 healthy volunteers after single application of Johnson & Johnson soap (pH 9) and face wash (pH 5.5)

The effect of alkaline and acid rinses on skin pH and its recovery

Five minutes after a single application of alkaline soap the mean skin pH increased from $4.9 \pm \text{SD } 0.5$ to $6.6 \pm \text{SD } 0.4$, by $1.7 \pm \text{SD } 0.5$ pH units. The mean skin pH increased up to $5.7 \pm \text{SD } 0.2$, by only $0.8 \pm \text{SD } 0.4$ units, when acidic cleanser was applied. Attempted recovery of skin pH was evident after one hour (figure 1). It was nearly complete (mean pH $4.8 \pm \text{SD } 0.4$) when the cleanser was applied, whereas the pH still remained elevated (mean $5.3 \pm \text{SD } 0.6$) when soap was used. The differences at 5 minutes and 60 minutes were statistically significant ($p < 0.0001$)

When recovery curves were extended ($n=18$), the basal skin pH had recovered in all but 3 subjects within

one hour on the hand washed with acidic cleanser (figure 2). 8 of the 18 subjects took more than one hour to return to the basal skin pH on the other hand washed with soap. One subject had not completely recovered even 5 hours after applying soap (figure 3).

The effect of repetitive rinses on skin pH

The skin pH fluctuated during repetitive application of the 2 rinse-off products and a significantly greater deviation from the basal value was noted when soap was applied (figure 4). With regard to both products the pH changes after 6 repetitive applications were significantly greater than those after a single application. When soap was used, the skin pH increased from its basal value of 5.0

Figure 2. Skin pH changes after single application of Johnson & Johnson face wash (pH 5.5) in 18 healthy volunteers

Figure 3. Skin pH changes after a single application of Johnson & Johnson baby soap (pH 9) in 18 healthy volunteers

$\pm$ SD 0.4 to $5.8 \pm$ SD 0.6 (by $0.7 \pm$ SD 0.4 pH units) at 30 min, and to $6.2 \pm$ SD 0.5 (by $1.2 \pm$ SD 0.4 pH units) at 3 hours ($p < 0.01$). When the cleanser was applied, the pH rose to $5.2 \pm$ SD 0.5 (by $0.2 \pm$ SD 0.4 pH units) at 30 minutes, and to $5.5 \pm$ SD 0.4 (by $0.5 \pm$ SD 0.4 pH units) at 3 hours ($p < 0.01$). After 3 hours the pH increase on the hand washed with alkaline soap was significantly greater than that of the hand washed with the acidic cleanser ($p < 0.0001$).

The effect of alkaline rinses on skin pH in real life situations

The mean skin pH value on the dorsum of hands in nurses during the work shift ($n=40$, mean skin pH $5.7 \pm$ SD 0.7) that involved frequent hand washing using alkaline soap was significantly higher than the baseline hand pH ($n=131$, mean skin pH $4.9 \pm$ SD 0.4) ($p < 0.0001$).

Discussion

The most common occupational skin disease in the industrialised world is hand dermatitis [17]. Wet work professionals are at high risk of developing contact dermatitis [18] from frequent contact of the skin with irritants in aqueous solution. The incidence of irritant contact dermatitis exceeds that of allergic contact dermatitis [19]. An increased stratum corneum hydration allows additional permeability of potential irritant: After 4 hours of experimental water exposure, the stratum corneum on the ventral aspect of the lower arm expands up to 3-fold [20]. Further, soaps, surfactants and detergents facilitate penetration, and some are themselves potential irritants. Like other wet work professionals, health workers must repeatedly wash and disinfect their hands for hygienic reasons. Although numerous studies have evaluated the antimicrobial efficacy of different hand decontamination measures, their simultaneous impact on barrier function has not been assessed [21].

Bioengineering studies are typically performed on the ventral surface of the lower arm [22]. To better understand the pathophysiology of occupational skin diseases, logically, data should instead be retrieved from the affected skin site ie. the hand. In this study a practice relevant experiment was chosen to study the effect of detergents on the skin surface pH upon repeated hand washings.

A solution that increases the skin's surface pH could perturb epidermal barrier function, due to the deleterious effects of an elevated pH on the barrier [23]. Recent studies have shown that a pH of 4.5-5.5 is required for optimal barrier function and repair [2, 24]. Maintenance of an acidic pH to prevent occupational skin diseases, particularly with respect to the hand, is challenged by repeated hand washes using an alkaline soap.

Rinsing the skin with water alone leads to a transient increase in skin pH [9]. The tap water used in our study had a pH of 6.9. Five minutes after hand washing the mean

skin pH increased from 4.9 to 6.6 with alkaline soap, and from 4.9 to 5.7 with pH balanced face wash. The effect was prolonged with alkaline soap. This increase in skin pH was significantly greater when hands were repetitively washed with either product. The pH change in the hand that was repetitively washed with soap was greater than that washed with the face wash. This effect appeared reversible but may be clinically significant in patients with skin diseases associated with an elevation of pH and in those who engage in frequent hand washing, ie. wet work professions. It may also be relevant in neonates and elderly who have a higher basal skin pH and poor alkaline neutralisation capacity. During a work shift involving frequent hand washing the skin pH of nurses was shown to rise significantly. Prolonged water contact (defined as 50% or more of the duration of one wet work shift), facilitates the development of irritant contact dermatitis by a number of known and still unknown mechanisms [25]. Further studies on the effect of pH changes and epidermal barrier function of the hand are required to understand the necessity of acidification of hand care products for wet work professionals.

References

- Schade HMA. Zur physikalischen Chemie der Hautoberfläche. *Archives of Dermatology and Syphilology* 1928; **154**: 690-716.
- Hachem JP, Crumrine D, Fluhr J, Brown BE, Feingold KR, Elias PM. pH directly regulates epidermal permeability barrier homeostasis, and stratum corneum integrity/cohesion. *Journal of Investigative Dermatology* 2003; **121**: 345-53.
- Mauro T, Holleran WM, Grayson S, Gao WN, Man MQ, Kriehuber E. Barrier recovery is impeded at neutral pH, independent of ionic effects: implications for extracellular lipid processing. *Archives of Dermatological Research* 1998; **290**: 215-22.
- Schmid MH, Korting HC. The concept of the acid mantle of the skin: its relevance for the choice of skin cleansers. *Dermatology* 1995; **191**: 276-80.
- Behne MJ, Meyer JW, Hanson KM, Barry NP, Murata S, Crumrine D. NHE1 regulates the stratum corneum permeability barrier homeostasis. Microenvironment acidification assessed with fluorescence lifetime imaging. *Journal of Biological Chemistry* 2002; **277**: 399-406.
- Fluhr JW, Behne MJ, Brown BE, Moskowitz DG, Selden C, Mao-Qiang M. Stratum corneum acidification in neonatal skin: secretory phospholipase A2 and the sodium/hydrogen antiporter-1 acidify neonatal rat stratum corneum. *Journal of Investigative Dermatology* 2004; **122**: 320-9.
- Caubet C, Jonca N, Brattsand M, Guerrin M, Bernard D, Schmidt R. Degradation of corneodesmosome proteins by two serine proteases of the kallikrein family, SCTE/KLK5/hK5 and SCCE/KLK7/hK7. *Journal of Investigative Dermatology* 2004; **122**: 1235-44.
- Eberlein-König B, Schafer T, Huss-Marp J, Darsow U, Mohrenschlager M, Herbert O. Skin surface pH, stratum

- corneum hydration, trans-epidermal water loss and skin roughness related to atopic eczema and skin dryness in a population of primary school children. *Acta Dermato-Venereologica* 2000; **80**: 188-91.
9. Gfatter R, Hackl P, Braun F. Effects of soap and detergents on skin surface pH, stratum corneum hydration and fat content in infants. *Dermatology* 1997; **195**: 258-62.
 10. Visscher MO, Chatterjee R, Munson KA, Pickens WL, Hoath SB. Changes in diapered and nondiapered infant skin over the first month of life. *Pediatric Dermatology* 2000; **17**: 45-51.
 11. Waller JM, Maibach HI. Age and skin structure and function, a quantitative approach (I): blood flow, pH, thickness, and ultrasound echogenicity. *Skin Research and Technology* 2005; **11**: 221-35.
 12. Schmid-Wendtner MH, Korting HC. The pH of the skin surface and its impact on the barrier function. *Skin Pharmacology and Physiology* 2006; **19**: 296-302.
 13. Strube DD, Nicoll G. The irritancy of soaps and syndets. *Cutis* 1987; **39**: 544-5.
 14. Bikowski J. The use of cleansers as therapeutic concomitants in various dermatologic disorders. *Cutis* 2001; **68** (Suppl): 12-19.
 15. Korting HC. Differences in the skin pH and bacterial microflora due to long term application of synthetic detergent preparations of pH 5.5 and pH 7.0. *Acta Dermato-Venereologica* 1990; **70**: 429-57.
 16. Morris RE. The use of nonparametric statistics in quantitative electron microscopy. *Journal of Electron Microscopy* 2000; **49**: 545-9.
 17. Diepgen TL, Coenraads PJ. Sensitivity, specificity and positive predictive value of patch testing: the more you test, the more you get? ESCD Working Party on Epidemiology. *Contact Dermatitis* 2000; **42**: 315-7.
 18. Dickel H, Kuss O, Blesius CR, Schmidt A, Diepgen TL. Occupational skin diseases in Northern Bavaria between 1990 and 1999: a population-based study. *British Journal of Dermatology* 2001; **145**: 453-62.
 19. Meding B, Jarvholm B. Hand eczema in Swedish adults - changes in prevalence between 1983 and 1996. *Journal of Investigative Dermatology* 2002; **118**: 719-23.
 20. Warner RR, Boissy YL, Lilly NA, Spears MJ, McKillop K, Marshall JL. Water disrupts stratum corneum lipid lamellae: damage is similar to surfactants. *Journal of Investigative Dermatology* 1999; **113**: 960-6.
 21. Winnefeld M, Richard MA, Drancourt M, Grob JJ. Skin tolerance and effectiveness of two hand decontamination procedures in everyday hospital use. *British Journal of Dermatology* 2000; **143**: 546-50.
 22. Pinnagoda J, Tupker RA, Agner T, Serup J. Guidelines for transepidermal water loss (TEWL) measurement. A report from the Standardization Group of the European Society of Contact Dermatitis. *Contact Dermatitis* 1990; **22**: 164-78.
 23. Hachem JP, Man MQ, Crumrine D, Uchida Y, Brown BE, Rogiers V. Sustained serine proteases activity by prolonged increase in pH leads to degradation of lipid processing enzymes and profound alterations of barrier function and stratum corneum integrity. *Journal of Investigative Dermatology* 2005; **125**: 510-20.
 24. Fluhr JW, Dickel H, Kuss O, Weyher I, Diepgen TL, Berardesca E. Impact of anatomical location on barrier recovery, surface pH and stratum corneum hydration after acute barrier disruption. *British Journal of Dermatology* 2002; **146**: 770-6.
 25. Meding B. Differences between the sexes with regard to work-related skin disease. *Contact Dermatitis* 2000; **43**: 65-71.