

# Development of a skin cream designed to reduce dry and flaky skin

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**Synopsis**—Dry and flaky SKIN can result from a low extensibility in the STRATUM CORNEUM. Because the EXTENSIBILITY of corneum depends upon its water content, HUMECTANTS are often added to skin products to increase the corneum water content. Measurements of extensibility and water holding capacity in isolated animal corneum showed that conventional humectants such as glycerol, sorbitol or sodium lactate can be effective but that the effect is lost on rinsing the corneum in water. It was found that isolated animal corneum adsorbed LACTIC ACID and that the resulting increase in extensibility was retained after rinsing in water. In consumer tests, hand skin dryness and flaking was assessed by trained observers. Two weeks' use of HAND LOTIONS, containing SODIUM LACTATE or lactic acid adjusted to pH 4, resulted in less hand skin dryness and flaking than the use of control lotions. A lactic acid lotion also resulted in less dryness and flaking than a sodium lactate lotion.

## INTRODUCTION

The function of the surface layer of skin, the stratum corneum, is to provide a protective layer over the surface of the body. This layer prevents excessive evaporative water loss and protects against physical and chemical

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insults in the environment. Because much of the body surface is continuously stretching and flexing the stratum corneum must be flexible and extensible in order to conform without cracking to changes in body posture.

The extensibility of corneum depends upon its water content (1, 2) and upon its temperature (3, 4). When the skin surface is exposed to cold or dry conditions, there must be a gradient of decreasing water content and temperature from the base of the corneum to the surface. This means that the corneum surface tends to be less extensible than the deeper layers so that surface cracks and flaking occur more frequently than deep cracks or chapping.

One objective of skin cream and lotions is, therefore, to maintain a high corneum water content and extensibility so that skin cracking and flaking is less likely to occur.

Several authors (2, 5-7) have shown that the water content of corneum depends upon the presence within the corneum of hygroscopic substances which can hold water in atmospheres of normal humidity. These hygroscopic substances are contained within the corneum cells by the cell walls which are permeable to water but not to electrolytes and they cannot be extracted unless the cell wall is damaged (2). The water held by the hygroscopic materials maintains the extensibility of the corneum (2). The cell wall can be damaged by physical disruption, by extracting its lipids with solvents or by prolonged treatment with detergents which also extract lipids (8). The loss of hygroscopic substances resulting from this damage reduces the water content and extensibility of corneum (2).

The knowledge of the way in which corneum normally holds water and maintains its extensibility enables one to postulate that extensibility of damaged corneum could be increased by adding hygroscopic substances and a number of skin preparations contain humectants such as glycerol and various mixtures simulating the natural hygroscopic substances. However, in intact corneum the natural hygroscopic substances are kept in by the cell walls. When hygroscopic materials are added to solvent- or detergent-damaged corneum they may penetrate into the corneum cells but are unlikely to be retained and will be washed out when the skin is exposed to water. Their effect on extensibility is therefore likely to be only temporary.

The objective of the work reported in this paper was to find a hygroscopic material which could increase the extensibility of solvent-damaged corneum and which would be retained by the corneum so that the increased extensibility would survive immersing the corneum in water. Solvent- rather than detergent-damaged corneum was selected because the damage is

greater and more reproducible. A further objective was to incorporate this material into hand lotion and compare the effect on dry and flaky skin with that of lotions containing no humectant or lotions containing humectants which were not retained by the corneum.

## EXPERIMENTAL

### *Studies on isolated corneum—stratum corneum*

Corneum was obtained from the rear footpads of guinea pigs. It was separated by incubating the whole footpad in 0.1 mol tris buffer, pH 7.2, containing 2 mol urea and 0.5% trypsin (BDH) for 18 h at 37°C (2). After this the soft underlying tissues could be scraped away and the resulting corneum was washed for 2 h in distilled water with only one change of water. It was solvent-damaged by immersion in diethyl ether at ambient temperature for 18 h, followed by immersion in distilled water at ambient temperature for 6 h. This procedure removed lipids and hygroscopic substances and reduced the water content and extensibility in humid atmospheres (2). This corneum was then used in experiments designed to increase water content and extensibility towards the levels for intact corneum.

### *Measurement of water content in humid atmospheres*

The technique for measuring water content or water holding capacity has been described previously (2). Briefly, it consisted of equilibrating pieces of corneum at 81% r.h. and ambient temperature over saturated potassium bromide solution (9) to constant weight. The pieces of corneum were then transferred to a dry atmosphere over molecular sieve (type 4A) and re-equilibrated before weighing. Both equilibria take about 6 days to attain. The water holding capacity was expressed as mg water held 100 mg<sup>-1</sup> dry weight of corneum at 81% r.h.

### *Measurement of extensibility in humid atmospheres*

The technique for measuring extensibility has also been described previously (2). From each piece of footpad corneum a strip measuring 0.6 × 1.5 cm was cut with a stainless steel punch. Extensibility was measured on an *Instron Tensile Tester*. The strip of corneum was clamped between two pairs of jaws and was stretched at a constant rate of extension. The load

required to do this was measured with a tension cell and the load-extension curve was plotted automatically on a recorder. Extensibility was calculated from the initial part of the curve and expressed as percentage extension 100 g<sup>-1</sup> load. Measurements were carried out at ambient temperature and in a controlled atmosphere at 81% r.h. This was achieved by enclosing the jaw assembly of the *Instron* in a polythene cabinet and recirculating air which was pre-equilibrated at 81% r.h. by passing it through columns of saturated potassium bromide solution.

After measuring extensibility, the water holding capacity was measured with the same pieces of corneum. The two pieces of corneum from the same animal were kept together. One was subjected to the treatment under investigation and the other served as a control. For statistical analysis the corneum from a number of animals was used. Each animal was taken as a statistical block and significant differences between treatment and control were assessed by analysis of variance.

#### *Adsorption studies*

The adsorption of materials by corneum was determined by measuring the decrease in concentration of an aqueous solution of the material in contact with corneum.

Weighed pieces of dry corneum were immersed in solutions of the material under investigation using a solid-solution ratio of approximately 10 mg in 1 cm<sup>3</sup> of solution. At the end of the experimental period the mixtures were centrifuged and the supernatants analysed for the material under investigation. Sorbitol and glycerol were analysed by a periodate titration method (10) and aromatic carboxylic acids by measuring their ultra-violet absorption at the wavelength of their absorption maxima using an *Optica CF 4R spectrophotometer*. Lactate was determined by the method of Barker and Summerson (11) or by using sodium DL lactate-2C<sup>14</sup> (Radiochemical Centre, Amersham) and determining the concentration by comparing with standards in a *Packard Liquid Scintillation Spectrophotometer model 3224* with 1 cm<sup>3</sup> of lactate solution added to 10 cm<sup>3</sup> of Bruno-Christain scintillator (12).

Control aliquots which had not been in contact with corneum were analysed using the same solution in each case. The results were expressed as mg of material adsorbed mg<sup>-1</sup> dry weight of corneum under the conditions of the experiment.

*Consumer tests with lotions*

Three consumer tests were carried out, each comparing the effects of three lotions on housewives' hands. In each test, all three had the same oil phase and two of the lotions contained humectant in the aqueous phase and the third did not and served as a control.

At least 100 women took part in each test. Each woman used each of the three lotions for a period of 2 weeks. There were equal numbers of women using the lotions in each of the six possible sequences. The amount of hand dryness and flaking was assessed at the start of the test and after two weeks' use of each lotion and the effects of the lotion were compared.

In order to assess the effect of a lotion on skin dryness and flaking there must be some initial dryness and flaking. The hands of about double the number of women required were examined and those with the most hand skin dryness and flaking were selected. The tests were all carried out in winter to obtain the maximum amount of skin dryness.

The method of assessing hand skin dryness and flaking has been reported previously by Gibson (13). It consists of a trained assessor scoring six areas of each hand according to the following scheme:—0=no relevant visible damage; 1=slight dryness; 2= marked dryness; 3=slight flaking; 4= marked flaking/slight cracking; 6=severe cracking. The areas of the hand assessed are: back of hand, thumb web, other webs, back of fingers, palm, and front of fingers. There is no clear distinction between any of the grades of dryness and flaking, but with practice, assessors can become consistent in their scoring. The 12 areas on each panellist are summed to give total hand score.

To obtain a proper statistical balance for the experiment, the women who were to take part in the test were arranged in decreasing order of hand score. They were then allocated to one of the six possible sequences of hand lotion usage by taking the first six on the list and allocating them at random to one of the six sequences. This process was repeated down the list. In this way the mean and range of hand scores in each sequence was approximately the same.

In each test the same person assessed the hands and did not know which lotion the panellists had been using. Also the panellists themselves received coded products and did not know which lotions contained the humectants.

Using the six possible sequences of hand lotion usage allows the statistical analysis of the results to take account of any variations in the overall mean hand score with time. Such variations may occur as the result of

changes in the weather. In order to ascertain whether there are significant differences between hand lotions, the statistical analysis must take account of differences between subjects in their mean hand scores and also the differences between the two weekly hand scoring sessions. In an analysis of variance, each of the six sequences of hand lotion usage was analysed as a randomized block experiment with some missing observations, subjects corresponding to blocks and scoring sessions to treatments. The treatment means which are given by this analysis are the scoring session means corrected for differences between subjects. They contain information on differences between lotions as well as between sessions. These results were then analysed as a generalized latin square experiment, sequences corresponding to rows, sessions to columns and lotions to treatments. The treatment means which are given by this analysis are the overall mean hand scores for each lotion corrected for differences between subjects and for differences between scoring sessions.

## RESULTS

### *Effect of normal humectants on isolated corneum*

In the first series of experiments, the effect of a number of humectants on the water holding capacity and extensibility of solvent-damaged guinea pig footpad corneum was investigated. *Table I* shows the effect of immersing the corneum for 30 min in 5% aqueous solutions of glycerol, sorbitol, sodium lactate and the sodium salt of 5-pyrrolidone-2-carboxylic acid (NaPCA). Glycerol and sorbitol are commonly used humectants in skin creams. NaPCA (14) and lactate (5) are important constituents of the natural hygroscopic material in intact corneum. In each experiment, the effects of the humectant solution were compared with those of water on a number of replicate pairs of corneum pieces. The table indicates where there were statistically significant differences between the effects of humectant and water, as assessed by analysis of variance. All the humectants increased the extensibility of corneum under these conditions. With the exception of sorbitol, they also significantly increased the water holding capacity.

*Table II* shows the effect, in a different series of experiments, of immersing the treated corneum in water. Solvent-damaged corneum was immersed in 5% solutions of the humectants for 30 min, followed by immersion in water for 30 min. Control pieces of corneum were immersed in water for two successive periods of 30 min.

Table I. Effect of 5% humectant solutions on water holding capacity and extensibility at 81% r.h. of solvent-damaged guinea pig footpad corneum

Humectant	Water held (mg 100 mg <sup>-1</sup> dry corneum)	Extensibility (% per 100 g load)
Glycerol	19.9 (9)	1.24 (10)
Water	17.4* (9)	0.60* (10)
Sorbitol	18.6 (8)	0.82 (8)
Water	17.5 (8)	0.53* (8)
Sodium lactate	21.6 (9)	1.71 (20)
Water	17.8* (9)	0.43* (20)
NaPCA	23.3 (10)	2.07 (10)
Water	17.5* (10)	0.54* (10)

Figures in brackets represent number of replicates.

\* Significant difference ( $P < 0.05$ ) between humectant and water. Treatment times 30 min.

Table II. Effect of rinsing on water holding capacity and extensibility at 81% r.h. of solvent-damaged guinea pig footpad corneum with 5% humectant solutions

Treatment	Water held (mg 100 mg <sup>-1</sup> dry corneum)	Extensibility (% per 100 g load)
Glycerol : Water	Not done	0.76 (20)
Water : Water		0.76 (20)
Sorbitol : Water	16.5 (10)	0.44 (10)
Water : Water	17.1 (10)	0.42 (10)
Sodium lactate : Water	17.2 (18)	0.48 (30)
Water : Water	17.5 (18)	0.41 (30)
NaPCA : Water	15.6 (10)	0.33 (10)
Water : Water	15.5 (10)	0.41 (10)

Figures in brackets are numbers of replicates.

All treatment times were 30 min.

In no case was there a significant difference between the water holding capacity or extensibility of corneum treated with humectant followed by water and corneum treated with water alone. The supposition is that water removes the added humectant and this results in a loss of the increased water holding capacity and extensibility.

*Adsorption studies*

The results given above indicate that any beneficial effect of most humectants will only be temporary and that the effect will be lost when the skin is immersed in water. A more effective humectant would be one which is adsorbed by the corneum so that it is not easily rinsed out.

The adsorption of glycerol, sorbitol and sodium lactate on to solvent-damaged corneum was studied by determining the reduction in concentration of the humectant in an aqueous solution in contact with corneum. No reduction in the concentration of these three humectants could be detected, indicating that there was no adsorption to the corneum. This observation was consistent with the loss of effect on water holding and extensibility after rinsing corneum treated with the three humectants. In the next series of experiments the adsorption of aromatic carboxylic acids was investigated in the same manner. Carboxylic acids have been shown to adsorb to hair keratin (15) and aromatic compounds were selected as examples of carboxylic acids because of the ease of estimating their concentration in aqueous solution by ultra-violet absorption.

Table III shows the adsorption of three aromatic carboxylic acids after immersing the corneum in an aqueous solution of the acid for 4 h at a concentration which gave a convenient reading on the spectrophotometer.

Table III. Adsorption of aromatic carboxylic acids by solvent-damaged corneum

Acid	Concentration (mmol)	Wavelength (nm)	Adsorption (mg acid mg <sup>-1</sup> dry corneum)
Phthalic	0.5	278.5	0.0041
Salicylic	0.2	295	0.0089
Mandelic	3.0	256	0.0021

The results showed that there was some adsorption of carboxylic acids. The acids investigated were not hygroscopic. Further experiments were therefore carried out with a hygroscopic acid, lactic acid.

In preliminary experiments using Barker and Summerson's method (11) for determining lactic acid, an average adsorption of 0.056 mg lactic acid mg<sup>-1</sup> corneum was obtained after immersing corneum in 0.5% lactic acid solution for 2 h. The adsorption was investigated in more detail using C<sup>14</sup> labelled lactate which allowed a simpler and more accurate analytical determination of lactate and lactic acid.

*Table IV* shows a comparison in duplicate experiments of the uptake of lactic acid by solvent-damaged and intact corneum after immersing the corneum in 0.01 mol acid (0.09%) for 2 h and for 24 h.

Table IV. Adsorption of lactic acid by solvent-damaged and intact corneum

Time (h)	Adsorption (mg lactic acid mg <sup>-1</sup> corneum)	
	Solvent-damaged	Intact
2	0.0089, 0.0089	0.0007, 0.0012
24	0.0094, 0.0093	0.0016, 0.0021

The results of the method using C<sup>14</sup> lactic acid agree with those using the Barker and Summerson method in that there is approximately one fifth of the adsorption at one fifth of the concentration of lactic acid. The results show a much greater adsorption of lactic acid by solvent-damaged corneum than by intact corneum. This is consistent with the cell walls preventing the passage of lactic acid in intact corneum. After 2 h there is little further increase in adsorption by damaged corneum, but this is not true for intact corneum.

The effect of pH on adsorption of lactic acid is shown in *Table V*. The pH of lactic acid solutions was adjusted with sodium hydroxide and final concentration of lactic acid plus sodium lactate was 0.01 M. Solvent-damaged corneum was immersed in the solutions for 2h.

Table V. Effect of pH on adsorption of lactic acid by solvent-damaged corneum

pH	Adsorption (mg lactic acid mg <sup>-1</sup> corneum)
2.9	0.009
3.0	0.009
3.4	0.0085
3.8	0.006
3.95	0.0045
4.2	0.0034
4.55	0.0020
4.85	0.0036
5.1	Zero
6.2	Zero

Each figure is the mean of three experiments.  
Corneum immersed in 0.01M lactic acid/lactate solution for 2 h.

The adsorption of lactic acid decreases as the pH increases. Above pH 5 there is no detectable adsorption. These observations are consistent with the adsorption of undissociated lactic acid. The pH of lactic acid is 3.88 and above pH 5 there will be very little undissociated lactic acid in solution.

*Effect of lactic acid solution on water holding capacity and extensibility*

The adsorption studies showed that lactic acid was adsorbed by solvent-damaged corneum. The effect of lactic acid on corneum water holding and extensibility was then determined. Pieces of guinea pig footpad corneum were immersed in a 10% W/V solution of lactic acid for 30 min and water holding and extensibility were measured (*Table VI*). In a separate experiment, the effect of a subsequent 30 min immersion in water was investigated. In both experiments the effect of lactic acid was compared with that of water. The results of separate experiments showing the effect of 10% sodium lactate, which is not adsorbed, are included for comparison. *Table VI* shows the results.

Table VI. Effect of 10% lactic acid and sodium lactate solution on water holding capacity and extensibility of solvent-damaged corneum at 81% r.h.

Treatment	Water held (mg 100 mg <sup>-1</sup> dry corneum)	Extensibility (% per 100 g load)
Lactic acid	34.0 (6)	30.6 (6)
Water	18.9* (6)	0.5* (6)
Lactic acid then water	16.9 (10)	1.1 (10)
Water	15.6 (10)	0.6* (10)
Sodium lactate	47.3 (10)	29.8 (10)
Water	19.1* (10)	0.9* (10)
Sodium lactate then water	18.0 (10)	0.85 (10)
Water	18.0 (10)	0.61 (10)

Figures in parentheses are numbers of replicates.

All treatment times were 30 min.

\* Denotes significant difference ( $P < 0.05$ ).

Both lactic acid and sodium lactate caused large increases in water holding and extensibility, provided that the corneum was not rinsed after treatment. After a 30 min rinse the effect of the sodium lactate had been lost, but the corneum treated with lactic acid still had a significantly greater extensibility than corneum treated with water, although much of the effect

had been lost during the rinsing period. No detectable increase in water holding capacity remained after rinsing corneum treated with lactic acid.

These experiments showed that adsorption of lactic acid resulted in the corneum maintaining an increased extensibility after rinsing in water under conditions where the effect of other humectants was lost.

*Effect of hand lotions containing lactic acid on corneum water holding and extensibility*

The pH of lactic acid itself is too low for incorporation into hand lotions. Hand lotions containing lactic acid were prepared by partially neutralizing lactic acid with sodium hydroxide to give a pH of 4, and incorporating this into the aqueous phase of a lotion to give a product containing 10% by weight of the lactic acid-sodium lactate mixture, calculated as lactic acid. Similar lotions containing 10% sodium lactate, and a control lotion containing water in place of the lactic acid or lactate, were also prepared.

The lotions were rubbed into both sides of pieces of solvent-damaged guinea pig footpad corneum for a total period of 90 s with the fingertips while wearing rubber gloves. Excess lotion was removed by wiping with tissues and the treated corneum was either equilibrated at 81% r.h. or rinsed by immersion in water for 30 min before equilibration. The control pieces of corneum from the same animals were either left untreated or were immersed in water for 30 min as appropriate. *Table VII* shows the effect of the lotions on corneum water holding capacity and extensibility.

Table VII. Effect of hand lotions on water holding and extensibility of solvent-damaged guinea pig footpad corneum at 81% r.h.

Treatment	Water held (mg 100 mg <sup>-1</sup> corneum)		Extensibility (% per 100 g load)	
	Unrinsed	Rinsed	Unrinsed	Rinsed
Control lotion	17.6 (9)	18.6 (12)	0.68 (10)	0.93 (12)
Untreated	17.7 (9)	18.1 (12)	0.59 (10)	0.87 (12)
Lactic acid lotion	17.4 (16)	18.3 (19)	1.19 (10)	0.98 (11)
Untreated	16.4* (16)	18.3 (19)	0.58* (10)	0.59* (11)
Sodium lactate lotion	19.9 (10)	18.1 (11)	0.81 (10)	0.74 (11)
Untreated	17.8* (10)	17.4 (11)	0.59* (10)	0.75 (11)

Figures in parentheses are numbers of replicates.

Treatment time with lotions was 90 s, rinsing time was 30 min.

\* Denotes significant difference ( $P < 0.05$ ).

The results showed that the control lotion had no effect on water holding or extensibility. Both the lactic acid lotion at pH 4 and the sodium lactate lotion increased water holding and extensibility. After rinsing for 30 min, the corneum treated with lactic acid lotion had retained an increased extensibility, and that treated with the sodium lactate lotion had not. As with the lactic acid solution, the increased water holding capacity caused by the lactic acid lotion was lost after rinsing.

These results indicated that a relatively short treatment (90 s) with a lotion at pH 4 containing lactic acid resulted in an increased extensibility and that after a relatively prolonged rinsing in water (30 min) the extensibility was still higher than that of control pieces of corneum.

#### *Effectiveness of lactic acid hand lotions in consumer tests*

In the first consumer test, 143 women used each of three hand lotions for 2 weeks. The lotions were a control, a sodium lactate lotion and a lactic acid lotion. The effect of these lotions on corneum water holding and extensibility was shown in *Table VII*. *Table VIII* shows the mean hand scores after using the three lotions.

Table VIII. Consumer test 1. Mean hand scores after using hand lotions

Hand lotion	Hand score
Control	12.3
Sodium lactate	9.6
Lactic acid	9.0
Difference required for significance ( $P = 0.05$ )	1.2

143 women completed the test.

Lotions contained 10% lactic acid/sodium lactate.

The mean hand score after using the control lotion was significantly higher, i.e. there was more hand skin dryness and flaking than after using the sodium lactate or lactic acid lotion. The lactic acid lotion resulted in a lower mean hand score than the sodium lactate lotion, but the difference between the two was not statistically significant. This test, therefore, showed that the presence in a hand lotion of a humectant, such as sodium lactate, which is not adsorbed by corneum, can result in less skin dryness and flaking. It did not demonstrate that a humectant which is adsorbed results in a better hand condition than one which is not.

Although the first consumer test was carried out in winter, the weather was exceptionally warm and there was relatively little skin dryness and flaking amongst the panellists. It was thought that this may have reduced the sensitivity of the test.

A second test was carried out during the following winter using the same humectants incorporated into a different lotion. *Table IX* shows the mean hand scores after 2 weeks' use of each lotion.

Table IX. Consumer test 2. Mean hand scores after using hand lotions

Hand lotion	Hand score
Control	13.2
Sodium lactate	11.9
Lactic acid	10.7
Difference required for significance ( $P = 0.05$ )	0.9

156 women completed the test.

Lotion contained 10% lactic acid/sodium lactate.

The weather was colder during the second test and the hand scores were slightly higher. The second test confirmed the result of the first test in showing that a hand lotion containing humectant can result in less hand skin dryness and flaking than a control lotion. In the second test, the lactic acid hand lotion resulted in a lower hand score than the sodium lactate lotion. This indicates that a humectant which is adsorbed by the corneum can prevent skin dryness and flaking to a greater extent than one which is not adsorbed.

In a third test, the effect of lowering the lactic acid content from 10% to 5% was investigated. Lotions containing 10% or 5% of the lactic acid-sodium lactate mixture at pH 4 were compared with a control lotion. In the expectation that colder weather would result in higher hand scores, this test was carried out in Scandinavia in winter. *Table X* shows the mean hand scores after using the lotions for 2 weeks.

Despite the cold weather in Scandinavia, the mean hand scores were much lower than in the previous tests carried out in the U.K. The probable explanation for this is that in Scandinavia, women protect their hands by wearing gloves much more than they do in the U.K. Although there was relatively little skin dryness and flaking, the effectiveness of the lactic acid lotions could still be demonstrated. This indicates that lactic acid lotions are

Table X. Consumer test 3. Mean hand scores after using hand lotions

Hand lotion	Hand score
Control	6.42
5% lactic acid	5.36
10% lactic acid	5.32
Difference required for significance ( $P = 0.05$ )	0.90

107 women completed the test.

not only effective for women with severe skin dryness, but can also be expected to be of benefit in cases where there is relatively little dryness.

#### DISCUSSION

The results of the experiments on isolated animal corneum showed that increasing the water holding capacity by the addition of humectants resulted in an increased corneum extensibility. The experiments also indicated that the use of a humectant, lactic acid, which was adsorbed by the corneum allowed the treated corneum to be subjected to a prolonged washing without all the effect being lost. The results of the animal experiments predicted that lotions containing humectants, such as sodium lactate, which are not adsorbed might be less effective than lotions containing humectants such as lactic acid which are adsorbed. The results of the consumer tests showed that these predictions were valid and that animal corneum is a useful model system for studying effects in the human.

The precise mechanism of action of lactic acid in reducing hand skin dryness and flaking is not clear. The results on animal corneum (*Tables VI and VII*) showed that corneum treated with lactic acid and then rinsed still retained an increased extensibility but there was no residual increase in water holding capacity. The explanation may be that the quantity of lactic acid adsorbed to the corneum after rinsing is too small to hold sufficient water for the gravimetric method to detect. Alternatively, the adsorbed lactic acid may itself have a direct effect on extensibility. Some separate, unpublished experiments on non-hygroscopic carboxylic acids, such as mandelic acid, indicated that these acids can increase extensibility of animal corneum without increasing water holding capacity, and that the increased extensibility survives rinsing the corneum. This suggests that lactic acid may have a direct effect on a corneum extensibility without influencing the water content.

It is extensibility and not water content which is important for the corneum in its resistance to flaking and cracking. The water content is only important in so far as it affects extensibility. Lactic acid, therefore, appears to have a dual action on the corneum. It increases extensibility by increasing the water holding capacity in the same way as conventional humectants. This effect is lost on rinsing the corneum in water, but is sufficient to result in some effect on skin dryness and flaking as shown in the consumer tests with sodium lactate lotions. The second effect, which is not shown by conventional humectants, is that the adsorbed lactic acid increases extensibility. In treated and unrinsed corneum, there is no evidence of an additive effect between the extra water and the adsorbed lactic acid, and the effect of the adsorbed lactic acid only becomes apparent on rinsing. This means that the effect of lactic acid is likely to be more persistent than that of sodium lactate, and should therefore result in less skin dryness and flaking. This was confirmed in the results of the second consumer test where the comparison of the sodium lactate and lactic acid lotions showed that the lactic acid lotion results in a significantly better hand skin condition.

(Received: 8th March 1974)

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