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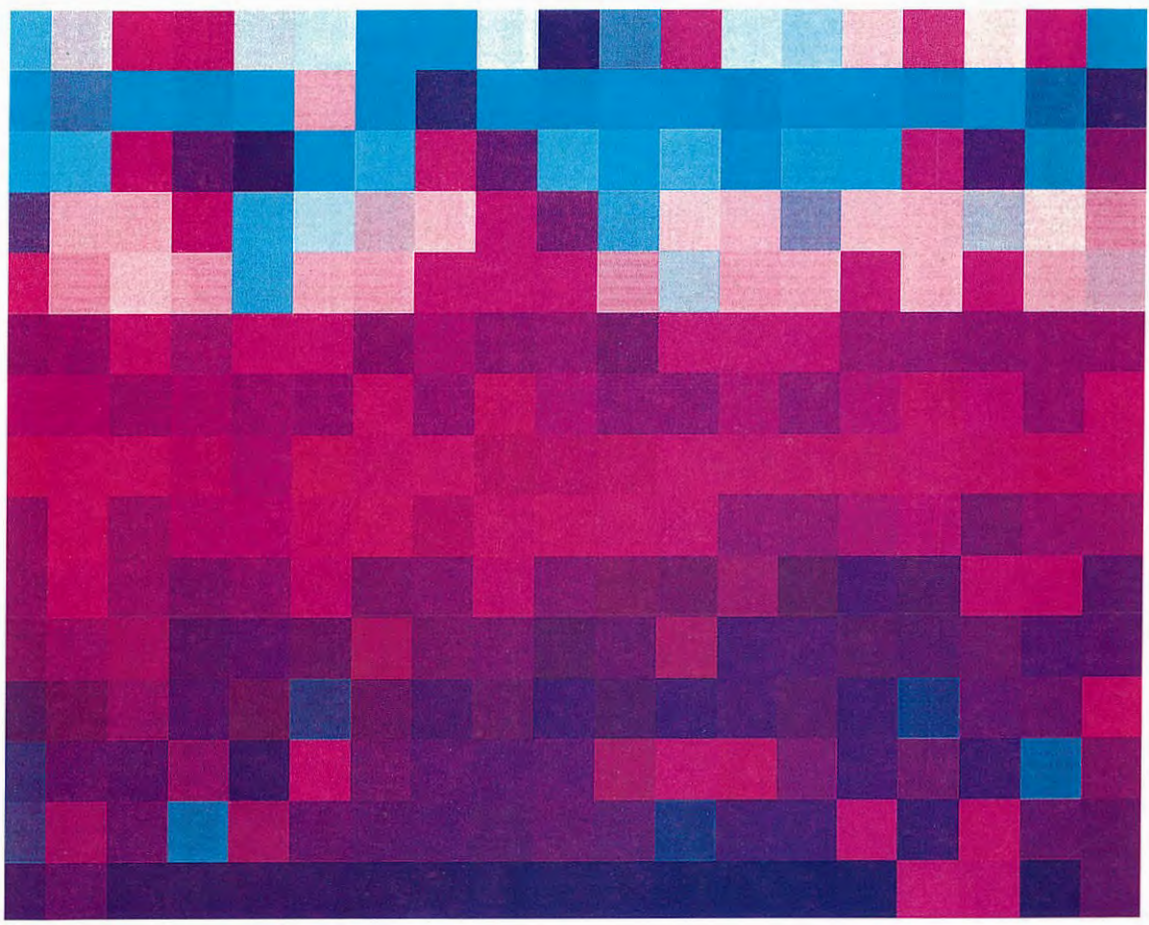

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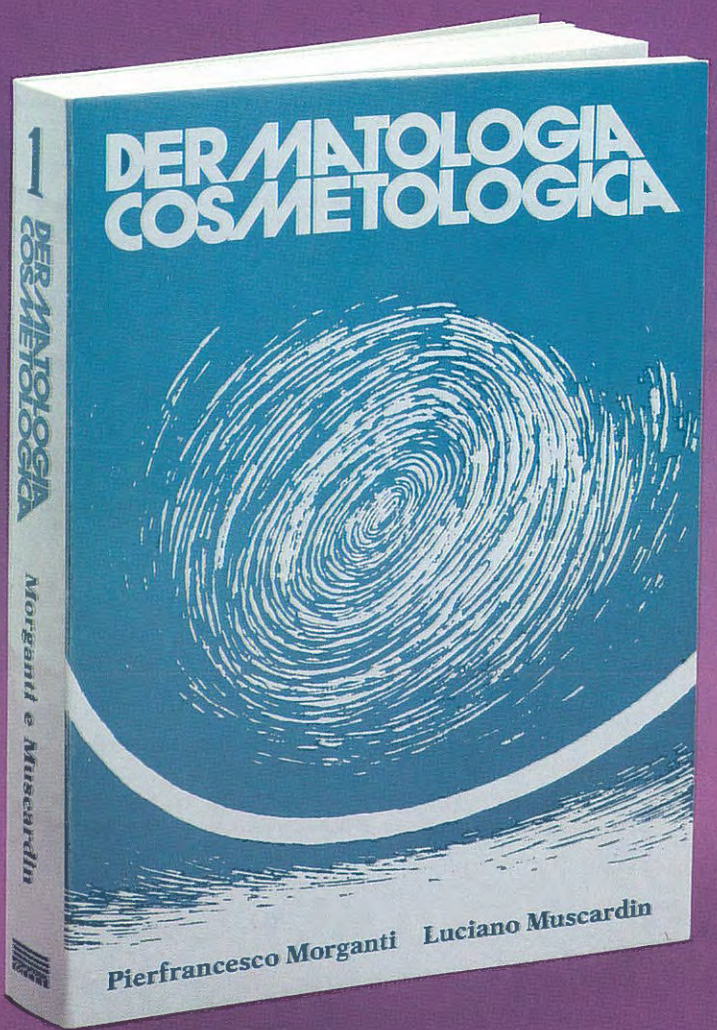

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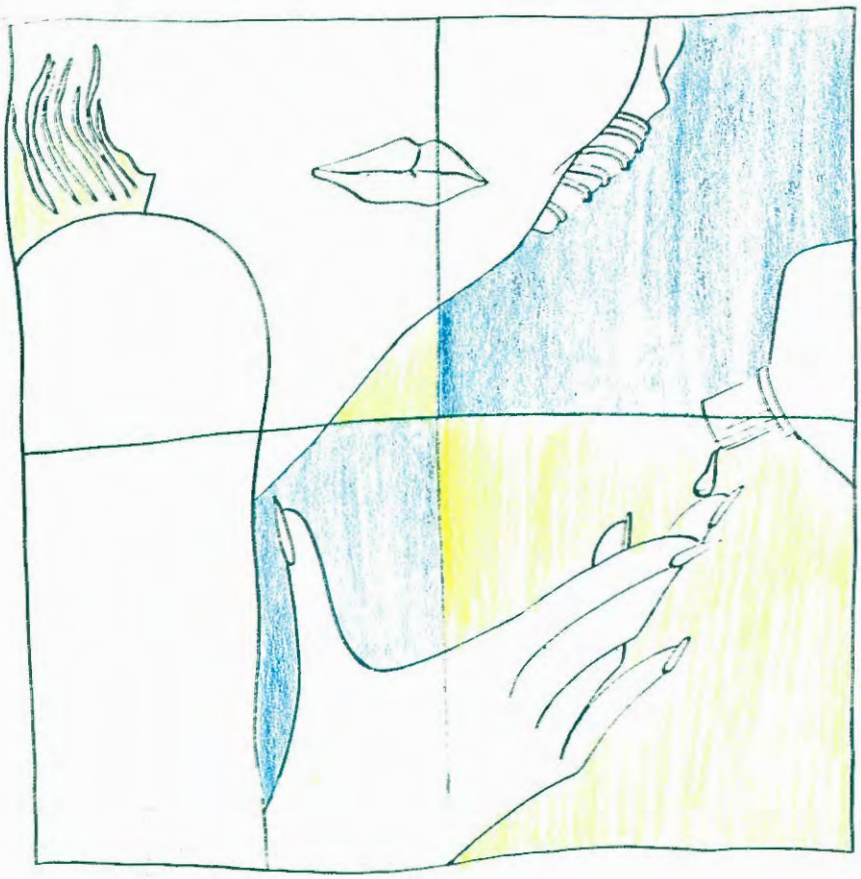

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1st International Meeting on Cosmetic Dermatology, Rome, Italy, March 7-9, 1985

Editors: P. Morganti, W. Montagna

The proceedings contained in this volume provide comprehensive view of the different aspects of the skin aging with its cosmetological implications.

Readership:

Third year undergraduates, research workers in the field of Cosmetic Chemistry, Biochemistry, Medicine, Pharmacy and Pharmacology, researchers and managers working in the cosmetic and pharmaceutical industries.

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A NEW LOOK AT OLD SKIN: A CHALLANGE TO COSMETOLOGY
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Rome - Italy October 30-November 2, 1991

J. Appl. Cosmetol. 8, 93-102 (October - December 1990)

SKIN AND WATER: AN UP TO DATE

S.D. Randazzo (1), P. Morganti (2)
(1) Head of Experimental Dermatology Department – Catania University
(2) Research & Development Manager - Mavi Sud S.r.l., Aprilia (Italy)

Received: *February 4, 1990. Presented at the "1st Course of Dermatological Science Updates". February 4, 1990. Roccaraso (Italy)*

Key Words: *Dry Skin; Skin Hydration; NMF; GAG; Skin Barrier; Skin Lipids; Alfa-hydroxy acids; Gamma-linolenic Acid; Cutaneus Hydration Measurement.*

Synopsis

Water helps maintain the physical properties of the stratum corneum. Polar and non Polar lipids in the epidermal layers promote the so-called "barrier function". The increase in saturated fatty acids is conductive to an increase in evaporation in the same way as with a large quantity of unsaturated acids. Finally skin permeability increases with excessive hydration and heat and is higher where the horny layer is more porous, as in the plantar region.
Normal hydration of the stratum corneum requires a proper water supply from dermis to epidermis. It is also necessary that the loss of water be undetectable and that the water retention capacity of the skin surface layers remains constant.
Besides depending upon polar lipids, water retention in the stratum corneum is regulated not only by the water content of the lower layers but by a complex of substances, the Natural Moisturizing Factors (NMF), coming from secretions of the sudiferous and sebaceous glands and from product of cell degeneration.
Local and general treatments are proposed for a soothing and moisturizing effect on the stratum corneum.

Riassunto

L'acqua è indispensabile per mantenere l'ecosistema cutaneo mentre i lipidi, polari e non polari ne regolano la funzione barriera. La permeabilità della pelle aumenta con l'idratazione ed il riscaldamento e varia nei diversi distretti cutanei anche in rapporto alla diversa presenza di acidi grassi saturi e insaturi.
Il contenuto di acqua negli strati più esterni della pelle è regolato, oltre che dal contenuto idrico degli strati sottostanti, da un insieme di sostanze, gli NMF, provenienti sia dalle secrezioni sudoripare e sebacee che dalla degradazione cellulare. Alcuni principi attivi quali gli alfaidrossidi-acidi, alcune vitamine e particolari acidi grassi come il gamma-linolenico vengono proposti ed utilizzati per reidratare la cute e riequilibrare l'ecosistema cutaneo.

Skin surface

The concept of normal, fatty or dry skin can be related to skin condition in certain regions or over the whole surface. Medical examination will determine the external aspect (surface uniformity, color, brightness or opacity), as well as thickness, flexibility, softness and humidity or oiliness of the skin.

Normal skin is bright pink, smooth, soft and elastic, neither oily nor wet, and capable of physiologically adjusting to environmental changes (cool-warm, dryness-dampness).

Oily skin appear in late childhood, and is seborrhoic mainly on the nose and scalp. It look oily and bright, flaxy and turgid, pale yellow.

Dry skin is rough, stiff, fragile, opaque, pale grey. It is clearly visible on extensor regions and become more noticeable with cold, atmospheric dryness and conditioned air, and hardly tolerate cleansers.

Subjectively, the subject with an oily skin feels the sensation of oiliness, a light itch and moderate warmth. A dry skin is felt as stiff and rigid, sometimes slightly itching.

A persistent excessive dryness - as well as hyperhydration - implies essential and lasting changes in the keratin which passes from the elastic stage (α-helicoid keratin) to the plastic stage (ß-sinusoidal keratin) due to a breach of hydrogen bonds. However, a moderate and light skin dryness is necessary to allow for normal surface desquamation and as a protection from physical, chemical and biological attacks (microorganism develop better in wet environments), as well as helping to limit transepidermal water loss through the stratum corneum (insoluble scleroproteins).

Epidermal homeostasis depends upon the activity of many intracellular (AMPc, GMPc, prostaglandins) and extracellular (epidermal growth factor, polyamines, hormones, neurotransmitters, chalones) agents and upon immunological conditions (Langerhans cells, T lymphocytes).

Consequently, a balanced keratogenesis, a selective barrier activity, and the balance of water in the stratum corneum all maintain a normal skin surface, but they can be affected by any change in dermoepidermal functionality.

Water

Not only is water a solvent in which biological phenomena occur, it is also a fundamentally active element in the metabolic functions of cells and tissues and helps maintain the physical properties of the stratum corneum (1-8).

Water reaches the epidermis from the dermis, where it constitutes 70% of the total. In the dermis, water is bound reversably with glucosoamiu-glycans (GAG) and especially with hyaluronic acid, depending on the polimerization rate and therefore on hyaluronic acid/hyaluronidasis ratio.

When GAG is saturated, water becomes free and this causes a rise in interstitial edema.

How water passes through the basal membrane is not yet known.

However, both intracellular and extracellular water in cell interstices reach the stratum corneum, exceed the maximum which can be absorbed and vaporize as "perspiratio insensibilis" (9).

Normal hydration (10-13%) of the stratum corneum requires a proper water supply from dermis to epidermis. It is also necessary that the loss of water be undetectable and that the water retention capacity of the surface layers remains constant.

Water could also come from that in the lipidic film, but the film's major hydrating function (for A/O emulsion, with continuous oil flow) consists of its slight insulating effect.

The stratum corneum is more important. In addition, in the case of hyperhydration, water affects the "barrier structure" causing stratum corneum permeability.

Proteins

For the establishment of the horny complex (fibrous bundles of amorphous α- and ß-keratins bound by fundamental substances) the contribution of keratinocytes tonofilament proteins is essential.
In the granular layer, biosynthetic processes convert the living cells of the malpighian layer to anucleate corneocytes. Pro-filaggrine can be found in the keratohyalin granules. The degradation of pro-filaggrine, together with nucleolysis, will help the formation of NMF (Jacobi's Natural Moisturizing Factors). In addition, vyniculin, involucrin and keratolinin are produced to form insoluble casing of the corneocytes. Involucrin and filaggrine are the most interesting proteins in relation to the structure of the stratum corneum. Involucrin derived from the granular cell cytoplasm and made up of aminoacids, mainly glutamic acid-glutamine and leucine, is supposed to provide the resilience and resistance of the horny lamellae. Conversely, filaggrine is connected with the aggregation of the fibrous filaments and is the main source of NMF. A basic cationic protein, filaggrine is made up mainly of histidine, arginine, serine, glycine, glutamic acid and glutamine and is scarce in ichthyosis vulgaris and in psoriasis, where hydration is reduced due to lack or shortage of NMF.

Lipids

Lipids can be found in the cellular membrane and in the interstices and change dramatically in quality and quantity as soon as epidermal cells leave the basal layer to turn gradually into desquamating cells. In the basal cells, phospholipids (in bilayer closed vesicles), cholesterol, unesterified fatty acids, triglycerides glycolipids prevail, together with a small amount of esterified cholesterol and ceramides. On the other hand, horny cell lipids are made up half of ceramides and half of a mixture of cholesterol and free fatty acids.
Immediately before desquamation, cholesterol esters and glycolipids have been detected showing that these polar lipids, fundamental components of the water barrier, help to maintain the physical integrity of the lower part of the stratum corneum. From a quantitative point of view, it is worth noting that protective lipids increase six times as they reach the stratum corneum from the basal layer, whereas cholesterol and ceramides (10) are, in the main, newly synthetized.
The lipid composition of the keratinocytes changes substantially due to the increase of unesterified fatty acid realeased in catabolic processes and, mainly, to this further lipid synthesis. Specific catabolic enzymes determine the progressive decay and synthesis of products, reflecting highly interesting morphological, structural and functional conditions in the granular and horny layers. Before the nuclei decay, bilayered liposome-like vesicles (Odland's bodies) arise from the Golgi complex of granular cells and are processed. They function to cement corneocytes and have a water-binding capacity. Passing from the compact to the unbound layer, lamellar bodies change their composition and eventually lose their typical bilayer feature. Enzymatic activities (glycosidase, steroidsulphatase, phospholipase, acid lipase) in the three epidermal layers thus induce chemical conversions of lipids to change the intercellular materials and cell structure in all sites (11).
1) In the malpighian layer, the total is made up of phospholipids together with phosphatedilcholine and, to a lesser extent, phosphatediletanolamine and sphingomyelin. However ceramides and glycosylceramides (that are useful to the epidermal barrier) can be found as well as sphingomyelin decay products.
2) Although substantially reduced, there still are polar lipids in the granular layer with a clear in-

crease of ceramides, cholesterol and fatty acids.
3) In the deep stratum corneum there are only traces of phospholipids and glycosphingolipids and these are completely absent from surface horny layer where, conversely, the content of ceramide, sterol and free fatty acid is substantial.

Barrier Function

Polar and non-polar features of lipids in the epidermal layers promote the so-called "barrier function" of the skin (12). The "barrier" concept relates to the selective permeability of stratum corneum due to special physical and chemical properties. Permeability increases with excessive hydration and heat and is higher where the stratum corneum is more porous, as in the plantar region.
Small lipid or water-soluble molecules cross the barrier under suitable physical and chemical conditions. In this case their capacity for transcellular and, to a lesser extent, intercellular diffusion (5% of the total volume of the stratum corneum) occurs according to Flick's law of diffusion.
Essential fatty acids, such as linoleic and gamma-linolenic, are the most active in maintaining barrier function.
When compared to hepatic and gastrointestinal sterolgenesis, cutaneous sterolgenesis seems to be autonomous and unrelated to tbe level of circulating or centrally regulated sterols.
However, diets deprived of essential fatty acids have been shown to alter the barrier, causing transepidermal water loss and desquamative dermatoses.
In the event of a lack of water, lack of fatty acids or faulty barrier function, epidermal lipogenesis is stimulated.
Desquamation of the stratum corneum is closely related to the presence of certain intra- and inter-cellular lipids.

Natural Moisturizing Factors. Integrity of the stratum corneum.

Besides depending upon polar lipids, water retention in the stratum corneum derives from hydrophile substances called Natural Moisturizing Factors or NMF made up of amino-acids (glycine, serine, proline, glutamic acid), sodium lactate, 2-pyrrolidone-5-carboxylic acid as a sodium salt (PCNa), urea, mineral salts (sodium, magnesium, potassium, calcium). The main components which bind water are deemed to be sodium lactate, some amino-acids such as glycine and PCNa, but NMF's sugar fraction, for its bond with lysine epsilon aminogroups, and urea, for the osmotic effect due to its low molecular weight, are also active.
Finally, a major role in water retention and barrier function, is to be given to the integrity of the protein and lipid structures of the corneocytes as well as the proper contiguity of the horny lamellae. These factors mediate the compatibility and adaptibility of the organism with the outer environment.

The Damage of Dehydration

Even though proper water retention in the stratum corneum is over riding, water cannot be considered as the only important factor. However, the water-lipid-NMF connection is so complex that its tasks and functions are at present quite difficult to determine (7). In old age, the relation between skin dryness and the water content of the dermis (proportional to its decreased thickness) is not completely clear. However, it is worth noting that, from a qualitative point of view, the senile interstitial dermis tissue is not a gel, but a viscoelastically modified solution, because of the lack of glucosaminglycans. In pathological terms, skin

is obviously compromised (dryness, roughness) in its water loss conditions, as well as in the forms of the so-called "dry cholera" and in the "Mouriquand syndrome" (the syndrome of the nursling midday wind). These conditions are typified by water-loss caused by unrestrainable diarrhoic discharges. In such cases the organism takes water from cutis (10-13% of the total) where it is much more mobile than in the internal organs. Skin dehydration can also be detected in subjects undergoing dialysis, continuously on diuretics or low-salt diets. In most subjects, however, the pathology of their dry skin depends on qualitative and quantitative alterations of many factors, though all relating to lack of water in the epidermis. These factors (lipids, PCA, amino-acids, electrolytes) imply a failure of the stratum corneum to bind and retain water.

When hydration of the stratum corneum drops below 10%, the skin suface becomes dry and rough with a clear reduction of cutis elasticity. The stratum corneum desquamates, fissures easily, and increases in permeability, thus becoming subject to external attack.

Some hereditary syndromes (progeria, Werner's syndrome, desmosome mitotic anomaly syndrome, ichthyosis), hormonal disorders (hypothyroidism, hypoadrenalism, hyperparathyroidism), reduction of abnormality of the granular layer, defective cellular cohesion, the natural process of ageing (atrophy, functional lack of organs and systems, structural chemical and physical changes), climatic and environmental dehydrating factors (wind, humidity and temperature fallas), external attack by chemicals (cleansers, paints, gasoline) which deplete the lipid of the horny lamellae, general errors of metabolism (cirrhosis, hypothyroidism, nephroses), all of which have no clear relationship with the skin nevertheless are associated with objective and subjective dry skin symptoms (11,13,15).

A dry skin can affect the whole cutaneous surface, as in ichthyosis and syndromes of premature senescence (progeria, Werner's syndrome) or show more clearly in certain areas such as the legs, and hands (especially for damage from touch) or the face (especially in pale-skin, and in phaeomelanic subjects after reiterated exposures to solar radiation).

Senile xerosis is seen in 80% of persons over 65 and is not deemed to be related to an excessive insensible loss of water or to dermal dehydration. Conversely, in old age, alterations in the hydrolipidic film can be detected with loss of corneocyte cohesion and a decrease in barrier function; the stratum corneum is thinner and sterolsynthesis is reduced (14,15).

Prevention Criteria

Skin needs exposure to air and therefore clothing must suit the requirements of age, climate, environment and work, in order to allow thermoregulation. It is preferable to avoid conditions which cause perspiration (excessive loss of water and mineral salts), reiterated exposure to wind, high and low temperatures (reduced relative ambient humidity), sun rays (arachidonic and diomo-gamma-linoleic acid are jeopardized by erythematogenic UVB). Although excessive and repeated sun exposure, is not advisable, particularly for subjects with fair complexions unprotected by melanin (phaeomelanics), the use of sun protective products is always advisable. Apart from the understandable damage caused by the contact of skin with detergents for domestic use, attentione must be drawn to the harmful effects of toiletries when these are not correctly formulated (16).

In the debate about possible damage from the alkalinity of the traditional Marseille-type soap and the certain damage by excessive delipidation by dermatological cleaners (non soaps) having an acid pH equivalent to that of the skin surface traditional soaps are undoubtedly to be

prefered. Marseille-type soap includes medium-length natural fatty acids, of vegetable or animal origin, which have an affinity with sebum and can partly restore the lipid film of dry skin.
The foam effect of synthetic cleansers requires the inclusion of great quantities of surfactants which destroy almost all (60%) of the lipid film and are strongly irritant. Furthermore, as to the damage from the alkalinity of traditional soaps, it is well known that acid pH is restored 5-30 minutes after rinsing, whereas the harmful effect of synthetic detergents on the stratum corneum is much more dangerous.
Damage can also be caused by incorrectly formulated cleansing milk or tonic lotions (16,17).

Treatment

Lipids and moisturizers

Local and general treatments are proposed for a soothing and moisturizing effect on the stratum corneum.
Locally applied compounds oppose the loss of water or supply water-retaining hygroscopic substances.
Oily substances oppose the loss of water forming an impermeable (occlusive) or partially impermeable film (partially occlusive or porous) under the form of A/O or O/A emulsion. This for a period reduces "perspiratio insensibilis", water evaporation. For such a purpose, mixtures of polar and non polar lipids which more or less reproduce the composition of the surface lipid are used.
Furtbermore, in order to retain and bind water at the skin surface, hygroscopic substances are used. Examples are the active principles of NMF and particularly the sodium salt of 2-pyrrolidone-5-carboxylic acid (PCNa), a physiological moisturizer found in the various organs, in the organic fluids and particularly in the epidermis, including the stratum corneum. Mixtures of PCNa, amino-acids, urea, lactic acid, sodium lactate, traceelements, known as "reconstituted NMF", are also frequently used. PCNa (as well as glycine, lysine and arginine) would regulate water fixation using, among others, the glucidic fraction of the amino-groups of cutaneous glycoproteins (18).
Urea (around 2-5%) is capable of increasing hydration of the corneum by 100%, both by an osmotic effect due to its low molecular weight and for its ability to solubilize insoluble proteins. However, when used for too long periods, urea compounds cause harmful disaggregation of the corneal lamellae and damage to the barrier.
Sodium chloride can have a hygroscopic effect, as well as several polyhydric alcohols such as sorbitol, propylene glycol and glycerol.
The lack of water can also be improved by local application of products containing native ox collagen (a water soluble protein molecule with a non altered trihelical structure), which is capable of retaining between 2,000 and 3,000% of its own weight of water. The polypeptide chains adhere to the surface of the corneum and create a hydrating film.
Hyaluronic acid plays an important role by its great hygroscopic effect.

Alfa-Hydroxyacids

They are used in cosmetic formulations for xerotic, hyperkeratotic and senescent skins in general, acting as modulators of keratin synthesis. The mechanism of action alpha-hydroxyacids is still unknown, even if their capacity for disaggregating corneocytes is established.
These substances are thus useful in hyperkeratosis and seem to have an interesting "anti-ageing" action as well (19, 20).

Linoleic and gamma-linolenic acids

Atrophic, senescent, xerotic and hyperkeratotic skins require emulsions containing vegetable oils rich in linoleic acid (soy, corn, grapeseed oils etc.) and in gamma-linolenic acid (borage and evening primrose oils).
Such unsaturated oils appear to promote mitoses and regulate cell differentiation as precursors of eicosanoids.
Furthermore, dry skins show and increase (doubling) in palmitic acid (C 16:1) together with a great reduction (-50%) in linoleic acid (C 18:2). Both acids return to normal values with the local application of creams rich in gamma-linolenic acid (21, 22).
A build-up in time of gamma-linolenic acid has been observed on the stratum corneum and this is supposed to promote epidermal cell differentiation (23, 24), thus helping local hydroxylation of unsaturated acids. Finally, linoleic and gamma-linolenic acids are supposed to help exchange of water soluble compounds which affect cell permeability with rehydrating effects on the stratum corneum (25, 26).

Vitamins

In moisturizing and hydrating emulsions the inclusion of some vitamins is proposed on the grounds that they are necessary for normal keratinization (27, 28).
Vitamin B5, in the form of panthenol (an active and biologically stable form of pantothenic acid) is deemed to be effective on dry and wrinkled skins.
Vitamin A (retinol, vitamin A alcohol) acts mainly as a regulator of the growth of epithelial tissue. It produces protein synthesis in ribosomes, labilizes lysosomial membranes, regulates the epithelial mitotic index and affects the metabolism of acid mucopolysaccharides. Therefore its deficiency causes dry and wrinkled cutis. From a cosmetic point of view, the local application of vitamin A is very useful especially in winter time.
However, its derivative, retinoic acid (vitamin A acid), has proved to be much more active since it is capable of penetrating dermis (even though in small quantities). Specific proteins bind retinol and retinoic acid, and occur in dermis and epidermis in equal quantities. In the dermis, retinoic acid is believe to stimulate mast cells for angiogenesis and fibroblasts for the synthesis of new elastic fibres and collagen.
Vitamin B6 intervenes in fatty acid metabolism and as coenzyme (pyridoxal phosphate) for the oxidative de-amination of the free amino-group of lysine and oxylysine.
Betacarotene provitamin A or carotenoid, when taken "per os", is transformed to vitamin A in the intestinal wall and is absorbed as such. In normal dosages betacarotene is deemed to protect against ultraviolet rays slowing down degradation of dermal collagen and inhibiting the oxidation of proline to oxyproline. After being taken per os, it is, in fact, deposited in the dermis to act as an anti free radical (29).
Vitamin E acts as an antioxidant to such compounds as are essential to cellular metabolism and has therefore a protective action for vitamin A, carotenes and polyunsaturated fatty acids. Furthermore, synergizing with vitamin A, vitamin E would prevent the formation of peroxides and thus of free radicals, which are toxic. In the form of linoleate, vitamin E is also indicated to help restoring the surface lipid barrier. Both as the ester and in the non-esterified form, this vitamin has proved to be a precious therapeutic factor in the treatment of dermatoses or of highly itching cutaneous affections. From a cosmetic point of view, it is worth remembering that vitamin E helps the reabsorption of fatty acids, promotes metabolism, peripherally protects the natural fat content of the epidermis, and activates the cutaneous microcirculatory system.

Vitamin B12 improves atrophic and pigmented skin. Vitamin B12 deficiency causes folic acid deficiency (a coenzyme in the catabolism of amino-acids such as methionine, histidine, serine, glycine) stopping intracellular penetration.
Vitamin C intervenes in collagen formation by proline hydroxylation and corrects keratosis follicularis, which is a typical sign of deficiency.
Vitamin B2 or riboflavin is necessary for the synthesis of long-chain fatty acids.
Vitamin B1 or thiamin acts as a coenzyme in many cellular processes and it is indispensable for lipid synthesis.
Vitamin H or biotin is a constituent of many enzymes (of the carboxylase type) and affects the metabolism of amino-acids and pyruvic acid. Its deficiency is indicated by a grey, dry and wrinkled skin.
Vitamin D is indispensable for the maintenance of calcium and phosphates in the plasma. Together with food supply (vit. D2), it is also synthesised in the skin by proper exposure to ultraviolet rays.
The precursor, 7-dehydrocholesterol, is converted into vitamin D3 (in the Odland bodies). Vitamins D2 and D3 speed up metabolic processes and increase the turgidity and tonicity of epidermal tissues. Their action on the granulation of a healthy skin and on the re-epithelization of a "burnt" skin is particularly known.

Measurement of cutaneous hydration

Measurement of skin hydration in vivo, using instrumental techniques which are not invasive, is based on the evaluation of biological and biophysical state of the stratum corneum (30). Here are the most representative methods.
Infrared ray spectroscopy: this is based on water absorption capacity of infrared radiations and therefore it is possible to measure the infrared spectrum in the stratum corneum through the total attenuated reflectance technique.
"Photoacoustics": this technique involves the estimation of the absorption light radiation by the stratum corneum from local heat increase and the pressor effect on skin surface by means of an acoustic sensor.
The evaporation measurement (TWL), that is water loss by transpiration. It is performed with a) ventilated technique, by measuring the humidity variation of a gas passed through a closed container on the cutaneous surface; b) non ventilated technique, using an open cylinder to measure relative humidity, variation. Temperature, relative ambient humidity, and the influence of occlusive factors on traspiration may alter the evaluations.
Electrical measurements are based on survey of: 1) the bipolar orientation of the constituents of the stratum corneum (keratin); 2) the ionic mobility of the stratum corneum; 3) water mobility and proton exchange in the stratum corneum.
Corneometry is widely spreading because of its simplicity in use, accessible cost and reliability of results. This method is based on the dielectric constant of water acting on a special condenser, unlike other substances, and gives a numerical indication (normal values are among 90 and 100 units) (31).
3C System dermotest: this is a computerized system composed of a sebum detector and a hydration detector, connected to a PC through ad-hoc software. It provides values for both sebum and cutaneous hydration, which are expressed both per unit area and as indices which reflect the cutaneous biotype. The soothing index is used to restore skin lipid balance, whereas the hydrating index shows hydration requirement. Such numerical values refer to set cosmetic products (31, 33). The effects of cutaneous dehydration may also be estimated by "profilometry" in which macrophotographs of imprints of the cutaneous surface are analysed, or by "microsurvey quantification" in which the

profiles of the imprint of the cutaneous surface are registered ("integrator anaglyphograph"). Finally "ballistometry" compares skin hydration by the capacity for absorption of mechanical energy.

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SKIN HYDRATION CONTROL & TREATMENT RECENT UPDATES

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Synopsis

A major cosmetic problem is keeping skin young and always capable of retaining a proper amount of water in the horny layer. In Cosmetic Dermatology moisturizing creams are used to solve this problem of dry an dehydrated skin. Cosmetic science utilize a wide range of materials to maintain cutaneous moisture. The application of hydrosoluble and moisturizing compounds is one of the best known methods for increasing the humidity of the skin. Glycine together with PCA (Pyrrolidone Carboxilyc Acid) seems to be the most active water-linking compound. They are presumed to regulate water exchanges between the horny layer and the dermis. The local or the systemic use of unsaturated fatty acids, mainly gamma-linolenic acid, seems to be also effective in the treatment of dry and dehydrated skin. Nevertheless, if it is true that cosmetic treatments help to improve both the external aspects and function of the skin, they are not in themselves enough for restoring altered skin. It is still necessary to avoid smoking, excessive alcohol and to have sufficient sleep and a natural, rich and balanced food.

Riassunto

Il problema cosmetologico più importante è di mantenere la giusta quantità di acqua a livello dello strato corneo. Nella Dermatologia Cosmetologica si utilizzano quindi le creme idratanti e nutrienti da giorno e da notte, utilizzando quali principi attivi alcuni aminoacidi e soprattutto la glicina ed il sale sodico dell'acido pirrolidone carbossilico o PCA. Questi derivati sembrano essere in grado di legare acqua regolandone l'interscambio tra epidermide e derma. La cute secca e disidratata viene anche normalizzata mediante l'uso topico o sistemico di acido gamma-linolenico. Se è indubbio che l'uso regolare di cosmetici possa alleviare il fenomeno della cute secca, è necessario anche integrarne l'attività con l'uso di una dieta ben bilanciata evitando anche l'uso del fumo e degli alcoolici.

Introduction

A major cosmetic problem is keeping skin "young", and always capable of retaining a proper amount of water in the stratum corneum. For this purpose, the aim of so-called emollients and moisturizers is not only to act as simple lubricants, but to maintain skin homeostasis. Well formulated cosmetics delay water evaporation in the "perspiratio insensibilis", increasing the capacity of the stratum corneum's to retain water and restoring the surface lipid film which is the indispensable regulator of water exchanges (1, 2, 3).

Dry and dehydrated skin

"Dry skin" describes skin which lacks suppleness and is fragile and wrinkled. The stratum corneum tends to flake and chaps which sometimes even bleed, frequently appear on fingers and areas of friction, mainly in winter. A dry skin is highly sensitive to atmospheric agents and hardly tolerates cleansers (soaps, detergents, etc.) which often produce itching (4).
Dry dehydrated skins can also be differentiated from dry alipic skins. Dry dehydrated skins suffer excess water loss due to insufficient sweating or to increased evaporation caused by lack of Natural Moisturizing Factors (NMF) (5).
On the contrary, dry alipic skins lack polar hydrophil fats and surface lipid film, due to altered or reduced sebum secretion. Obviously, these situations often coexist even though dehydration mostly occurs first and more frequently (6).

Dry and/or dehydrated skin identification

Dry-alipic and dry-dehydrated skin cannot be distinguished easily. To date, the tecbniques used for precise skin classification have relied first upon the naked-eye a second examination with a magnifying glass a third by "fingertip touch". These preliminary examinations were followed by the use of simple tools such as spatulas, vitropressure slides, Wood's light etc. Thanks to modern technologies a thorough skin check-up can now be made by avant-garde computer techniques. These systems quickly provide a reliable determination of the surface lipid (surface lipidic film) as well as NMF-related water content, pH level, temperature and elasticity. In addition, exact topographies, can be drawn of skin areas which have been magnified hundreds of times. These can, moreover, be stored to allow any future variation to be monitored.

Hydrating and soothing indices

Recent experimental work shows that the amounts of surface lipid (casual level) and water (skin hydration) can be quantified. Numerical values can be used to express how much any skin is dehydrated (deprived of water) or alipic (deprived of fats). This new experimental approach makes it possible to calculate the amounts of water (hydration) and lipid (surface hydrolipidic film) necessary to balance the skin of the investigated subject. Thus cosmetics can be suggested or specifically prescribed just as sun protection products have been for many years. For example, Hydrating Index (HI) expresses the moisturizing capacity of the cosmetic in the same way as the sun protection factor expresses the filter capacity. The surface lipidic film balancing capacity is known as the Soothing Index (SI) (7).

Usage of the hydrating index

There are many well-known problems in determining the amounts of sebum (casual level) and

water (skin hydration) in the stratum corneum. The methods so far used have been complicated and research orientated rather than suitable for use with large numbers of subjects. The use of hydrating and soothing indices through Dermotest has made possible a first italian nation-wide screening by age and climatic areas. 6,000 subjects in various geographic areas and at different seasons have been tested under conditions of controlled humidity and temperature. The first results showed high skin dehydration levels for people aged 26 to 45. High skin dehydration levels were always related to a constant lack of surface lipids, regardless of age in North, in Central and in Southern Italy. These somewhat unexpected data seems to relate to climate changes. As the relative humidity rate increases (Southern Italy), in fact, skin dehydration decreases as well in people aging 26 through 45 while the surface lipid film tends to normal values (8).

Optimal replenishment of skin hydration

Sebum and sweat flow on to the stratum corneum as a heterogeneous mixture of lipids, water and mineral salts known as the surface lipid film. This mixture, enriched with amino-acids, pyrrolidon-carboxylic acid (PCA), sugars and other hygroscopic derivatives from filaggrine catabolism, filters between the squames to form NMF (Natural Moisturizing Factor) (9, 10). NMF is made up of a set of substances acting as skin moisturizers capable of "binding" water from "perspiratio insensibilis" and retaining it in the stratum corneum. Surface lipids are made up of fatty acids with chain lengths from C8 to C22, waxes and cholesterol esters with chains between C26 and C42, triglycerides, squalene and a small amount of paraffins (3.14%) with lengths of C16 to C32, from the external environment (11). It is not to be forgotten that 15% of all fatty acids, whether free or not, and of wax-related alcohols are made up of saturated and unsaturated ramified chains making the surface lipidic film more "porous" (12, 13, 14). In Cosmetologic Dermatology, moisturizing creams are used to solve the cosmetic problem of dry and dehydrated skin. For effective action, such creams must rebuild and restore both the surface lipidic film and NMF components.

If misformulated and improperly used, besides depleting lipid, cleansing products have been shown experimentally to deprive skin of water-binding materials, that is NMF, long periods. It has been established that the dehydrating power of cleansers can be measured, e.g. by their capacity to remove certain aminoacids from the stratum corneum (15, 16). In addition, once cleansing, has occurred, most amino-acids in the wash water are those believed to have a major and active role in skin hydration. This is how the importance of glutamic acid was ascertained as a PCA precursor, and the hydrating action of glycine is considered proven, as it has been shown to be, active both topically and in systemic use. In fact, glycine, when taken per os in the form of gelatin-glycine, seems to be capable of stimulating both the production of PCA by the stratum corneum and collagen synthesis in the dermis (17, 18, 19).

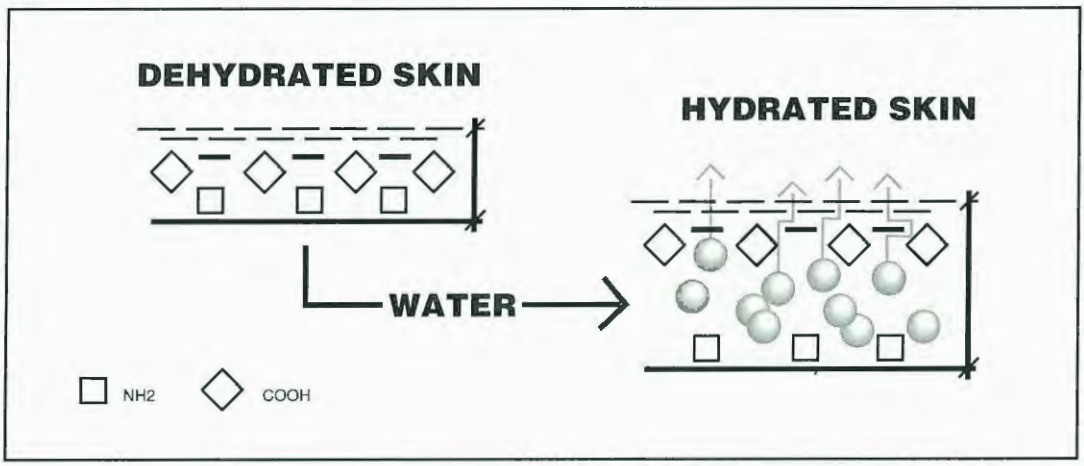
Furthermore, for topical use, glycine, together with lysine and arginine, is deemed to be the most active water-linking amino-acid. Thus, PCA, as a sodium salt (PCNa), and these amino-acids are presumed to regulate water exchanges between the stratum corneum and the dermis, . Therefore, any "active" cosmetic moisturizer must be capable of penetrating the lamellae of the stratum corneum's, linking water.

The importance of cosmetic vehicles

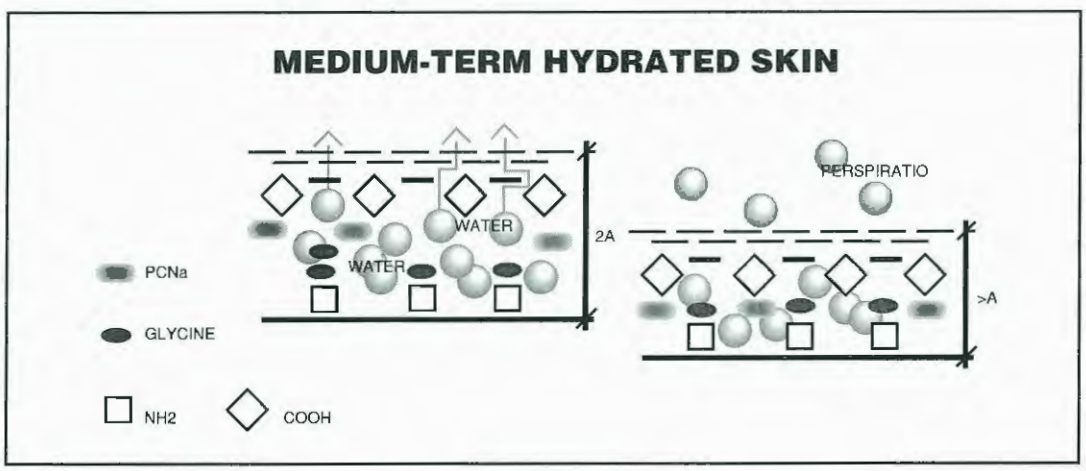
Unlike drugs, which the vehicles serve only to convey the active principle to the site where it is

expected to exert its pharmacological activity, cosmetic vehicles are often an active principle themselves.

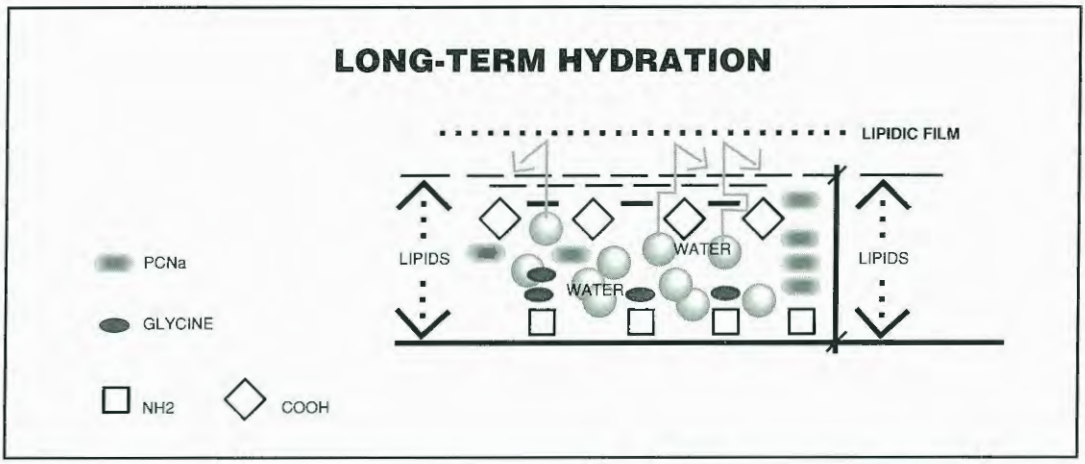
The cosmetic vehicle of a moisturizing cream, for example, is made up of a set of sebum-like lipids which are not only expected to convey the hydrating substances through the lamellae of the stratum corneum, but even become absorbed by them to restore the lipid film, which has been partially or totally destroyed by pathological conditions, environmental polluters or excessively strong cleansers. In this way a special connection between the cream's hydrating active principle, water and lipids is set up. The water delivered by the cosmetic could break the inter-protein hydrogen bonds of the keratins and induce a rapid soothing effect. This is summarized by the following scheme:



However, this quickly evaporating water can hydrate skin only for a very short time. Conversely, the active compounds used (PCNa, glycine, etc.) are deemed to establish more stable hydrogen bonds with the NH2 and COOH groups of skin keratins, thus retaining water for a longer period and allowing for medium-term hydration:



Finally, lipids are further presumed to slow water evaporation, promoting long-term hydration:



The thorough selection of lipids and active compounds together with their physical and chemical features is fundamental for the hydrating capacity of the cosmetic. It is not to be forgotten that lipids, due to their more or less accentuated occlusive power, induce build up of water in the skin-vehicle interface and, having an affinity for sebum, thus also helping penetration of the active principles.

However, the same affinity of both water and lipids is an important factor for their distribution through the skin layers.

Therefore the content in the vehicle of more "porous" and "hydrophilic" unsaturated fatty acids, such as linoleic and gamma-linolenic acid is not to be underated. These acids are well-known for being indispensable to the functioning and maintenance of the biological membrane structure. Likewise it is well known that the more unsaturated a membrane the greater the activity.

The topical administration of both linoleic and gamma-linolenic acids balances the fluidity and hydrophily of the cellular membrane, thus helping exchange of hydrosoluble compounds such as NMF and definitely improving hydration of the whole cutaneous ecosystem (20, 21, 22).

"Selective permeability" of cosmetic vehicles

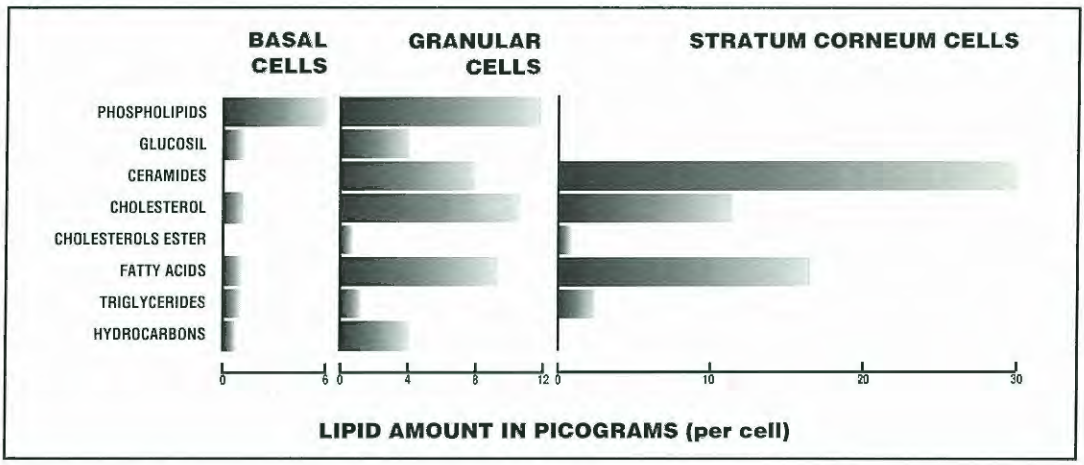
Skin is well known as a protective filter thanks to its protein and lipid barriers which lie mainly in the strautm corneum. Some of the (hydrophile) proteins and (lipophile) lipids of such barriers make up the basic material of the cell walls of the corneocyte.

The rest is contained in keratin fibers that are, in turn, wrapped in lipids and part of an amorphous protein matrix. Therefore, by the nature of this multi-layered hydrophilic and lipophilic structure, the stratum corneum forms a barrier to establish the skin's important protective function. These features permit a buildup of externally applied substances in the stratum disjunctum (upper horny layer) as a "reserve" for fairly long periods. This corneal barrier is impermeable to almost all chemical agents but may be traversed by small molecules mainly when their water/lipid distribution coefficient is equal to or nearly one.

Therefore, the simultaneous solubility of the active principles both in water and in lipids is to be regarded as a major factor when an actual "passage" through the skin layers is desired.

Conversely, such substances whose only feature is liposolubility can reach the interior of the sebaceous glands through the pilosebaceous ducts, although these make up only 1% of the whole cutaneous surface.
In addition to molecular size and solubility, there are other potential modifiers of the vehicle and absorption, such as environmental humidity, pH and surfactant effects, contact time, area and frequency of administration, temperature, skin thickness and condition (23, 24, 25, 26).

quality and quantity. The high variability of epidermal lipids must not be forgotten. A basal cell, in fact, contains some 10 picograms of lipids and a squame of the straum corneum about six times as much. In addition, both basal and granular celles have a high phospholipid content. There are no phospholipids in the stratum corneum, but a substantial amount of ceramides and fatty acids that are almost non-existent in basal and granular cells (27). Good cosmetic vehicles must first be easy to spread, so as to achieve close contact with the skin surface.



Diffusion indices

It seems that, for skin rehydration, a thorough selection of "safe" and "tested" active principles is fundamental. These have then to be inserted into a cosmetic vehicle which helps their diffusion and "anchoring" in the stratum corneum. Thus several vehicles with different "diffusion indices" can be formulated.
The task of a good vehicle is to help the contact between the active principle of the cosmetic and the cellular absorption membranes and, possibly, to release them over the desired period to the relevant cutaneous sites.
To achieve this, the vehicle is to be composed of a lipid mixture that makes it compatible with the lipids present on cutaneous area both for

They must also be perfectly tolerable, even when applied on large body surfaces for very long period and must be formulated to permit "perspiratio insensibilis", though this can be accelerated or reduced as desired. Finally they must be chemically and physically hydrophile (O/A emulsion), lipophile (A/O emulsion) or both (A/O/A emulsion) and have variable sizes for easily reaching the final cutaneous sites. Cosmetic vehicles must thus be "selectively permeable" according to the cosmetic and the active principles used. In sun products, for example, the vehicle must be designed to anchor the UV filter it to its components. UV filters, in fact, do not need to permeate the skin layers but to adhere to the vehicle which, in turn, is bound on the surface corneum. Conversely, hydrating

creams yield NMF over a longer time toboth surface and deep layers of the corneum. Finally, when the target is dermis, it is necessary to use a vehicle which yields the active principle rapidly and completely, helping penetration through all the epidermal layers (28, 29). For better control and balance of activity of cosmetic products, it will be necessary to formulate special vehicles with different "diffusion indices" giving their precise and selective permeability in relation to the skin components. This will allow an exact forecast of the penetration rate of both the product and the active principles.

Linoleic and gamma-linolenic acids (GLA) in skin hydration

The fast biological turnover of skin cells implies a very rapid exchange between biochemical substrates and molecular precursors for the final establishment of new cellular membranes. This is why the metabolism of membrane phospholipids and the related saturated and unsaturated fatty acids takes place extremely rapidly in the dermis (30, 31). In fact, the activity and functionality of skin tissue cells are conditioned by the hydrophobic interaction between unsaturated fatty acids and the apolar heads of the membrane proteins. Corneocytes, for example, accelerate water evaporation thus promoting diffusion of water vapour through the skin layers. However, an excessive increase of saturated fatty acids or an imbalance in the unsaturated fatty acid content of the cell membrane of the corneocyte can cause sudden water evaporation and "dry and dehydrated skin". A proper ratio of saturated "crystal structure" and unsaturated "liquid structure" fatty acids is thus an absolute requirement for an elastic and well hydrated skin. On the one hand, decreased skin hydration is related to a change in the ratio of saturated/unsaturated fatty acid in the surface lipid and, consequently in the cell membranes of the corneocytes. On the other hand, linoleic and gamma-linolenic acids (GLA) are well known for having deep hydrating effect if applied locally. Prostaglandin E1 and its precursor GLA are also known for their protective action at a cutaneous level (20). Further data have indicated that the amount but not the quality of skin's unsaturated fatty acids vary with age, even though some pathological states or ageing can lead to loss or reduction of the capacity to convert linoleic acid into GLA (32). Even a bad diet can affect these long-chain polyunsaturated fatty acids. When GLA is lacking, skin appears dry, fragile and dehydrated, without its natural elasticity. Furthermore, keratin synthesis becomes disorganized, barrier function is altered and PCA production decreases. It is well known that PCA is connected with filaggrine metabolism. Substantial lack of GLA leads to cutaneous pain, fragility of capillaries and fissuring, mainly in the folds of photo-exposed areas (33, 34, 21). The lack of polyunsaturated acids, the failure of "arachidonate" synthesis or of its metabolism into prostaglandins is supposed to underlie skin biomembrane injuries whose common factor is hyperkeratosis. Acne sufferers are well known for their shortage of linolenic acids, while psoriatics are richer in free arachidic acid probably due to insufficient conversione into prostaglandins. It seems that either the local or the systemic use of unsaturated acids, mainly linoleic and gamma-linolenic, is highly effective in the treatment of dry and dehydrated skin and atopic eczema (35, 36, 34, 37, 38). In addition, if well conveyed, gamma-linolenic acid seems active in local use for treatment of psoriasis (39).

Hydrating creams and UVA filters

Many dermatological investigations have shown that the rays of the sun and UVA radiaton directly affect the many biochemical processes that determine and accelerate cutaneous ageing and photopathology. In fact, unlike UV-B that is known for a superficial erythemic effect, UVA penetrates deeply to the basal layer and the connective tissue, degrading and dehydrating elastic fibers and collagen. In addition it oxidises membrane lipids and promotes formation of free radicals (40, 41, 42). Human skin clearly needs to be protected as far as possible from daily dosage of UVA in order to slow the skin ageing. To achieve this goal, modern hydrating creams, receive the addition of sun filters and screens aimed at neutralizing UV-A radiation (43).

Hydration and diet

As already mentioned, a relationship between skin hydration and oral administration of gelatin-glycine has recently been proved. Preparations enriched with vitamins C and B6 and mineral elements such as magnesium, calcium and iron, gelatin-glycine appear to improve bydration of the stratum corneum by about 30% after 60/90 days. This remarkable rehydrating effect seems to be caused by an increased PCA production which can be detected in the stratum corneum of the subjects (17, 18). Relationships between diet and skin hydration, diet and keratinogenesis, diet and skin in general are going to be deepened in the future. Nevertheless, if it is true that cosmetic treatments help to improve both the external aspects and function of the skin, they are not in themselves enough for restoring an altered skin. Therefore, it is still necessary to have sufficient sleep and to avoid smoking and excessive alcohol that have been proved to increase skin dryness. Finally, a natural, rich and balanced diet is fundamental to achieve a better quality of life.

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COMPUTERIZED REFLECTED OPTICAL DENSITOMETRY. A RESEARCH ON THE COLOUR OF THE SKIN

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Synopsis

In the field of dermatology, colour has always been a very important parameter of reference in diagnosis and clinical development of many dermatoses. The quantification of the chromatic variations of the cutis is conditioned by sensorial and perceptive characteristics of the observer, for that reason the study of the colour of the skin and the instrumentation for its measurement either in the red field (erythema) or in the dark (iper or acromia) is a problem that has interested many researchers.
After a brief review of the various international colorimetric systems (RGB, CMY, HLS, HSV, Tristimulus) which make it possible to assess every type of colour, and an analysis of the relationship that exists between light and the cutis, the authors describe a system which they have devised.
The system is composed of a light reflected densitometer X-Rite 404 which is able to quantify on a logarithmic scale both the total optical reflected density (named visual = V) of an opaque circular surface of 3.4 mm in diameter, and the values of the colours cyan, magenta and yellow that contribute to define V. The instrument can provide automatically the difference between two consecutive readings. For the graphic representation of the colour surveyed by the densitometer a 386 personal computer with mathematic co-processor and configured with hardware Targa 16 of the AT&T is utilized. The graphic card, capable of representing 32.760 colours, is directly connected to a high resolution monitor with persistent phosphorus and to the Ramtek photographic apparatus.
Tha graphic software RIO of the AT&T through the file colour allows insertion into the computer of the values obtained from the densitometer, their conversion automatically into the various systems

RGB, CMY, HLS and HSV and reproduction of the colour under examination on the monitor.
With this system, available to other workers, it is possible to analyze and quantify, in vivo, even small variations in skin colour and to reproduce them by means of a computer on a high definition monitor.
The methodology can be applied to determine and visualize the colour of normal skin or any cutaneous lesion or of the difference between healthy and unhealthy cutis, and applied to the quantification of the erythema. Parameters such as the intensity of the erythema (IE) and the erythema gradient (EG), which represents the difference between the IE of the damaged cutis and the IE of the apparent healthy cutis are described.
This methodology, non-invasive and easy to apply, appears useful for several areas in the medical field such as: dermatology, pharmacology, photobiology, forensic medicine, plastic surgery and cosmetology.

Riassunto

In campo dermatologico il colore è sempre stato un parametro di riferimento molto importante per la diagnosi e la valutazione del decorso clinico di molte dermatosi.
La quantificazione delle variazioni cromatiche della cute è condizionata dalle caratteristiche sensoriali e percettive dell'osservatore, per tale motivo lo studio del colore della pelle e la misura strumentale delle sue variazioni sia nel campo del rosso (eritema) che del bruno (iper o acromia) è un problema che ha interessato molti Ricercatori.
Gli Autori, dopo una breve rassegna sui vari sistemi colorimetrici (RGB, CMY, HLS, HSV, Tristimulus) mediante i quali è possibile valutare e rappresentare ogni tipo di tinta, e dopo l'analisi dei rapporti che intercorrono tra luce e cute, descrivono un sistema, da loro approntato, che permette di analizzare e quantificare, in vivo, anche piccole variazioni del colore cutaneo e di riprodurlo mediante computer su monitor ad alta definizione.
Premesso che la metodica può essere applicata per determinare e visualizzare il colore della pelle normale o di qualsivoglia lesione cutanea, o la differenza cromatica tra cute sana e cute malata, viene qui riferita la sua applicazione sulla quantificazione dell'eritema. Sono descritti e valutati parametri quali l'intensità dell'eritema (IE) e il gradiente di eritema (GE) che rappresenta la differenza tra l'IE della cute lesa e quello della cute apparentemente sana perilesionale.
Questa metodica non invasiva e di facile uso sembra utile per le numerose applicazioni che può avere in campo medico, potendo interessare la Dermatologia, la Farmacologia, la Fotobiologia, la Medicina Legale, la Chirurgia Plastica e la Cosmetologia.

Introduction

In the dermatological field colour has always been an important parameter of reference for the diagnosis and evaluation of the clinical course of many dermatoses.
Tha quantification of colour variations, even if trusted to the attentive and expert eye of the dermatologist, is not in fact the same for all observers. It depends on various physical and environmental conditions (colour temperature, light incidence, quantity of lumen, type of surface examining) and on the sensorial and perceptive characteristics of each person, and it can be influenced by physiological conditioning.
For these reasons, the study of skin colour and the measurement of its variations both in field of red (erythema) and in that of brown (iper or acromia) is a problem that has interested many authors and is until today not completely resolved.
The evaluation of the erythema induced by ultraviolet rays (UV) was attempted for the first time in 1927 by Hausser and Vahle who used red cards as standards for comparison. A similar technique, based on the apposition of various red photographic filters on the erythematous area, was described by Berger, Urbach & Davies in 1968.
In 1969, Tronnier examined a number of suitable instruments for the quantification of erythema, but the technological limitations at that time remained insurmountable for the preparation of an accurate apparatus easy for clinical and experimental use. Daniels & Imbrie (1958) and Breit & Kligman (1969) were the first to obtain useful results with a suitable instrument.
The recent introduction of computerized spectrophotometry and densitometry has allowed many authors (Dawson et al. in 1980; Wan, Jaenicke & Parrish in 1987; Andreassi et al. in 1988) to attain credible results. Although these instruments can offer valid measurements, the time needed to obtain results, the cost and the limited areas of use are critical factors for the acceptability of the technique.
We have tried to set up a system that would permit analysis and quantification in vivo of even small variations of skin colour and to reproduce them by computer on a high definition monitor. This methodology, non-invasive and easy to apply, appears useful for several applications in the medical field, in particular dermatology, pharmacology, photobiology, forensic medicine, plastic surgery and cosmetology.

Scientific basis of the method

A) Definition of colour

The visible solar spectrum, broken down by means of a prism, is a coloured band with wave lengths between 400 and 700 nm. The principal colours that can be distinguished are red, orange, yellow, green, cyan, blue and violet (without magenta and purple). For each colour there is a corresponding electromagnetic wave of clearly defined frequency.
The human eye is, however, unable, for example, to isolate the red colour from a white light or to analyze the various wave lengths that make up a particular colour. It, therefore, combines or synthesizes the stimulus in a complex sensation of colour.
The visual system of the retina is made up of a complicated interlacement of neurosensitive elements: one being sensitive to red light, one to green light and one to blue light. When these elements are stimulated, they produce a colour sensation. For example, if the element sensitive to red and the element sensitive to blue are simultaneously stimulated the sensation of magenta is attained.
Therefore, the human vision of colour seems to

be in relation to red, green and blue which are for this reason defined as primary additive colours. Combining these three colours in varying proportions every kind of hue can be produced even purple and magenta which are not included in the solar spectrum.

Based on this the International Commission of Light has elaborated a three-dimensional system known as Tristimulus or Triangle of Light or Horseshoe where all the colours perceptible by man are represented and the quantity in each one on the three primary colours that is needed to reproduce approximately every wave length of the spectrum. The three axes of the system represent the dominant wave length, the purity of excitation expressed in percentage (a colour from the spectrum can be 100% pure, while grey, white and black have 0% of purity), and finally the function of luminosity or transmittance or luminous reflection also expressed in percentage. These descriptive terms - dominant wave length, purity of excitation and function of luminosity - are the equivalent to colour, saturation and luminance.

The visible spectrum is also represented conventionally with a chromatic circle. Red (R), green (G) and blue (B) are the three primary additive colours and form the system RGB. By means of this model every type of light can be represented. Adding the three colours we obtain white light.

Examining the chromatic circle (Fig. 1) it becomes evident that, situated geometrically opposite the primary additive colours, are three others: cyan, magenta and yellow which are composed by coupling two adjacent primary additive colours. These colours are described as subtractive primaries since they represent white light minus a primary additive colour; they are considered as complementary colours of the primary additives and are therefore as negative colours. Yellow, for example, is the complementary of blue ad is made up by linking together red and green that are two primary additives; adding blue light

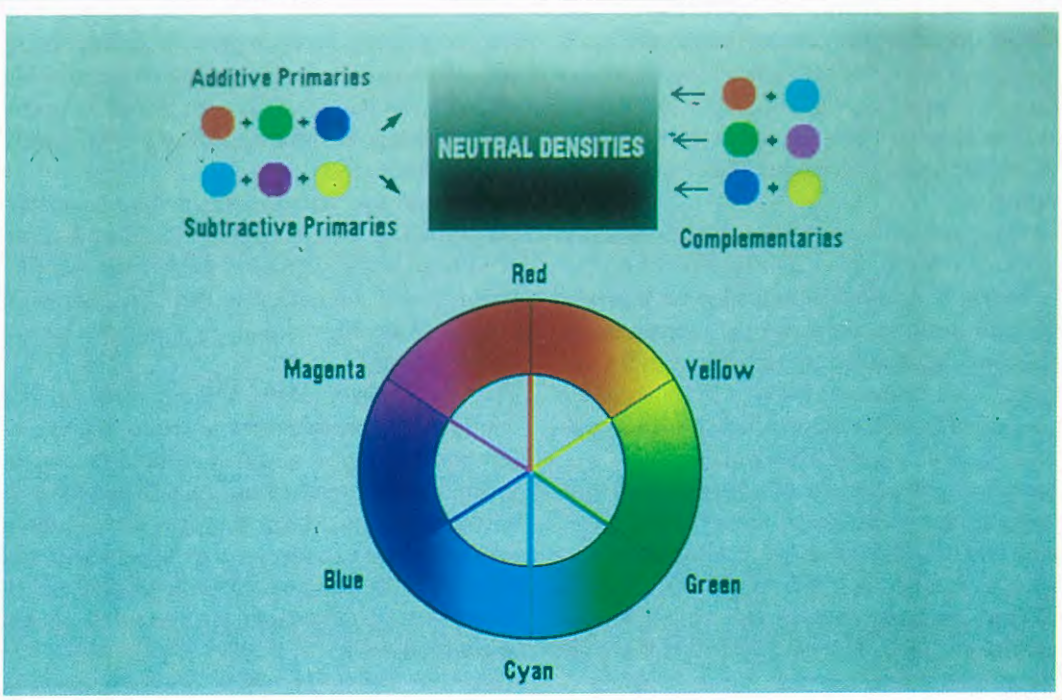

FIGURE 1

to yellow the entire pattern of primary additive colours is attained and therefore white light.
Cyan (C), magenta (M), and yellow (Y) from the system CMY by means of which it is possible to represent every kind of hue. From a mixture in equal parts of the three, primary subtractive colours black, or rather, no colour, is obtained.
The addition in equal parts of single couples of complementary colours, one additive and the other subtractive, gives an average tonality of grey.
In the models RGB and CMY the amounts of the colours that make up the final hue are expressed in percentages (Fig. 2).
The colour (hue = H) can also represented through the models HLS and HVS where H is expressed in degrees of the arc. Pure red is at zero.
In the HLS system the luminance (L) is expressed in percentage: with L = 100% the colour will always be white, with L = 0%, always black, indipendently of the saturation (S), also expressed in percentage. Keeping the luminance constant and varying the saturation, will give a scale from grey (S = 0%) to maximum colour (S = 100%).
In the model HSV, varying the power or colorimetric value (value = V) a scale from black (V = 0%) the maximum colour (V = 100%) will be attained, whereas varying the saturation, white is obtained with S = 0% and maximum colour with S = 100%.

FIGURE 2

B) Relationship between light and cutis

When the light of the visible spectrum hits a body, it primes a series of optical phenomena that define tha characteristic colorimetric response of the object: Trasmittance, Reflectance, Opacity and Density.

In particular, if one is dealing with an opaque body like the skin, part of incident light absorbed and the remainder is reflected. It is this reflected light, variuosly composed, that determines the colour perceived by the human eye and that is defined as the optical reflected density.(Fig. 3)

The term optical reflected density (D) corresponds to the logarithm to base 10 of a reciprocal of the reflectance (R):

$$D = \log 1/R$$

where R is the ratio of reflected light/incident light.

There are two types of optical reflected density: specular and diffuse. In the dermatological field it is more useful to evaluate the diffuse optical reflected density as the cutaneous surface is not perfectly smooth and produces the phenomena of multiple diffraction and refraction.

The band of light reflected from the skin is conditioned by the spectrum of absorption of chromophoric substances present both at the epithelial and dermal levels. The most important are DOPA-melanin, hemoglobin, oxyhemoglobin and bilirubin.

The colour of the skin, therefore, is the result of numerous components that determine the relationship light/vision and that render the colour which appears.

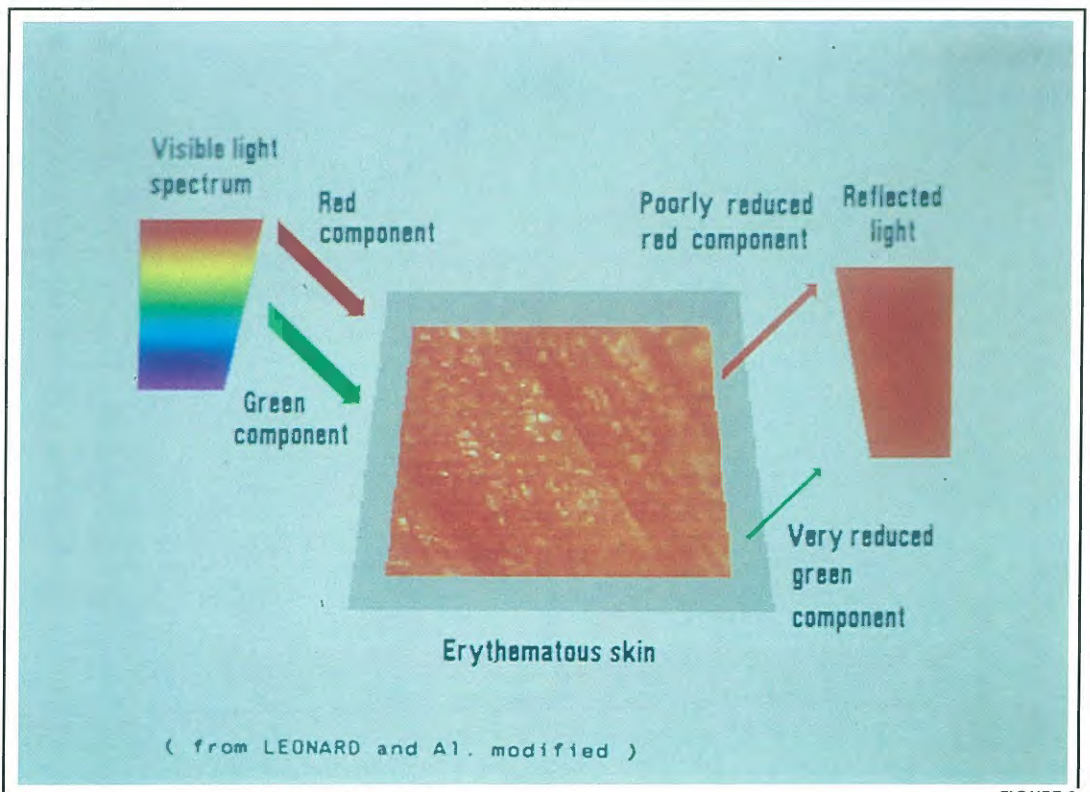

FIGURE 3

Material and instruments

Our system is composed of a light reflected densitometer X-Rite 404 which is able to quantify with logarithmic values to base 10 both the total optical reflected density (named visual = V) of an opaque circular surface of 3.4 mm in diameter, and the logarithmic values of the colours cyan, magenta and yellow that contribute to define V. The instrument automatically provides the difference between two consecutive readings.

For the graphic representation of the colour surveyed by the densitometer we utilize a 386 personal computer with mathematic co-processor, 20 MHz clock, 2.048 Kb RAM, a hard disk of 110 Mb, and configured with hardware Targa 16 of the AT & T.

The graphic card, capable of representing 32.760 colours, is directly connected to a high resolution monitor with persistent phosphorus and to the Ramtek photographic apparatus.

The graphic software RIO of the AT &T through the file colour allows us to insert into the computer the values obtained from the densitometer, to commute them automatically into the various systems RGB, CMY, HLS nd HSV and to reproduce the colour under examination on the monitor. The software encompasses work palette of 256 colours made up of 32 completely saturated colours, a spectrum of 32 low-luminance colours, a range of 32 reds, a range of 32 greens, a range of 32 blues, three ranges in cyan, magenta and yellow for a total of 32 colours, a scale of grey and one of brown (32 colours in total). The palette represent a part of the 32.768 hues that can be recalled in case of need.

Methods

Having already considered application of the method to determine and visualize the colour of normal skin, of cutaneous lesions or of the difference between healthy and unhealthy cutis, we now discuss its use for the quantification of erythema.

The intensity of erythema (IE) is due to the vasodilatation of the cutaneous microcirculation with a consequent increase in the quantity of red blood cells and therefore of hemoglobin (Hb). This Hb absorbs a considerable quantity of green light and reflects red light. Consequently the greater quantity of Hb will be present in the skin, the greater absorption of green light will be attained with an increase in reflected red colour.

The quantification of the IE is gained by subtracting the logarithm to base 10 of the inverse reflectance (R) of the red light from that of the green light:

(1) $IE = \log (1/R \text{ green}) - \log (1/R \text{ red})$

and then, using the scale of complementary colours:

(2) $IE = \log R \text{ magenta} - \log R \text{ cyan}$

The melanin content of the epidermis and the reflection of the light from the deep tissue layers do not affect the results of the equation (Diffey & Coll.).

The difference between the IE of the damaged cutis and the IE of the apparently healthy perilesional cutis represents the gradient of erythema (GE) (Diffey & Coll., Leonard & Coll.).

The densitometer, as already mentioned, quantifies with log 10 values the optical reflected density of cyan, magenta and yellow. So it is sufficient to substistute in equation (2) the values of M and C attained by the instrument to determine the IE of the damage or healthy cutis or the difference between the two (GE).

For the graphic representation of the colours obtained from the densitometer reading it is sufficient to transform from the logarithm into the cardinal number the values of cyan, magenta and yellow and to operate with the file colour of software RIO according to the model RGB or CMY.

Dealing with pure colours is attained.

Converting the scale of colours from RGB or CMY in HLS, the value of H in degrees of arc is attained. Giving to L the value obtained with the numerical transformation of logarithm to base 10 of the total optical reflected density expressed by V of the densitometer, and keeping invariable the values of saturation (S) attained with the construction of H with the model RGB and CMY, a similar or almost identical colour to that of the cutaneous surface under examination appears on the monitor.
Subtracting the values of the perilesional and apparently healthy skin from those of damaged skin, gives a hypothetical colour that represents the GE. Such chromatic difference in many cases shows a very high percentage luminance, close to 100% almost imperceptible by the human eye and quantifiable only by means of an instrument.
Our system is different from those presented by various authors (Diffey & Coll., Leonard & Coll., Thomas & Coll., Andreassi & Coll.) as it is interfaced witb a personal computer configured with a graphic card by means of which is possible to reproduce the skin colours under examination.

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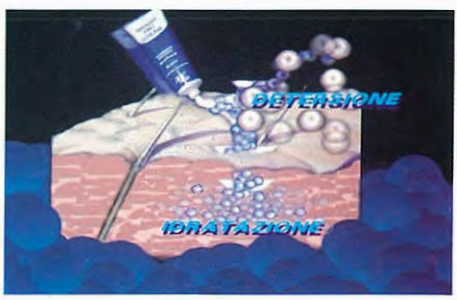

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