Assessment methods for evaluating the whitening effect of cosmetics on human skin

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Abstract

Quantitative measurement of melanin is the best method to evaluate whitening effect of cosmetics on human skin. However, non-invasive method to quantify human skin melanin with high precision has not been established. Whitening effect of cosmetics on the skin results in lightening of skin color. Therefore, it is reasonable to measure skin color in a reproducible manner for the assessment of whitening effect. Several instruments or methods, such as colorimeter, mexameter, and visual assessments by experts, have been used for this purpose. In this lecture I will review the details of various assessment methods for the evaluation of whitening effect and discuss the pros and cons of each method. Then I will present briefly the results of clinical trial. Finally I will introduce new non-invasive modalities to quantify melanocytes.

EDUCATION

1986 Chungnam National University College of Medicine, Daejeon, Korea

1996 MS in Medical Sciences, Department of Medicine, the Graduate School of Chungnam National University, Daejeon, Korea

PROFESSIONAL AND RESEARCH EXPERIENCE

1995 Internship, Chungnam National University Hospital, Daejeon, Korea

1996 Residency, Department of Dermatology, Chungnam National University Hospital, Daejeon, Korea

2000 Faculty, Department of Dermatology, Chungbuk National University Hospital, Chongju, Korea

2000 Instructor, Department of Dermatology, Chungbuk National University College of Medicine, Chongju, Korea

2002 Assistant Professor, Department of Dermatology, Chungbuk National University College of Medicine, Chongju, Korea

국문요약

멜라닌의 정량은 인체에서 화장품의 미백효과를 평가하기 위한 가장 좋은 방법이지만 인체의 멜라닌 측정을 위한 높은 정확성을 가진 non-invasive방법은 아직 확립되지 않은 실정이다. 피부에서 화장품의 미백효과는 피부색의 밝기로 나타낼 수 있으므로 화장품의 미백효력 평가를 위한 재현성있는 방법으로는 피부색측정을 하는 것이 합리적이다. 이에 colorimeter, mexameter와 전문가의 육안평가같은 여러 기기나 분석법이 사용되었다. 이 강연에서는 미백효과에 대한 평가를 위한 다양한 평가방법에 대해 자세히 보고하고 각 방법에 대하여 토의하게 될 것이다. 그리고 간단히 임상시험에 대한 결과를 보고하고 마지막으로 melanocyte를 정량하는 새로운 non-invasive방법에 대한 model을 제시하려고 한다.

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Purposes of this Lecture

- Reviews the details of various assessment methods for the evaluation of whitening effect
- Discusses the pros and cons of each method
- Presents briefly the results of clinical trial
- Introduces new non-invasive modalities to quantify melanocytes

Contents

1. Assessment methods for evaluating the whitening effect
   - Instrumental assessment
     - ✓ Colorimeter
     - ✓ Mexameter
     - ✓ Image analysis
   - Visual assessment by expert
     - ✓ Photography systems
       - Stereotactic device
       - Light sources
       - UVA photography
       - Fluorescence photography
       - Polarized light photography
     - ✓ Visual assessment using a 4-point scale
     - ✓ Visual assessment of high-resolution digital images using a 13-point balanced categorical scale

Contents

2. Test model
   - UVB induced skin pigmentation
   - Designs of clinical study
3. Clinical trial
   - Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation
4. New non-invasive modalities to quantify melanocytes
   - Reflectance laser scanning confocal microscopy
     Optical coherence tomography(OCT)

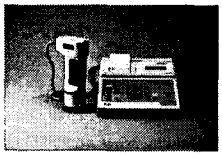
Assessment methods for evaluating the whitening effect

Instrumental assessment

- Colorimeter
- Mexameter
- Image analysis

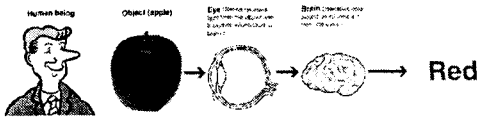
Colorimeter

- Tri-stimulus colorimeter

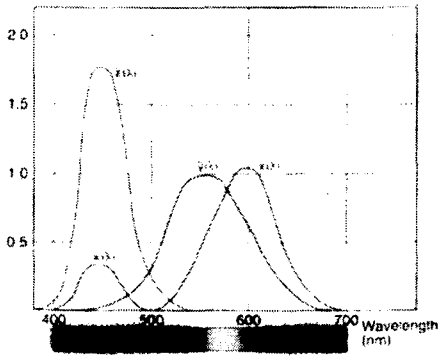


- Spectrophotometric colorimeter

Color-sensing methods

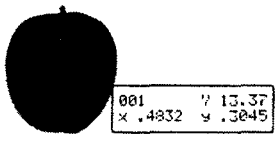


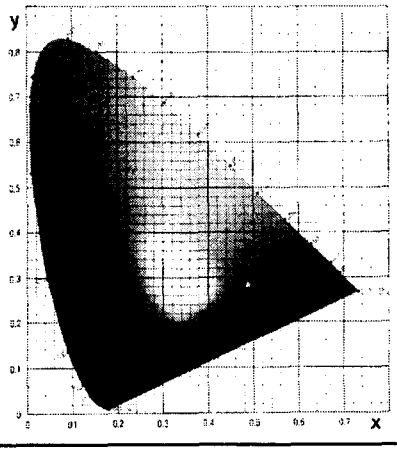
Spectral sensitivity corresponding to the human eye
(Color-matching functions of the 1931 Standard Observer)



Yxy color space

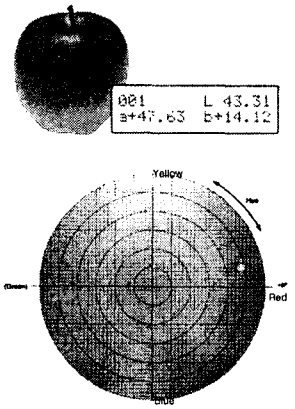
- Major problem
  - Equal distances on the x, y chromaticity did not correspond to equal perceived color differences

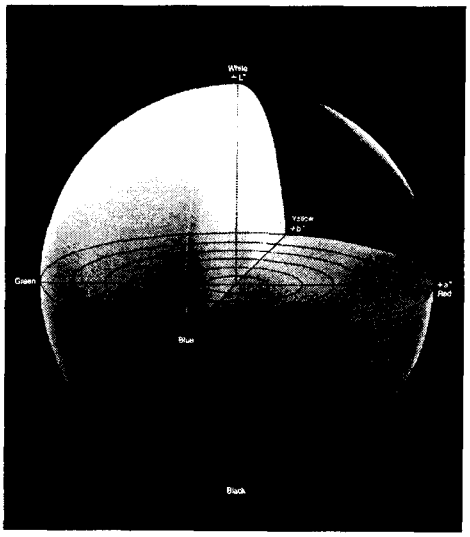




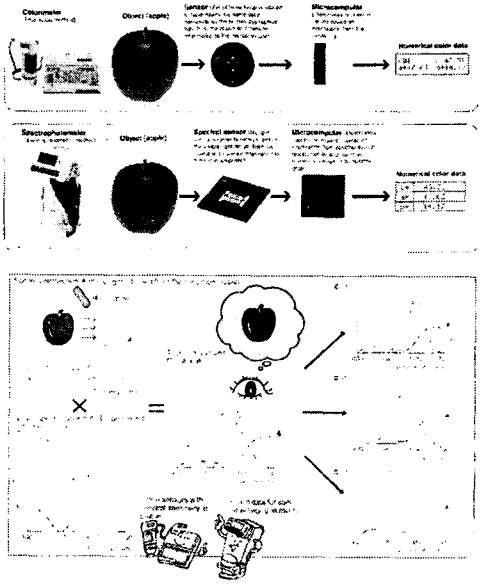
L*a*b* color space

- Uniform color space

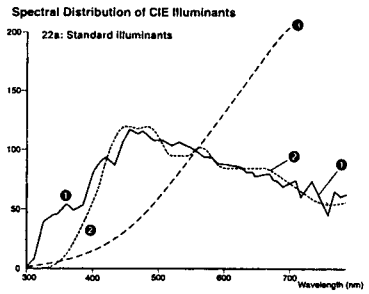




Color-sensing methods



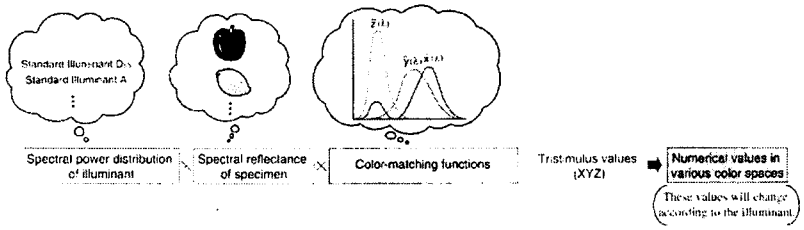
How will the apparent color change when light source is changed?



① Standard Illuminants D65
- Average daylight(including UV region)
- Color temperature : 6504K

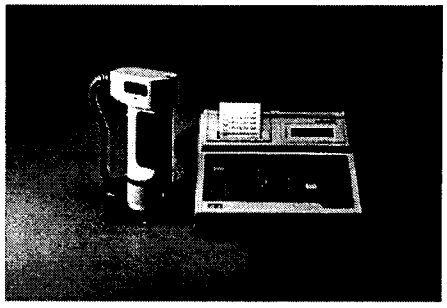
② Standard Illuminants C
- Average daylight(not including UV region)
- Color temperature : 6774K

③ Standard Illuminants A
- Incandescent light
- Color temperature : 2856K



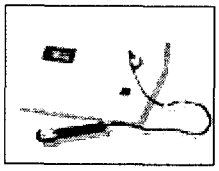
Colorimeter

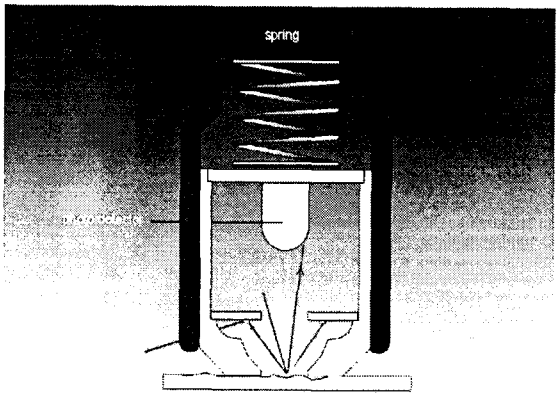
- Chromameter CR-300®(Minolta, Osaka, Japan)
  - Tri-stimulus colorimeter
  - Measuring area : 8mm in diameter



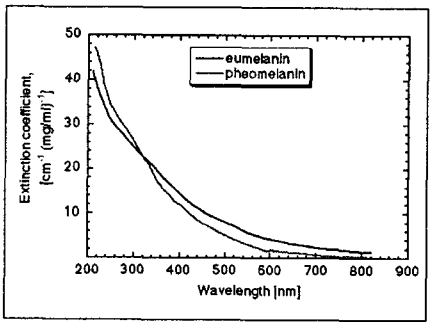
Measurement of Melanin Index

- Mexameter MX® 16(CK electronic, Koeln, Germany)
  Measuring area : 5mm in diameter
  0 ~ 1000





Mexameter



3 pre-defined wavelengths (568 nm: green, 660 nm: red, and 880 nm: infrared)

Melanin index = 500/ log 5 x (log infrared-reflection/ red-reflection + log 5)

Image analysis for the quatitation of skin color

- Quantitative analysis of skin pigmentation on clinical pictures using a videomicroscope interfaced with a computer(Br J Dermatol, Taikiwaki et al., 1994)
- Suitable for the evaluation of pigmented lesions that are too small or irregular

Assessment methods for evaluating the whitening effect

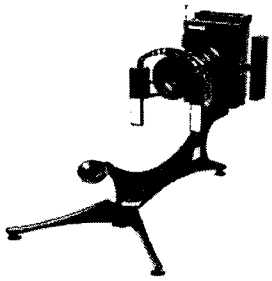
Visual assessment by expert

Photography systems

- Stereotactic device
- Light sources
- UVA photography
- Fluorescence photography
- Polarized light photography

Photography systems

- Subject posing stage

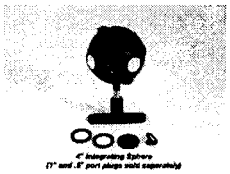


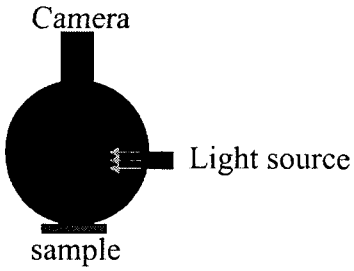
Photography systems

- Light sources
  - Flash light
    - ✓ Strong specular reflection(surface reflection or glare)
    - ✓ color temperature : not constant
  - Visible light
    - ✓ Weak specular reflection
    - ✓ Constant color temperature and output intensity are required
  - Polarized light
    - ✓ Easy to eliminate the surface reflection
    - ✓ Emphasizing subsurface skin features(pigmentation, erythema)
  - UVA
    - ✓ Strobe equipped with a UVA band-pass filter
    - ✓ used in UVA photography and fluorescence photography

Photography systems

- Lighting methods
  - Direct lighting
    - ✓ Strong specular reflection(surface reflection or glare)
  - Indirect lighting
    - ✓ Weak specular reflection
  - Integrated sphere

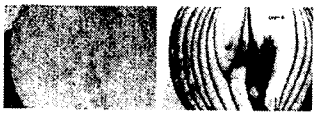


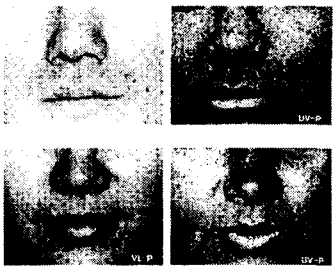


Photography systems

- UVA photography

Section of a onion





  - Principles
    - ✓ Greater reflection of UV rays than visible light on the skin surface
    - ✓ UV rays absorption by melanin
    - ✓ UV photography catches mainly pigmentation in the epidermis because UV rays penetrate less deeply into the skin than visible light

Photography systems

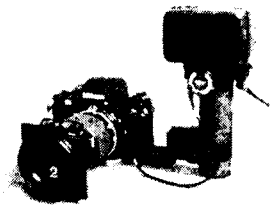
- UVA photography

  Construction

  - ✓ UV lens

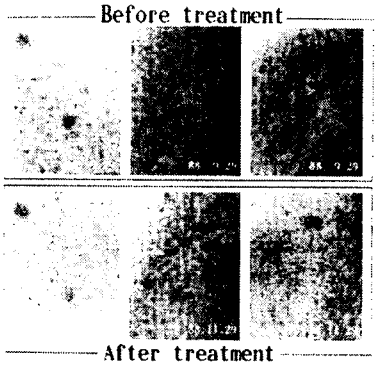
    comprised of fluorite and quartz glass

    UV rays pass through
  - ✓ UV band-pass filter combined with UV lens
  - ✓ Strobe equipped with a UV band-pass filter
  - ✓ UV sensitive film or UV CCD



Photography systems

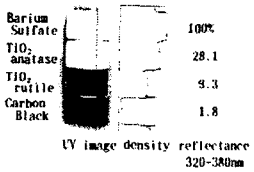
- UVA photography

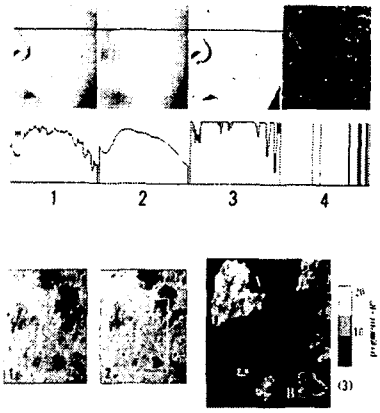


Photography systems

- UVA photography

Image analysis





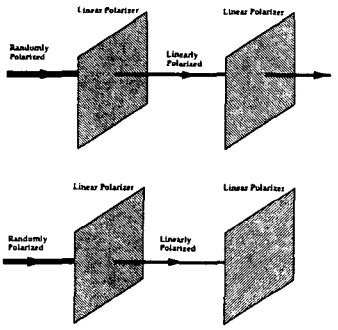
Photography systems

- Fluorescence photography
  - Principles
    - ✓ Skin is illuminated with UV(centered about 365nm)
    - ✓ stimulated fluorescence emission by collagen bundles
    - ✓ Fluorescence is attenuated by hemoglobin in capillaries and the epidermal melanin

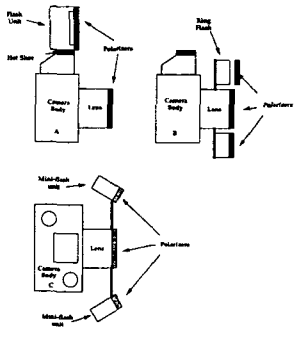
Photography systems

- Polarized light photography

Principles



Construction



Assessment methods for evaluating the whitening effect

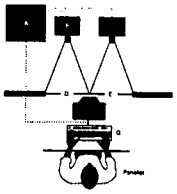
Visual assessment by expert

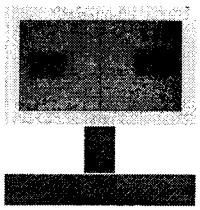
Visual assessment using a 4-point scale

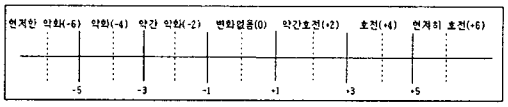
Visual assessment of high-resolution digital images using a 13-point balanced categorical scale

Visual assessment by expert

- 4-point scale vs 13-point balanced categorical scale
  - Visual assessment of high-resolution digital images using a 13-point balanced categorical scale





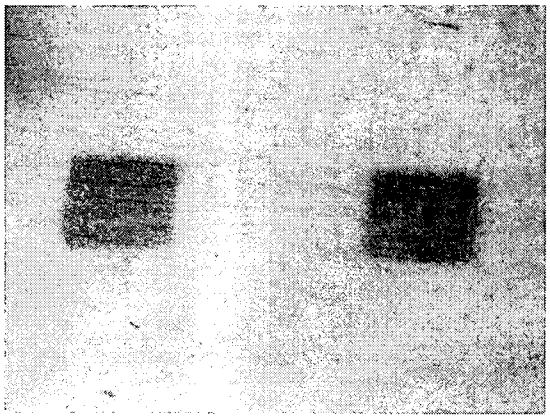


Test model for evaluating the whitening effect

- UVB induced skin pigmentation
- Designs of clinical study

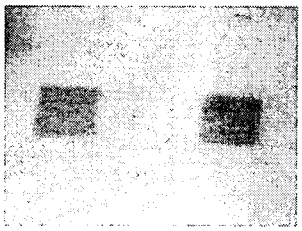
Test model

- UVB induced skin pigmentation

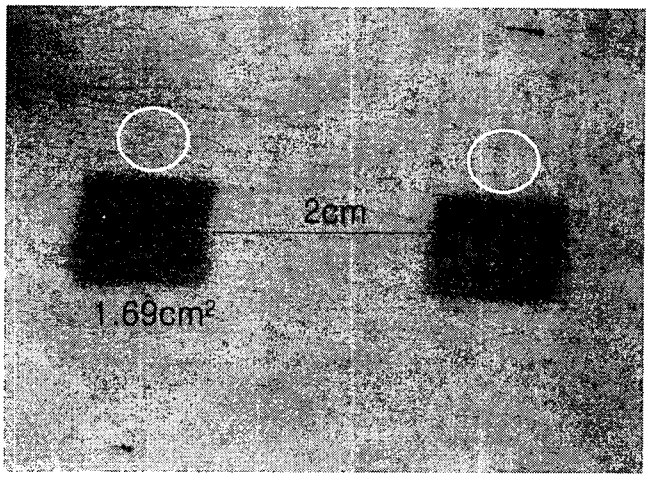


Designs of Clinical study

- Randomized double-blind paired comparison
- UVB-induced skin pigmentation



Sites of colorimeter measurements in UVB-induced skin pigmentation



Clinical trial

- Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

Subjects and Treatment

- UVB-induced skin pigmentation
  - 25 healthy adults were enrolled in this study
  - 25 subjects were treated with 5% EGCG and vehicle

MED(Minimal Erythematous Dose)

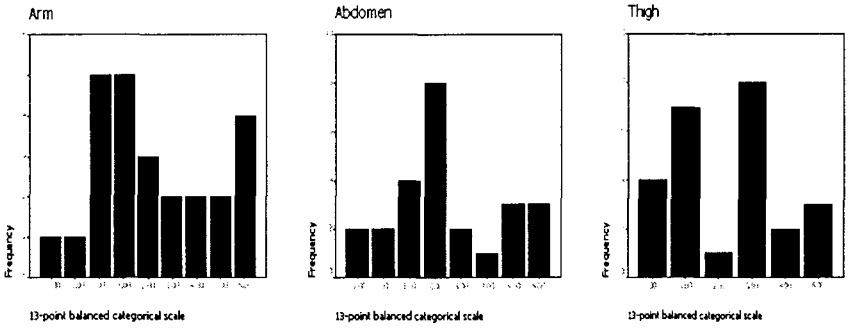
- Light source : UVB(Waldman UVB-800, Germany)
- Assessed MEDs after 24 hours from irradiation of UVB rays
- 30 ~ 50 mJ/cm^2(40.6 mJ/cm^2 on average)

Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

- Application of 5% EGCG and vehicle
  Five percent EGCG and vehicle were applied to the inner arm, abdomen, and inner thigh 30 minutes before exposure with a 2-MED dose of UVB light
- Assessments(10 days after the irradiation of UVB light)
  - colorimeter
  - mexameter
  - visual assessment of high-resolution digital images using a 13-point balanced categorical scale
  - self-assessment of treatment response
  - local cutaneous side effects

Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

- Visual assessment of digital image (13-point balanced categorical scale)



Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

- Colorimeter analysis

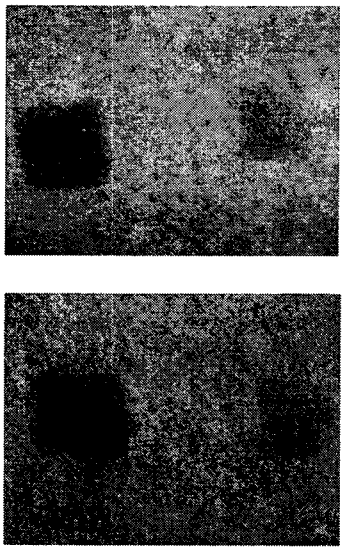
Sites	5% EGCG(n=25) L value	Vehicle(n=25) L value	mean differences	p Value
inner arm	62.83 ± 0.61	60.77 ± 0.61	2.05 ± 0.37	0.000
abdomen	61.87 ± 0.80	58.69 ± 0.74	3.17 ± 0.45	0.000
inner thigh	64.61 ± 0.86	61.62 ± 0.86	2.66 ± 0.42	0.000

Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

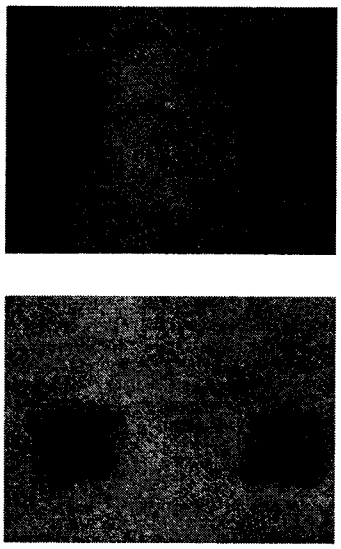
- Mexameter analysis

Sites	5% EGCG(n=25) melanin index	Vehicle(n=25) melanin index	mean differences	p Value
inner arm	491.84 ± 3.62	491.40 ± 2.53	0.44 ± 3.83	0.909
abdomen	497.44 ± 4.28	498.64 ± 4.84	1.20 ± 3.55	0.739
inner thigh	486.16 ± 2.89	486.80 ± 3.00	0.64 ± 2.68	0.813

Visual assessment : +6



Visual assessment : +1



Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

- Self-assessment of treatment response(n=25)

Response category	5% EGCG	Vehicle
marked improvement	13(52.0%)	2(8%)
mild improvement	2(8%)	2(8%)
no change	6(24%)	
mild worsening		
marked worsening		

Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

- Correlation between visual assessment and colorimetric measurement

Site	Pearson correlation coefficient	p Value
inner arm	0.423	0.035
abdomen	0.735	0.000
inner thigh	0.762	0.000

Preventive effect of 5% epigallocatechin-3-gallate(EGCG) on UVB-induced skin pigmentation

- Concordance between visual assessments of two dermatologists

Site	Kendall's W	p Value
inner arm	0.894	0.010
abdomen	0.930	0.006
inner thigh	0.842	0.019

Local cutaneous side effects assessed by a dermatologist

had not been observed in this study

Summary

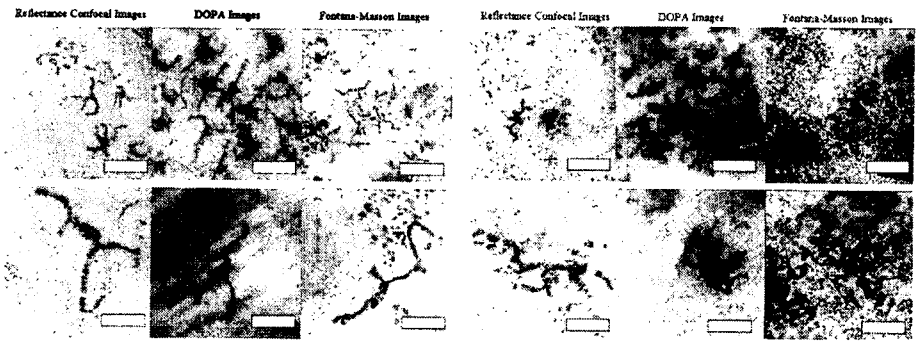
Colorimetric measurements, visual assessments of high-resolution digital images, and self-assessment of treatment response showed statistically significant preventive effect after 5% epigallocatechin-3-gallate(EGCG) compared with vehicle. There was a statistically significant correlation between visual assessment of high-resolution digital image and colorimetric measurement in 5% epigallocatechin-3-gallate(EGCG) trial.

New non-invasive modalities to quantify melanocytes

- Reflectance laser scanning confocal microscopy
- Optical coherence tomography(OCT)

Reflectance laser scanning confocal microscopy

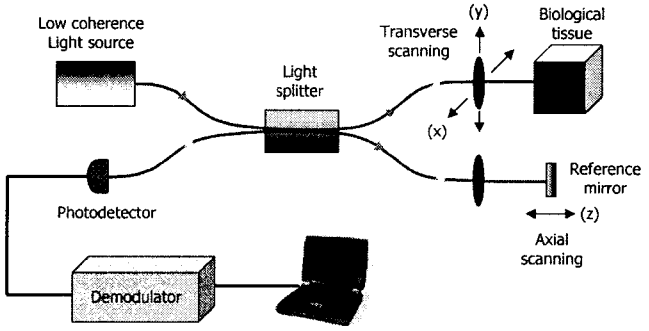
- Real-Time, in vivo Quantification of Melanocytes by Near-Infrared Reflectance confocal Microscopy in the Guinea Pig Animal Model(Wang LT et al., J Invest Dermatol 119:533-535, 2002)



Back Ear

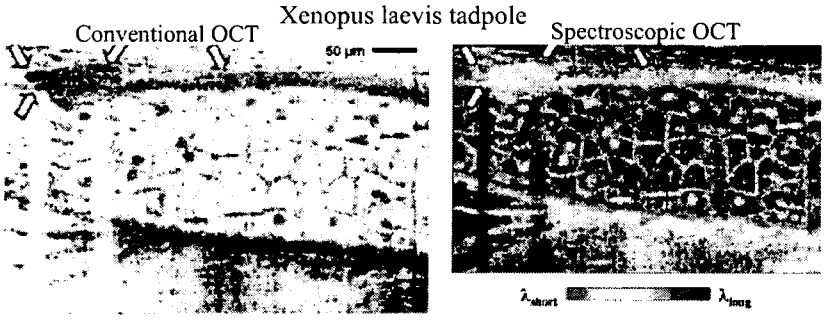
Optical coherence tomography(OCT)

- Michelson interferometer using low coherence light source
- Recently developed as a diagnostic method for high resolution non-invasive imaging of living biological tissues



Optical coherence tomography(OCT)

- Spectroscopic optical coherence tomography(Morgner U et al., Optics letters, 2000)



*arrows : melanocytes