朴 京 淑 敎授指導
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Comparative Measurement of Irritation of Several Surfactants in Korean Women of Various Ages

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誠信女子大學校 大學院

生物學科

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論 文 槪 要

화장품에서 다양하게 사용되는 계면활성제는 irritant contact dermatitis(ICD)를 일으키는 원인물질 중 하나이며 피부 자극 반응은 Exogenous factors(자극제의 물리화학적 성질, 제형, 농도, 노출시간) 와 Endogenous factors(성별, 연령, 민족)에 따라서 다양하게 나타난다. 계면활성제는 수용액 상태에서 극성 부분에 따라 음이온계, 양이온계, 양쪽성이온계, 비이온계로 구분 되며 피부에 접촉 시 피부 각질층의 손상과 barrier lipids를 붕괴시켜 피부 자극을 일으키게 된다. 최근 화장품산업에서 피부 자극을 최소화 하기 위해 천연 계면활성제의 사용이 증가되고 있으며 각 성분 별 자극성에 관한 비교 연구는 많이 실행되었으나 본 연구에서는 2종의 semi-natural 계면활성제(hydro-lecithin, decyl-glucoside)와 2종의 합성 계면활성제(sodium lauryl sulfate, Tween-80)를 육안측정과 기기측정을 통해 유형별, 농도별 (0.5%, 1%, 2%) 제형별 (toner type, cream type)로 육안측정과 기기측정을 통해 연령에 따라 비교 분석하고 육안측정과 기기측정간의 상관성을 비교하였다.

유형별 결과에는 음이온계인 sodium laury sulfate (SLS)가 대조군과 비교 시 모든 연령대에서 피부 홍반 반응이 유의하게 높았고, 계면활성제간의 비교에서도 모든 연령대에서 유의하게 높은 반응을 나타냈다(p<0.05). 비이온계인 decyl-glucoside는 semi-natural 계면활성제임에도 불구하고 50대 연령에서 SLS 다음으로 높은 홍반 반응을 나타냈다. 연령에 따른 자극 반응 양상은 50대 > 20~40대 > 10대 연령 순으로 나타났으며 10대와 20~40대 연령에서 첩포 제거 30분에 가장 높은 홍반 반응을 보인 반면 50대 연령에서는 첩포 제거 24시간에 가장 높은 홍반 반응을 보였다. 농도에 따른 결과에

서 SLS의 모든 시험농도는 연령대 모두에서 대조군에 비해 유의하게 높았으며 농도간 비교에서 1%와 2%에서 0.5%와 비교 시 유의하게 높은 홍반 반응을 나타냈다(p<0.05). Decyl-glucoside는 20대와 50대 연령에서 1%와 2%가 대조군과 비교 시 유의하게 높은 결과를 보였으나 농도간 비교에서는 유의하지 않았다. 제형 간 비교시험에서는 10대 연령에서 SLS를 제외한 모든 연령대에서 시험물질 SLS, Tween-80, hydro-lecithin, decyl-glucoside 모두에서 toner type이 cream type 보다 유의하게 높은 홍반 반응을 보였다(p<0.05). 육안측정과 기기측정간의 상관성은 육안측정 자극지수와 Laser Doppler perfusion imager (LDPI)의 측정결과와의 상관계수보다 mexameter와 spectrophotometer의 측정 결과 사이의 높은 상관계수 갖는 결과를 나타냈다.

결론적으로 자극이 가장 낮으리라 생각했던 semi-natural surfactant인 decyl-gulcoside는 1%의 농도부터 50대 이상 연령대에서 자극 감수성이 높은 것으로 생각되며, SLS에 의한 피부 자극도는 50대 이상 연령에서 10대와 20~40대 연령에 비해 skin barrier의 기능 저하로 인해 홍반 반응이 증가되며 회복 또한 늦은 것으로 생각된다. 특히 본 시험의 toner type 제형이 cream type 제형 보다 skin barrier 기능을 더 악화시켜 홍반 반응을 증가시키는 것으로 생각되며 기기 측정방법은 mexameter와 spectrophotometer가 LDPI보다 육안측정과 비교적 상관도가 높은 유용한 측정 방법이라 생각된다. 따라서 계면활성제에 대한 피부 안전성 검사는 연령별로 평가하는 것이 의미 있을 것으로 생각되고, 천연계면활성제의 피부 안전성에 관한 지속적인 연구가 필요하리라 생각된다.

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Introduction

Irritant contact dermatitis (ICD) is a very common disease and is well-known as occurring more frequently than allergic contact dermatitis (Gebhard et al., 2004; Meding et al., 1989). Also, ICD is frequently shown in low concentrations of frequent exposure to irritants more than high concentrations of exposure to irritants that occurred over a short period of time (Lee et al., 1999). Surfactants which once were widely used in the cosmetic industry are one of the causes of ICD and are also used for experimentation of skin irritant. Application of surfactant under occlusion can increase penetration of chemicals and antigen into the skin and therefore can disrupt barrier lipids and damage the stratum corneum (Hongbo et al., 2002). Using surfactants for experimentation of skin irritation was supposed to show the low irritant potential of new chemicals and new products in the industry when the experimentation of skin irritant has had to increasingly rely on human skin models. Traditionally, testing for skin irritation (so-called hazard identification testing) has been conducted in animals (Robinson et al., 2002), but pressure has come from animal welfare organizations to eliminate its use altogether, and the realization that animal tests for skin irritation are rather poorly predictive for humans (Robinson, 2001). For these reasons, in recent years, this method has been superceded by various in-vitro and human clinical test methods (Robinson et al., 2005).

Human clinical test methods are performed on human skin patch tests

which are still commonly assessed visually, just as they had been when first introduced more than a century ago (Goon et al., 2004). Furthermore, that test method is mostly used with non-invasive bioengineering method and used for objectification of data and quantification of skin response (Lee et al., 1999). Also, human patch test is referred to as exogenous factors and endogenous factors. Exogenous factors include the irritant's chemical and physical properties, and the vehicle, concentration and frequency of application. Endogenous factors have been determined to be age, sex, pre-existing skin diseases, skin sensitivity, genetic background, and ethnicity (Modjtahedi et al., 2002).

When previous studies dealt with exogenous factors in surfactants, they showed results of high degrees of skin irritant according to the surfactant properties; anionic> cationic> amphoteric> nonionic (Park et al., 1999) and according to formulation type; liquid type> emulsion type (Park et al., 2001). In addition, different chemical classes of surfactants have mainly been performed in comparative studies (Lee et al., 1999; Wilhelm et al., 2001; Tornier et al., 2006). Recently, however, the comparison data with natural surfactants lacked study allowing the use of natural surfactants in the cosmetics industry. In studies dealing with endogenous factors, there were reported tendencies of increasing skin irritation induced by surfactants in Asian populations (combined Chinese and Japanese) than in Caucasian populations (Robinson., 2002; 2000). About sex variations, thought there is often a perception that women are

more reactive to skin irritants than men, there are reports of men who are more reactive to skin irritants than women (Robinson., 2002). According to age variation, there have been reports of a reduced irritation response in older versus younger test subjects (Robinson., 2002). Age variations of endogenous factors are important to investigate as the skin irritation induced by surfactants has become more widespread because people use cosmetics more frequently, extending the time of cosmetic use. In Korea, epidemiologic studies have been conducted for contact dermatitis induced from cosmetics, and there have been many published reports which dealt with contact dermatitis induced by cosmetics (Eun et al., 1999). However, there is a lack of data in Korean women concerning endogenous factors and a lack of data in comparison between natural surfactants and synthetic surfactants.

Therefore, this study has evaluated skin erythema induced irritant reaction according to age in Korean women using toner type and cream type formulas and concentrations of 0.5%, 1% and 2% with two semi-natural surfactants (amphoteric; hydro lecithin and nonionic; decyl glucoside) and two synthetic surfactants (anionic; sodium lauryl sulfate, nonionic; Tween80) that are mainly used in skin care and toiletry products. The degree of correlation between visual scores and instrumental measurement has also been studied.

Materials and Methods

Subjects

In this study, 55 Korean women participated: 18 teenagers (mean age 18.2±1.15 years), 18 adults (ages 20's~40's, mean age 29.7±6.49 years) and 19 seniors (aged over 50', mean age 55.9±2.64 years). Exclusion criteria were: skin diseases, pregnancy, breast feeding and oral contraceptives, such as antihistamine and anti-inflammatory medication. For the over 50 years of age group were selected postmenopausal women. All procedures were explained in detail to all study subjects, who individually read and signed informed consent.

Materials

Four surfactants, anionic surfactant; sodium lauryl sulfate (SLS)(Miwon, Korea), nonionic surfactant; polysorbate 80 (Tween-80) (Uniqema Americas, USA), amphoteric semi-natural surfactant (soybean extracted); hydrogenated lecithin (Nikko, Japan) and nonionic semi-natural surfactant using fatty alcohols and glucose extracted from plant origin; decyl-glucoside (Seppic, France) were used in this study. These included in two formula type base (toner type base and cream type base) that each have different concentration (0.5%, 1% and 2%) (Table 1). Patch test was performed using Finn Chambers® (Epitest, Helsinki, Finland) on Scanpor® tape.

Procedure of patch test

The individual application site was selected on the inner forearm avoiding the areas 3−4 cm from the elbow. Before the patch test, all test areas were marked using a green ink pen for baseline measurement. After the test site was evaluated using various instruments, the patches of surfactants were applied over 24 hrs. Test materials included bases (controls) were applied with 20 ㎕ at 0.5%, 1% and 2% in toner and cream base. Patches were removed after 24 h and then test skin site was gently wiped with a soft paper towel (to remove excess residual test material). Visual assessment and measurement of instruments were initiated on 30 min after removal of the chamber and again after 24 h (Figure 1). The washing of test sites was not allowed during the study period.

Method of Evaluations

Visual assessment

The visual scorings of the patch test readings were performed according to the International Contact Dermatitis Research Group (ICDRG) criteria (Koh et al.,1995) by a researcher under the expert researcher control.

The scoring system is as follows:

−: No visible reaction.

±: Doubtful reaction: mild redness only.

+: Weak, positive reaction: red and slightly thickened skin.

++: Strong positive reaction: red, swollen skin with individual small water blisters.

+++: Extreme positive reaction: intense redness and swelling with coalesced large blisters or spreading reaction.

The results were additionally scored (0, 0.5, 1, 2, 3) corresponding to the degree (−, ±, +, ++, +++) of the readings.

Instrumental assessment

Measurements were performed prior to application of test material (basal values) and 30 min and 24 h after removal of patch under standardized ambient conditions (air conditioning, room temperature between 20 ℃ and 22 ℃, and relative humidity between 45% and 50%). Prior to measurement the volunteers rested for at least 20 min. The measurement included three kinds of instruments with different measuring principles; Laser Doppler perfusion imager (LDPI, Perimed AB company, Sweden), spectrophotometer CM−2500d (Minolta, Osaka, Japan) and mexameter MX18 (Courage and Khazaka Electronic GmbH, Cologne, Germany). Before measurement, LDPI was set up with the distance between the scanner head and the skin fixed at 20−25 cm. The parameter settings during measurement were image format: 64 x 27 mm and resolution: medium. The results of measurement appeared perfusion images (Figure 2). The values were given in arbitrary units− i.e., volts (V). Spectrophotometer measures the a* value (as a measurement of erythema) of values (L* a* b*). The a* value

represents the color range from red (positive values) to green (negative values). Mexameter measures the erythema index (EI) that was calculated by the instrument according to the formula: EI = 1000 log (red−remittance/green−remittance). All instrumental test values were the average of three individual measurements.

Statistical analysis

Statistics were carried out using SPSS version 12.0 for windows. Analysis of the data was performed as the different value calculated from baseline - the arithmetical mean value (after 30 min patch removal and 24 h). Comparison of the skin erythema between four surfactants and between concentrations used one-way ANOVA model, the significant differentiation was obtained by F test and the multiple comparisons were obtained by multiple range test of Duncan. Comparison of skin erythema between toner type and cream type formula, comparison of skin erythema between control and surfactants and between control and concentrations used Student's T-test. Correlation between visual assessment and instrumental assessment was calculated by the Pearson correlation coefficient. A p value <0.05 was considered statistically significant.

Results

Comparison of the skin erythema between four surfactants

In comparison with the control and the four surfactants, sodium lauryl sulfate (SLS) showed significantly higher skin erythema in all age groups. Tween-80 showed significantly higher skin erythema in the age group 20's~40's at all evaluations except the visual evaluation. Hydro-l showed significantly higher skin erythema in the age groups, teens: visual, and ages 20's~40's: spec, and aged over 50': visual evaluation. Decyl-g appeared significantly higher skin erythema in ages 20's~40's and aged over 50' at all evaluations except the visual evaluation (Table 2). In comparison to the skin erythema between surfactants, a significant difference was detected between SLS and Tween-80, hydro-l and decyl-g in all age groups, respectively (Figure 3). All tested surfactants showed the highest skin erythema at 30 min after removal of patch in the age group teens (Figure 4) and in the age group 20's~40's (Figure 5). However, the age group over 50' showed the highest skin erythema of SLS at 24 h after removal of patch in evaluation of visual and LDPI (Figure 6). Also, skin erythema according to age showed as follows; in age teens: SLS > decyl-g > Tween-80 = hydro-l, in ages 20's~40's: SLS > Tween-80 > hydro-l > decyl-g and in aged over 50': SLS > decyl-g > hydro-l > Tween-80 (Figure 3).

Comparison of the skin erythema between concentrations

In the comparison between surfactants and control, SLS was shown to have significantly higher skin erythema in all tested concentrations in all

age groups. Tween-80 showed a significant difference in value in all tested concentrations in the age group 20's~40's and in the age group over 50' (2%: mexa), compared with the control. Hydro-l showed high difference value in age groups: teens (1%: spec), ages 20's~40's (2%: mexa, 0.5%, 1% and 2%: spec) and aged over 50' (1%, 2%: visual, 2%: mexa, 0.5%, 1% and 2%: spec, 2%: LDPI), compared with the control. Decyl-g did not show a significant difference at 0.5% in all ages but 1% and 2% which showed a significant difference in age groups: teens (2%: visual), ages 20's~40's (1% and 2%: mexa, 2%: spec and LDPI) and aged over 50' (2%: visual, 1% and 2%: mexa, and 1%: LDPI) (Table 3). In the comparison between concentrations, SLS showed significant differences between 0.5% and 1%, and between 0.5% and 2% in the age group 20's~40's (Figure 8) and the age group over 50' (Figure 9). However, Tween-80, hydro-l and decyl-g did not show any statistical significant difference.

Comparison of the skin erythema between toner type formula and cream type formula

All of the tested surfactants showed higher mean value of toner type than cream type in all age groups (Figure 10). In the age group teens, there were significantly higher mean values in toner type of Tween-80 (p=spec: 0.001), hydro-l (p=mexa: 0.003) and decyl-g (p=visual: 0.042 and LDPI: 0.032) when compared with the cram type formula. In the age group 20's~40's, there were significantly higher differences in

toner type of SLS (p=mexa: 0.016), Tween-80 (p=mexa: 0.031, Spec: 0.010 and LDPI: 0.004), hydro-l (p=mexa: 0.031) and decyl-g (p=mexa: 0.025) when compared with the cram type formula. In the age group over 50', there were also significantly higher differences in toner type of SLS (p=mexa: 0.000, spec: 0.002 and LDPI: 0.014), Tween-80 (p=spec: 0.004), hydro-l (p=visual: 0.010, spec: 0.005) and decyl-g (p=visual: 0.026, mexa: 0.009, LDPI: 0.046) when compared with the cram type formula.

Correlation between visual assessment and instrumental measurements

Overall, there was a positive correlation between visual scores and instrumental measurements. Particularly, the correlation coefficient of visual and mexa (r=0.80, p=0.0001) and visual and spec (r=0.80, p=0.0001) were higher than those of visual and LDPI (r=0.63, p=0.0001) (Figure 11). Therefore, spectrophotometer and mexameter presented a higher correlation with visual assessment than LDPI.

Discussion

Irritation contact dermatitis (ICD) occurs when epidermal cells are

damaged and inflammated by some physical or chemical irritant. It does not need to have a sensitized pathway of Langerhans cell (Lee, 2002). However, inflammation is caused by cytokines which is formed when stimulating keratinocyte. This is especially true in the case of a surfactant which is popularly used in cosmetic and toiletry products. The surfactants can cause various irritant reactions depending on each physical and chemical property when it comes into contact with the skin (Park, 1999).

This study evaluated the skin erythema induced by two semi-natural surfactants (hydro-lecithin, decyl-glucoside) and two synthetic surfactants (sodium lauryl sulfate, Tween-80). In the comparison between surfactants, the skin erythema according to age appeared as follows: in the teens; SLS> decyl-g> Teween-80 = hydro-l, in the ages 20's~40's; SLS> Teween-80> hydro-l> decyl-g, in the group aged over 50'; SLS> decyl-g> hydro-l> Teween-80. In this result, the teens group and aged over 50' group showed higher skin erythema after SLS, contrary to expectations that semi-surfactants (hydro-lecithin, decyl-glucoside) have the lowest skin erythema. Particularly, although non-ionic decyl-glucoside is a semi-natural surfactant, it was the second highest, after SLS in the group aged over 50'. Also, it showed a significant difference when compared with the control. Recently, Blondeel (2004) noted that there is an increase of decyl-g in the rinse-off cosmetics; shampoo, moose and soap and in the rinse-on cosmetics; sunscreen, from the year 1990. Therefore, there is an increased risk of

contact allergy and there has been a published case about contact allergy of decyl glucoside (Horn et al., 2005; Andersen et al., 2006). As a result, it may seem to lead to irritant reaction by cumulative contact of low concentrations of decyl-g in the age group over 50'.

Skin irritant reactivity is defined by the difference of reaction by age because of the aging process with physical and structural changes.
Won (1991) found that the skin barrier function of the elderly were less effective of than in youths. As seen in this study, skin erythema was seen in decreasing order of age group, aged over 50', 20's~40's and teens in SLS. Also, SLS showed the highest skin erythema at 30 min after removal of patch in the age group teens and in ages 20's~40's. However, in the age group over 50' showed the highest skin erythema at 24 h after removal of patch in the visual and LDPI evaluation. This result is similar to the results of Robinson (2002) who showed that acute skin reactivity with sodium dodecyl sulphate (SDS) resulted in the decreasing order of age 26~55, 18~25 and 56~74 years. Therefore, the higher skin erythema and the delayed response in the age group 50' may be associated with a weakened skin barrier function in the elderly.

As the result from each concentration of substance, this study has evaluated the skin erythema by selecting the range; 0.5%, 1%, and 2%. All the testing concentrations of SLS showed a significantly higher difference when compared with the control in all age groups. Particularly, there was a significant difference of skin erythema in 1% and 2% comparing 0.5% in the age group 20's~40's and aged over 50'

when compared between concentrations. In the Lee et al. (1999), the study about comparing concentrations of SLS resulted in higher irritant reaction in 1% rather than in 0.01%, 0.05%, 0.1% and it corresponds with this study. Therefore, SLS is considered to significantly affect the increasing irritant reaction at 1%. Decyl-g has high skin erythema when compared to the control of 1% and 2% in the age group 20's~40's and aged over 50', but it was not significant in comparing between the concentrations.

The comparison of formulations of this study showed significantly higher skin erythema in the toner type than the cream type in all of the surfactants; SLS, Tween-80, hydro-lecithin, and decyl-glucoside in all age groups, except in the substance of SLS in the age of teens. Previous studies, Kirk (1966) who noted that surfactant caused damage to the skin barrier function and increased the absorbedness of hydrophilic penetrant. Warner (1999) who noted that water under occlusion may disrupt barrier lipids and damage the stratum corneum. Also, a study by Park et al. (2001) showed that the irritation potential of different formulation was (by decreasing irritancy): form type, gel type, lotion and cram type and it corresponds with this study. Therefore, the toner type formula is thought to cause higher damage to the skin barrier and stratum corneum than a cram type formula.

For the evaluation of skin irritant reaction, beside the measurement of visual scoring, there is a need to use the non-invasive bioengineering methods for the objective results. This study is objectively evaluated

by using a colorimeter for measuring skin erythema, spectrophotometer CM-2500d and mexameter MX18 as reflectance spectrophotometer, and by using Laser Doppler perfusion imager for the assessment of tissue blood perfusion. A previous study indicated that the spectrophotometer and mexameter have good correlativity with visual scores of the skin erythema which is one of the skin irritant reactions (Park et al., 1999). Also, Fullerton et al. (2002) demonstrated that the Laser Doppler perfusion imager correlates with visual scoring in contact allergic reaction, but not in irritant reactions. In this study, the measurement value of the mexameter and spectrophotometer showed higher correlation coefficients with the visual scores than those of the Laser Doppler perfusion imager. Therefore, mexameter and spectrophoto-meter seem to be more sensitive for measuring skin erythema evaluation. In conclusion, this study indicated that decyl-glucoside, one of two semi-surfactants, was thought to have high irritant sensitization in the age group over 50' of over 1% concentration. The skin irritant response of SLS seem to show the increasing skin erythema and the delayed skin healing in the age group over 50' than those in the age group teens and in the age group 20's~40's by the weakened skin barrier function in elderly. Moreover, the toner type formula was associated with an increase in damage to the skin barrier than the cram type formula and caused an increase in skin erythema. Also, the mexameter and spectrophotometer seem to be more sensitive for measuring skin erythema evaluation than the LDPI. Therefore, it is suggested that human skin patch tests by

surfactants are needed to evaluate the various age ranges. This needs constant study for skin safety concerning natural surfactants.

Table 1. Information of test materials

Ages	Test materials	SLS	Group Tween-80	Base Hydro-1	Concentration Decyl glu	Control
Teens (n=18)	Visual	0.08±0.02*	0.02±0.01	Toner 0.02±0.01*	0.5%, 1%, 2% 0.02±0.01	0.01±0.01
	Mexa	13.17±2.40*	3.48±1.51	2.76±1.77*	6.20±1.49	5.83±1.82
	Spec	0.83±0.12*	0.31±0.08	Cream 0.45±0.11	0.5%, 1%, 2% 0.46±0.09	0.39±0.11
	LDPI	0.05±0.01	0.05±0.02	Toner 0.04±0.02	0.5%, 1%, 2% 0.03±0.02	0.05±0.03
20's ~40's (n=18)	Visual	0.29±0.06*	0.07±0.03	Cream 0.04±0.03	0.5%, 1%, 2% 0.04±0.02	0.02±0.02
	Mexa	27.95±3.31*	13.31±1.96*	9.80±1.99	10.38±1.83*	5.29±1.62
	Spec	1.57±0.25*	0.65±0.12*	Toner 0.56±0.11*	0.5%, 1%, 2% 0.46±0.07*	0.30±0.06
	LDPI	0.12±0.02*	0.05±0.01*	Cream 0.05±0.02	0.5%, 1%, 2% 0.03±0.01*	0.01±0.01
Over 50's (n=19)	Visual	0.34±0.05*	0.02±0.01	0.04±0.01*	0.05±0.02	0.01±0.01
	Mexa	10.25±5.94*	6.47±1.76	Toner 7.04±1.77	0.5%, 1%, 2% 10.02±2.74*	3.26±1.57
	Spec	2.14±0.26*	0.39±0.08	Cream 0.55±0.12	0.5%, 1%, 2% 0.44±0.13*	0.24±0.09
Control	LDPI	0.23±0.04*	0.07±0.02	0.09±0.03	0.10±0.03*	0.07±0.03

Sodium lauryl sulfate (SLS) — Anionic surfactant

Polysorbate80 (Tween80) — Nonionic surfactant

Hydrogenated lecithin (extracted from soybean) — Amphoteric semi-natural surfactant

Decyl glucoside (glucose extracted from plant) — Nonionic semi-natural surfactant

Toner type base: 94.5% D.I water, 5% ethanol, 0.5% mineral oil

Cream type base: 91% D.I water, 5% mineral oil, 1% cetearyl alcohol, 3% sodium magnesium silicate

Table 2. Comparison of the skin erythema between four surfactants and control (mean±SE)

* Statistically significant compared with four surfactants and control ($p < 0.05$)

SLS: Sodium lauryl sulfate, Hydro-l: Hydro lecithin, Decyl-g: Decyl glucoside, Visual: Visual score, Mexa: Mexameter, Spec: Spectrophotometer, LDPI: Laser Doppler perfusion image

Table 3. Comparison of the skin erythema between concentrations of four surfactants and control (mean±SE)

Ages		SLS 0.5%	SLS 1%	SLS 2%	Tween-80 0.5%	Tween-80 1%	Tween-80 2%	Control
Teens n=18	Visual	0.05±0.02	0.08±0.03*	0.12±0.04*	0.03±0.02	0.02±0.01	0.01±0.01	0.01±0.01
	Mexa	11.62±2.13*	11.49±2.33	16.40±4.03*	5.93±2.03	2.32±1.57	2.19±1.70	5.83±1.82
	Spec	0.77±0.16*	0.78±0.14*	0.94±0.15*	0.38±0.10	0.35±0.11	0.21±0.10	0.39±0.11
	LDPI	0.05±0.01	0.05±0.01	0.06±0.01	0.04±0.02	0.04±0.02	0.05±0.03	0.05±0.03
20's ~40's n=18	Visual	0.12±0.03*	0.31±0.06*	0.43±0.10*	0.08±0.03	0.06±0.03	0.07±0.03	0.02±0.02
	Mexa	18.88±2.29*	29.34±3.69*	35.63±5.46*	12.61±2.58*	11.15±2.25*	16.18±2.05*	5.29±1.62
	Spec	0.89±0.15*	1.64±0.27*	2.16±0.39*	0.60±0.12*	0.59±0.12*	0.77±0.14*	0.30±0.06
	LDPI	0.07±0.01*	0.12±0.02*	0.17±0.03*	0.05±0.02	0.04±0.10*	0.05±0.01*	0.01±0.01
Over 50's n=19	Visual	0.17±0.05*	0.36±0.06*	0.50±0.07*	0.01±0.01	0.01±0.01	0.03±0.02	0.01±0.01
	Mexa	24.80±4.72*	41.08±6.26*	54.86±7.62*	4.01±1.79	5.65±1.82	9.75±2.62*	3.26±1.57
	Spec	1.52±0.25*	2.19±0.29*	2.71±0.32*	0.41±0.10	0.33±0.08	0.41±0.10	0.24±0.09
	LDPI	0.15±0.04*	0.23±0.04*	0.31±0.05*	0.06±0.02	0.06±0.02	0.09±0.03	0.07±0.03

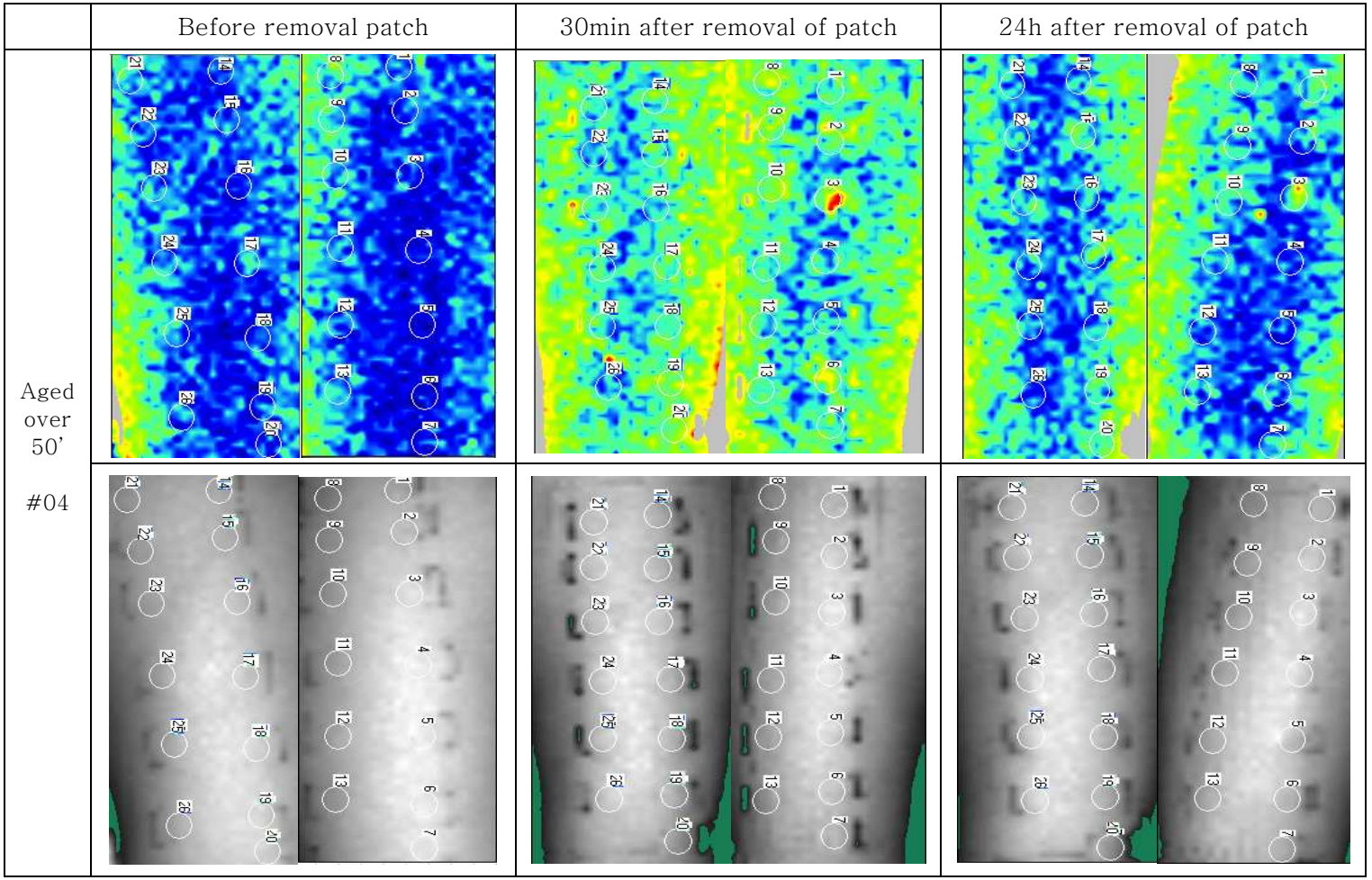
* Statistically significant compared with concentrations and control (p<0.05)

Ages		Hydro- lecithin 0.5%	Hydro- lecithin 1%	Hydro- lecithin 2%	Decyl-glucoside 0.5%	Decyl-glucoside 1%	Decyl-glucoside 2%	Control
Teens n=18	Visual	0.02±0.02	0.04±0.02	0.01±0.01	0.01±0.01	0.03±0.01	0.03±0.01*	0.01±0.01
	Mexa	1.63±2.40*	4.86±2.13	1.79±1.50*	5.13±1.60	6.66±1.96	6.81±1.83	5.83±1.82
	Spec	0.27±0.14	0.63±0.14*	0.44±0.11	0.35±0.10	0.43±0.13	0.60±0.14	0.39±0.11
	LDPI	0.04±0.02	0.05±0.03	0.04±0.02	0.03±0.01	0.05±0.02	0.07±0.03	0.05±0.03
20's ~40's n=18	Visual	0.04±0.02	0.04±0.03	0.06±0.04	0.04±0.03	0.03±0.02	0.04±0.02	0.02±0.02
	Mexa	8.88±1.51	8.70±2.23	11.82±2.76*	9.43±1.88	9.57±1.79*	12.13±2.33*	5.29±1.62
	Spec	0.48±0.09*	0.58±0.13*	0.63±0.14*	0.42±0.09	0.40±0.08	0.57±0.08*	0.30±0.06
	LDPI	0.04±0.01	0.04±0.02	0.06±0.03	0.03±0.01	0.03±0.01	0.04±0.01*	0.01±0.01
Over 50's n=19	Visual	0.02±0.01	0.05±0.01*	0.04±0.01*	0.03±0.02	0.04±0.02	0.07±0.03*	0.01±0.01
	Mexa	3.84±1.73	7.60±1.68	9.68±2.61*	7.51±2.06	9.22±2.95*	13.32±3.97*	3.26±1.57
	Spec	0.48±0.08*	0.56±0.15*	0.60±0.17*	0.38±0.16	0.45±0.15	0.49±0.15	0.24±0.09
	LDPI	0.08±0.03	0.08±0.03	0.10±0.04*	0.10±0.03	0.10±0.03*	0.11±0.04	0.07±0.03

* Statistically significant compared with concentrations and control (p<0.05)

	Before removal patch	30min after removal of patch	24h after removal of patch
Aged over 50' #05			

Figue1. Photograph of patch testing



Figue2. Image of perfusion by Laser Doppler Perfusion Image

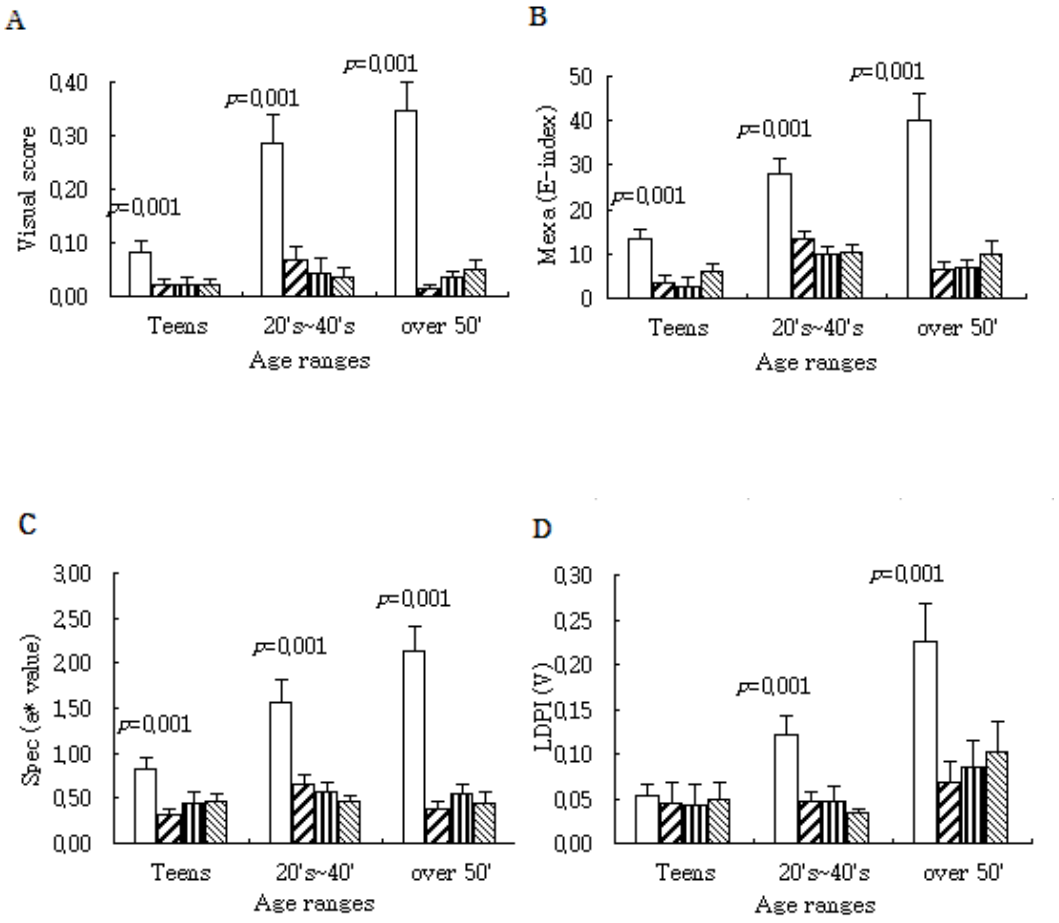


Figure 3. Comparison of the skin erythema between four surfactants

(ANOVA model; Mean±SE)

A: Visual score, B: Mexameter, C: Spectrophotometer, D: LDPI

SLS ween-80 hyd decyl-g

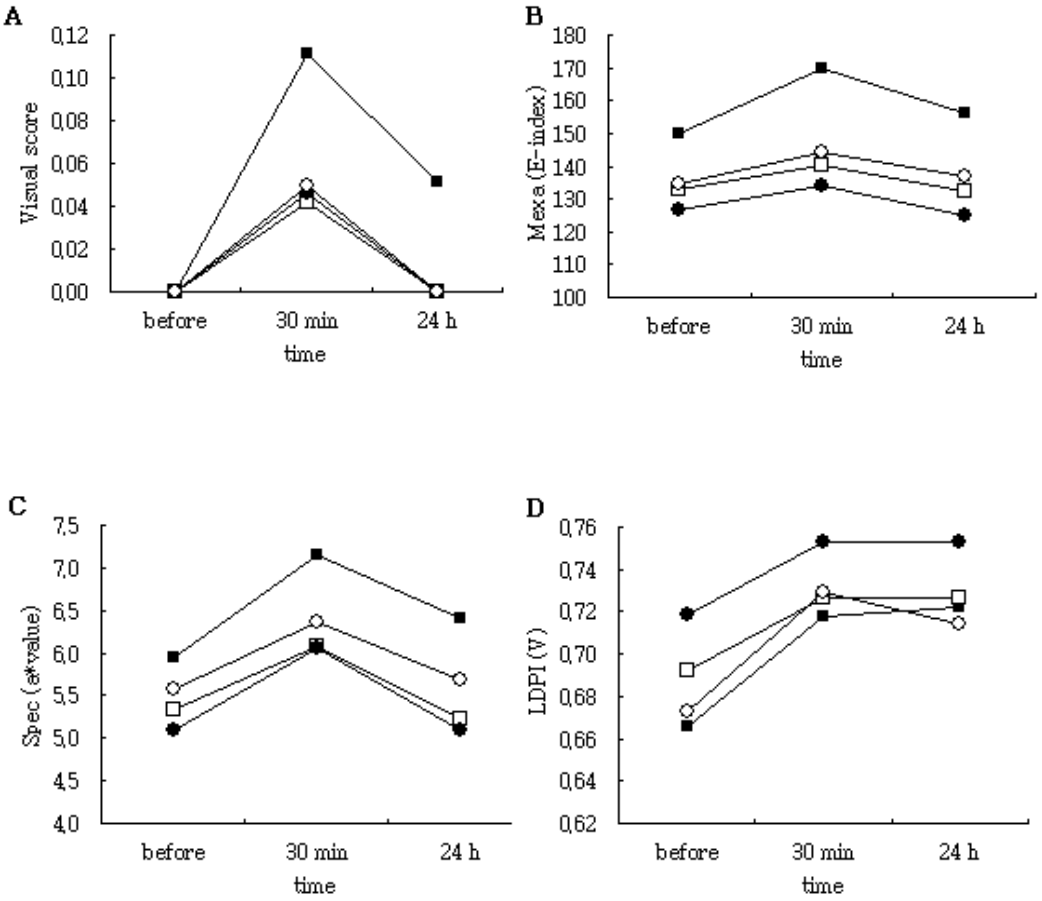


Figure 4. The skin erythema according to the at time course of four surfactants in the age group teens (mean value)

A: Visual score, B: Mexameter, C: Spectrophotometer, D: LDPI

SLS Tween-80 hydro-l decyl-g

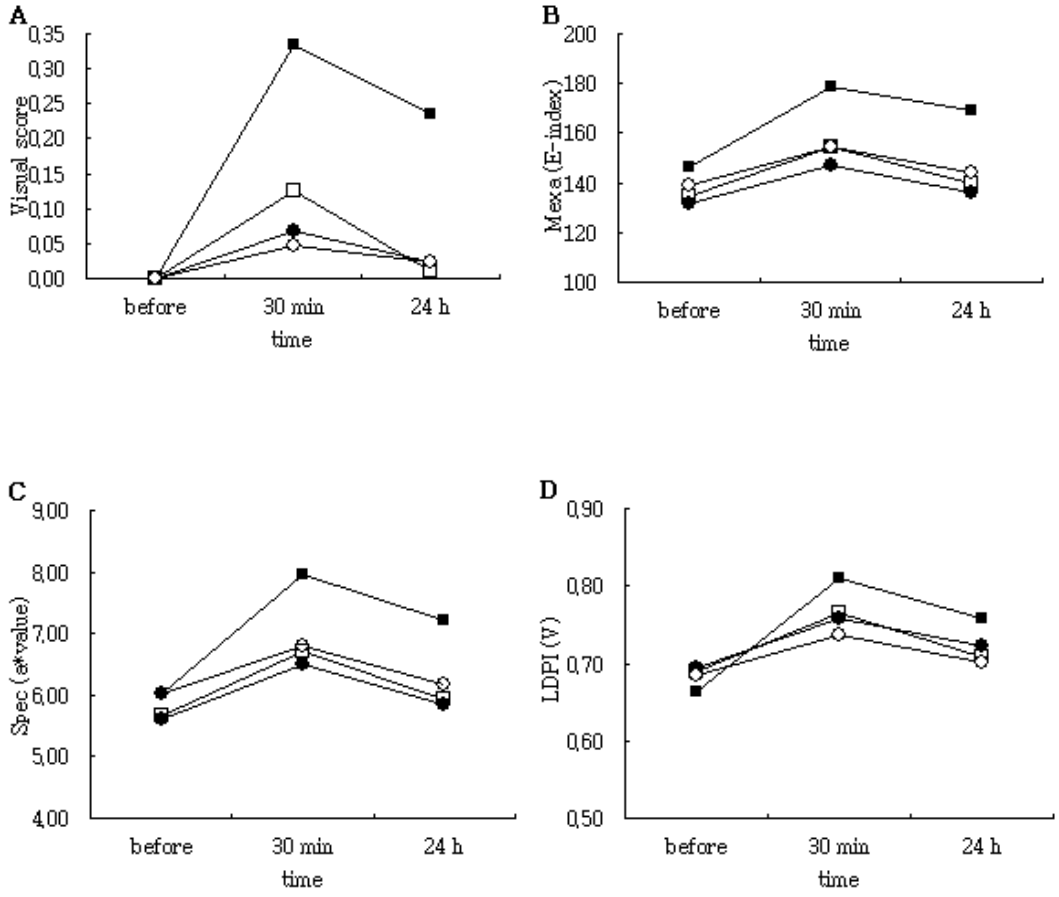


Figure 5. The skin erythema according to the at time course of four surfactants in the age group 20's~40's (mean value)

A: Visual score, B: Mexameter, C: Spectrophotometer, D: LDPI

SLS Tween-80 hydro-l decyl-g

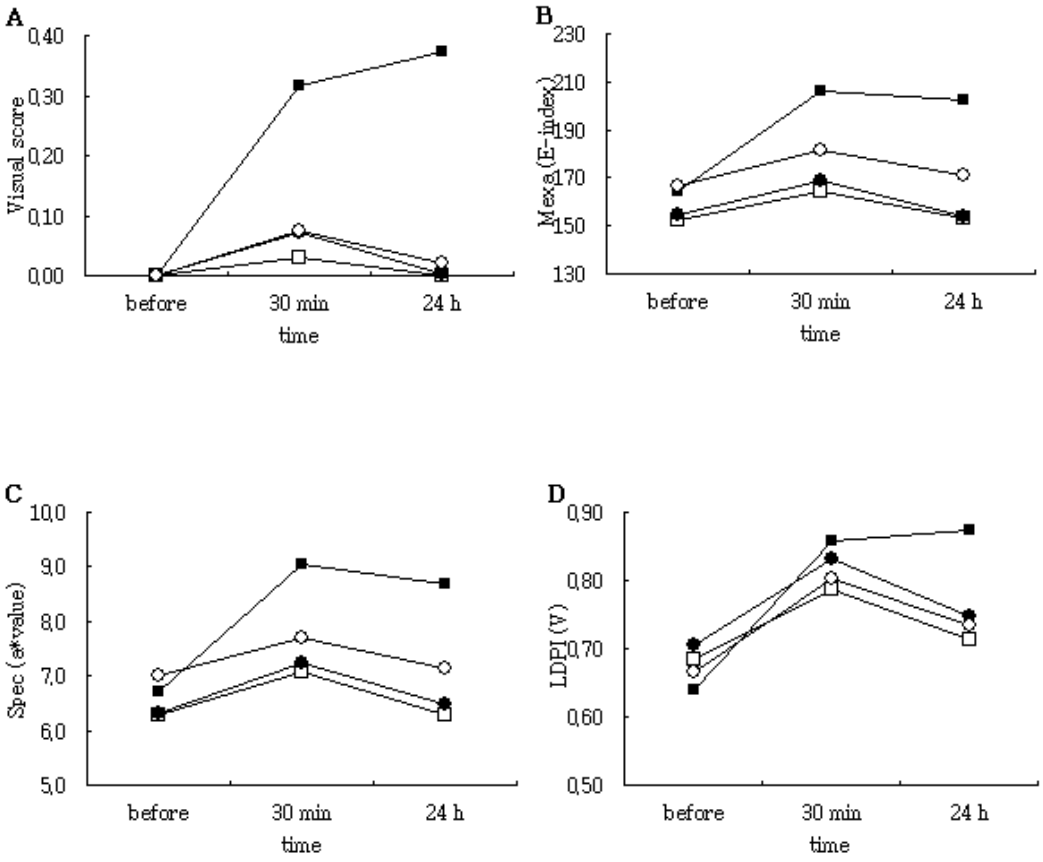


Figure 6. The skin erythema according to the time course of four surfactants in the age group over 50' (mean value)

A: Visual score, B: Mexameter, C: Spectrophotometer, D: LDPI

SLS Tween-80 hydro-l decyl-g

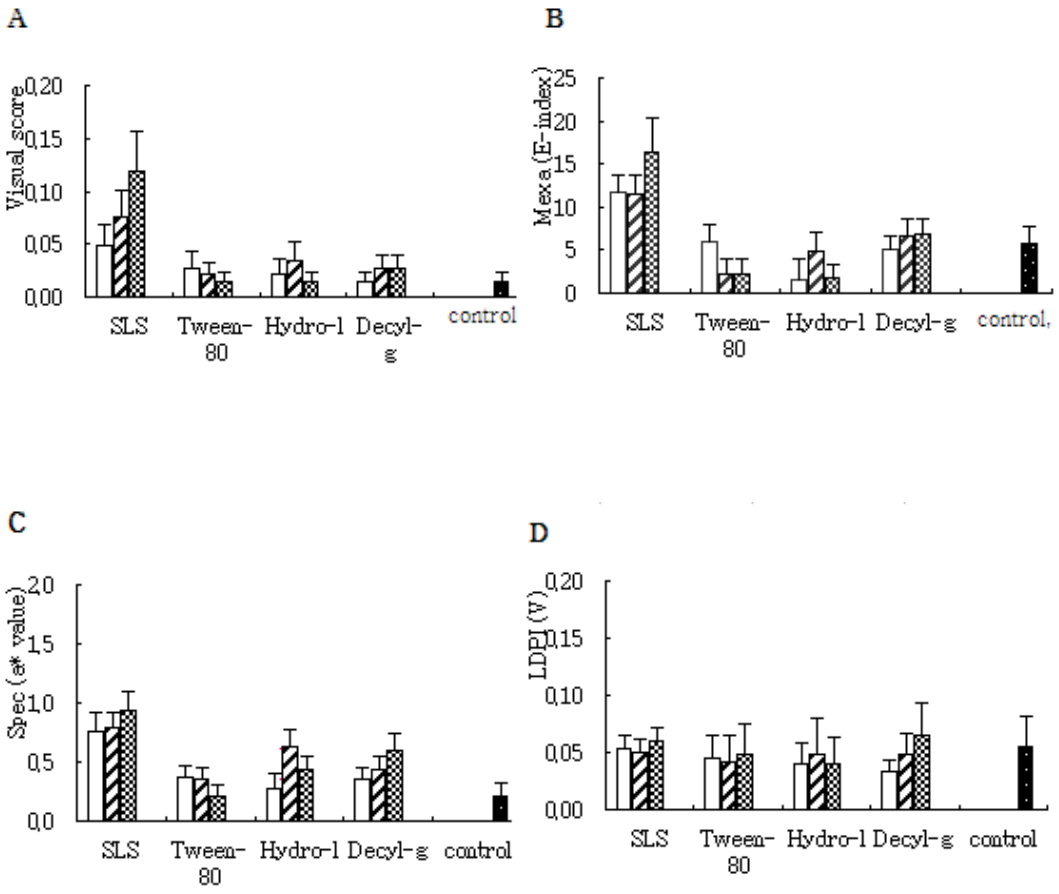


Figure 7. Comparison of the skin erythema between concentrations in the age group teens (ANOVA model; Mean±SE)

A: Visual score, B: Mexameter, C: Spectrophotometer, D: LDPI

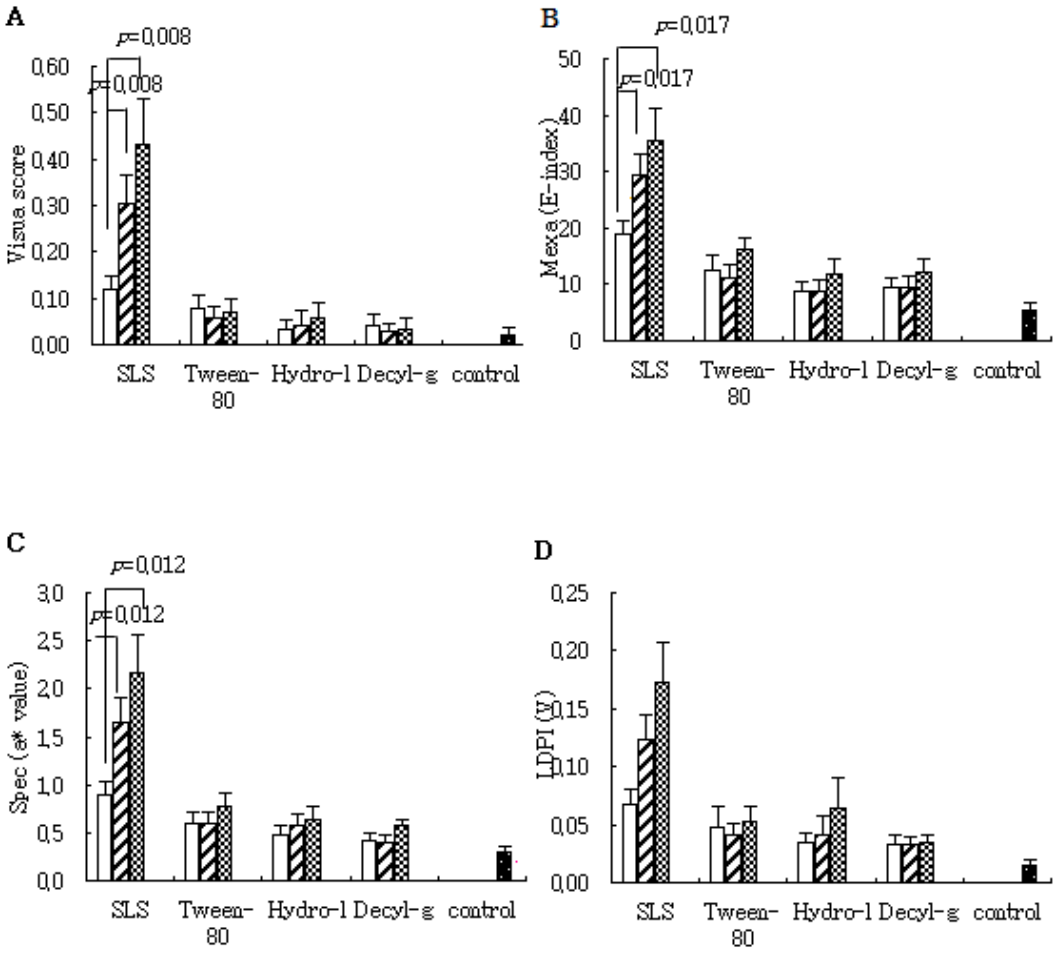


Figure 8. Comparison of the skin erythema between concentrations in the age group 20's~40's (ANOVA model; Mean±SE)

A: Visual score, B: Mexameter, C: Spectrophotometer, D: LDPI

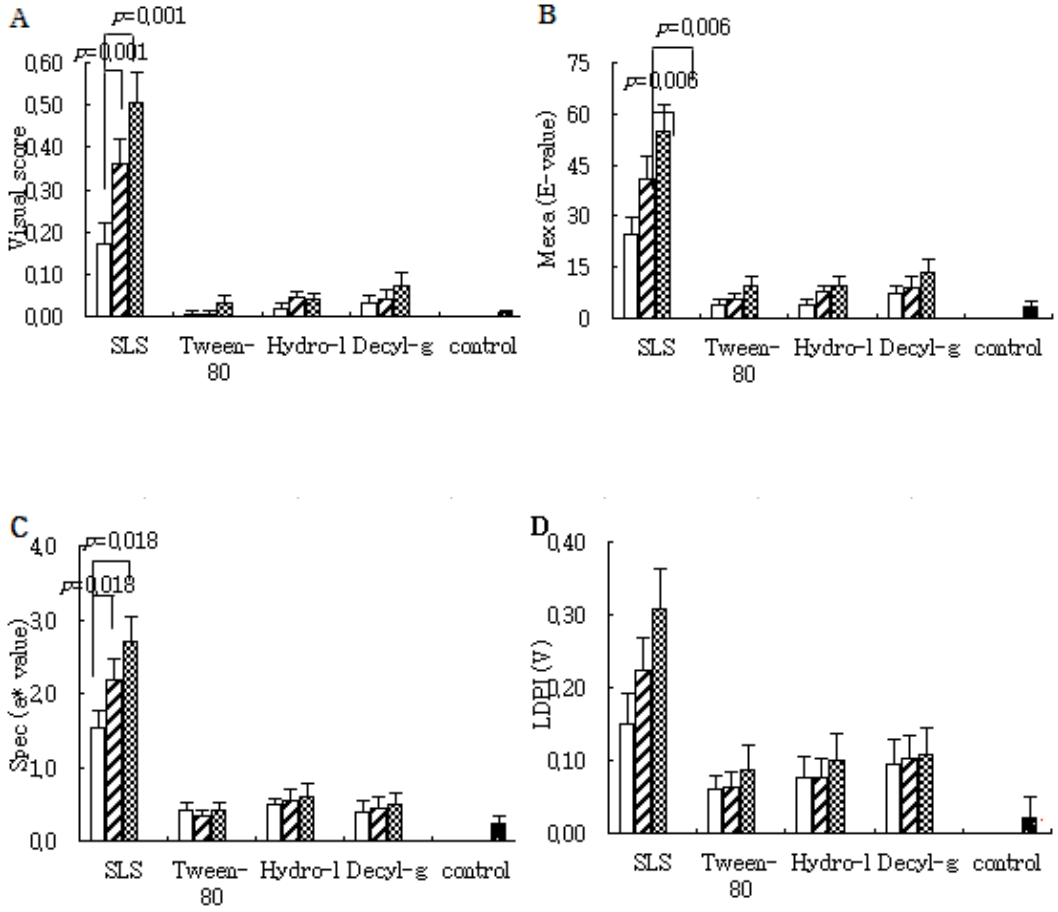


Figure 9. Comparison of the skin erythema between concentrations in the age group over 50' (ANOVA model; Mean±SE)

A: Visual score, B: Mexameter, C: Spectrophotometer, D: LDPI

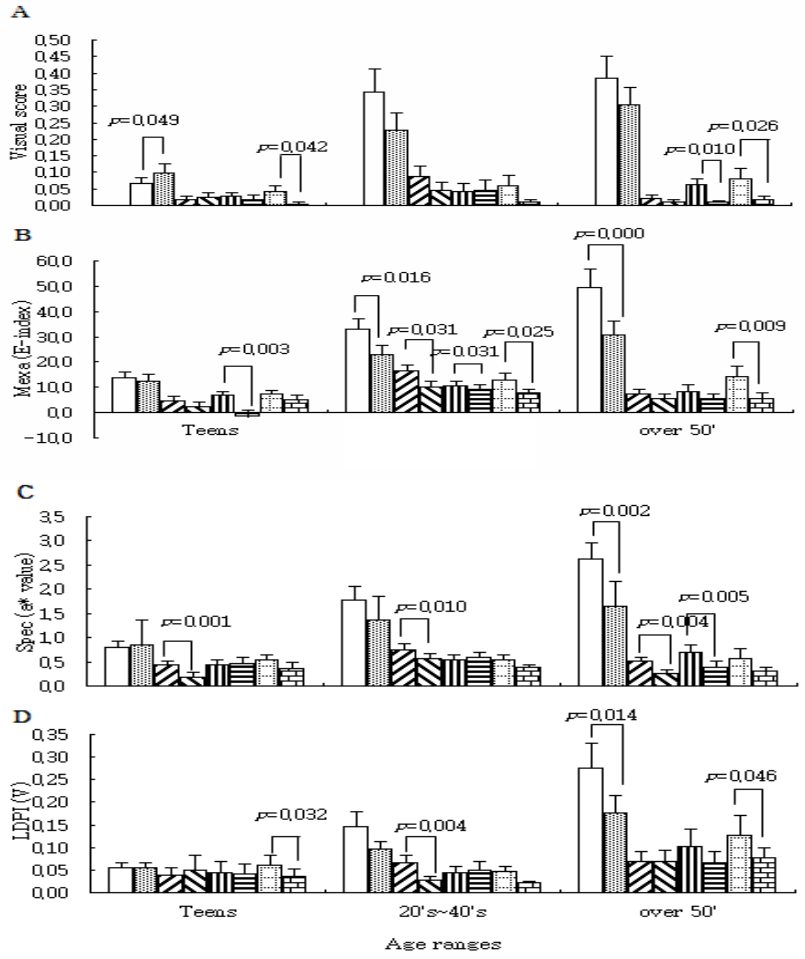


Figure 10. Comparison of the skin erythema between toner type and cream type formula (Mean±SE) A: Visual score, B: Mexameter C: Spectrophotometer, D: LDPI

S-T: SLS in toner base
S-C: SLS in cream base
T-T: Tween-80 in toner base
T-C: Tween-80 in cream base
H-T: Hydro-l in toner base
H-C: Hydro-l in cream base
D-T: Decyl-g in toner base
D-C: Decyl-g in cream base

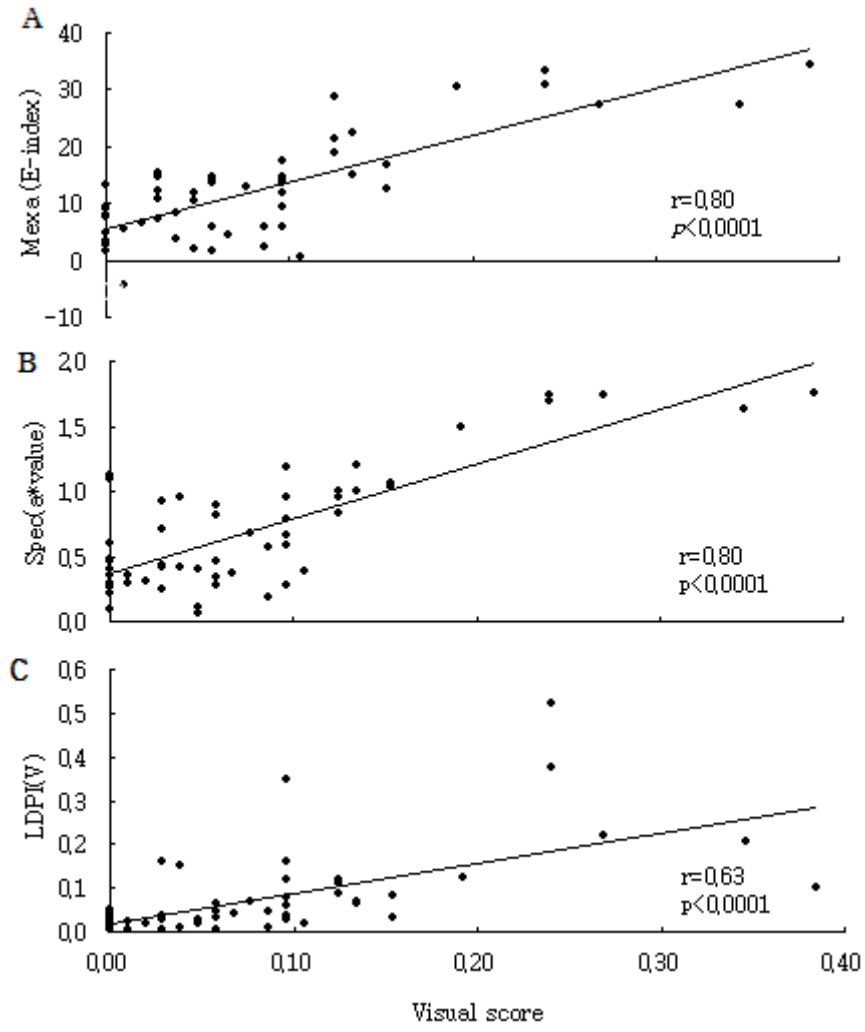


Figure 11. The correlation of visual scoring with Mexameter: A, Spectrophotometer: B and Laser Doppler Perfusion Imager: C

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Abstract
Comparative Measurement of Irritation of Several Surfactants in Korean Women of Various Ages

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Surfactants widely used in cosmetic and toiletry products are one of the causes of irritant contact dermatitis (ICD). The chemical classes (anionic, cationic, amphoteric and non-ionic) of surfactants have mainly been performed in comparative method studies. Recently, however, a lack of study on the comparison data with natural surfactants allowed the use of natural surfactants in the cosmetics industry. This study evaluated skin erythema by induced irritant contact reaction in 55 Korean women of different age group, different applications of formulas and concentrations of two semi-surfactants (hydro-lecithin and decyl glucoside) and two synthetic surfactants (SLS, Tween-80). The degree of correlation between visual scores and instruments has also been studied. The comparison between surfactants, SLS showed a significant difference in all age groups when compared with other surfactants. Although decyl-glucoside is a semi-natural surfactant, it

showed high skin erythema in individuals over 50 years in age and showed a significant difference of over 1% when compared with the control (p<0.05). The skin erythema response was seen in decreasing order of age group, aged over 50', 20's~40's and teens in SLS. Also, SLS showed the highest skin erythema at 30 min after removal of patch in the age group teens and in ages 20's~40's. However, in the age group over 50', showed the highest skin erythema at 24 h after removal of patch. In the comparison between tested concentrations, SLS showed between 0.5% and 1% and between 0.5% and 2% (p<0.05). In the comparison of formulations, the toner type formula of the four surfactants showed significantly higher skin erythema than the cream types in all age group except the visual evaluation of teens (p<0.05). Also, the mexameter and spectrophotometer presented a higher correlation with the visual assessment than LDPI. In conclusion, this study indicated that decyl-glucoside, one of two semi-surfactants, was thought to have high irritant sensitization in the age group over 50' of over 1% concentration. The skin irritant response of SLS seem to show the increasing skin erythema and the delayed skin healing in the age group over 50' than those in the age group teens and in the age group 20's~40's by the weakened skin barrier function in elderly. Moreover, the toner type formula was associated with an increase in damage to the skin barrier than the cram type formula and caused an increase in skin erythema. Also, the mexameter and spectrophotometer seem to be more sensitive for measuring skin erythema evaluation than the LDPI.