

Nutrition and nutritional supplementation

Impact on skin health and beauty

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Skin acts as a natural barrier between internal and external environments thus plays an important role in vital biological functions such as protection against mechanical/chemical damages, micro-organisms, ultraviolet damage. Nutrition has a critical impact on strengthening skin's capabilities to fight against these multiple aggressions.

Nutritional deficiencies are often associated with skin health disorders, while diets can either positively or negatively influence skin condition. More recently, the concept of nutritional supplementation has emerged as a new strategy in the daily practice of dermatology as well as a complementary approach to topical cosmetics in the field of beauty. Focusing on human clinical data, this paper proposes to illustrate the link between skin health and nutrition and to exemplify the beneficial actions of nutritional supplementation in skin health and beauty.

Introduction

Skin is the most extended and heaviest organ of the human body acting as a barrier between the internal and external environment. Skin structure associates tissues from various origins (epithelial, connective, vascular, muscular and nervous) and is organized in three different layers: the epidermis, the dermis and the hypodermis. With the exception of epidermis which is a non-vascular tissue, skin possesses a rich vascular network involved in tissues feeding, thermoregulation, wound healing, immune reactions and control of blood pressure.

Nutrition is defined as a biological process in animals and plants involving the intake of food and its subsequent assimilation into the tissues. From the 20th century scientists have identified different nutrients, which constitute the food and have defined nutritional standards and recommendations in order to prevent deficiencies and to promote human health. Nutritional supplements are defined as concentrated sources of nutrients or other substances with a nutritional or physiological effect that supplement the normal diet. At the beginning of the 21st century, increase life expectancy has emerged as new preoccupation for industrial countries and for nutritional science, which one of the challenges is to offer new strategies to improve the quality of human life.¹ In this context, nutritional supplements may be used to optimize diet and consequently to improve quality of life. Increased life expectancy is also associated with a need to appear healthy and handsome. Beside the traditional use of topical care, nutritional supplements have emerged as a new strategy to improve skin beauty.

Focusing on human clinical data, this paper proposes to illustrate the link between skin health and nutrition, and more particular the

effects of malnutrition and diets on cutaneous disorders and beneficial actions of nutritional supplementation in skin health and beauty.

Influence of Diet Deficiencies and Specific Diets on Skin Health

Nutrition is one of the most important parameters that is involved in modulating skin health and condition.^{2,3} Some of our understandings come from the description of the cutaneous manifestations of nutritional deficiencies.^{4,5} In the 1970s, Vasantha et al.⁶ demonstrated that kwashiorkor, a severe protein/calorie deficiency, was associated with skin biochemical changes in children, thus providing an explanation for the occurrence of cutaneous lesions of this syndrome. More recently, the reduction of total melanin content of scalp hair has been reported to be a characteristic of malnutrition in children.⁷

The impact of malnutrition on skin health is also illustrated by skin changes (xerosis, hair effluvium, nail modifications...) observed in anorexia nervosa.⁸

Vitamin deficiencies whether due to malnutrition or other factors (malabsorption and genetic defects) are associated with various dermatological modifications such as pellagra the classical image of niacin deficit,⁹ or hyperpigmentation which is associated with B₁₂ deficiency.¹⁰ Also trace elements are essential for skin health and their deficit is related to skin modifications.^{2,11}

Malnutrition as well as excessive food intake can impair skin physiology. Indeed, obese people exhibit significant increase in transepidermal water loss suggesting an alteration of skin barrier function. Furthermore, obesity may affect sebum production, contribute to micro and macro circulation changes, and modify

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collagen metabolism. Finally, obesity is associated with a number of dermatoses such as acanthosis nigricans, acrochordons and keratosis pilaris.¹²

Wound healing is a complex phenomenon involving interactions between different cells type, cytokine, and the extracellular matrix. Nutritional deficiencies can impair wound healing, while some nutrients (vitamins A and C, zinc, glucosamine) may reduce healing time and improve wound quality.¹³

Still controversial,¹⁴ the link between diet and acne has been recently highlighted by a study on male volunteers with acne showing a greater improvement in total lesion count in the low glycaemic diet group compared to the control group.¹⁵ In the same study, acne lesion count has been shown to be correlated with the increase of the ratio of saturated to monounsaturated fatty acids of skin triglycerides.

Atopic dermatitis (AD) is a chronic inflammatory skin disorder characterized by an impaired skin barrier function associated with a Th2-driven T cells overproduction. Foods hypersensitivity seems to play a pathogenic role in the development of AD lesions¹⁶ and dietary exclusion of specific food has been reported to improve the disease in children.¹⁷ Moreover, Tanaka et al.¹⁸ have recently evaluated the effect of a vegetarian diet as an alternative therapy for the management of AD. After 2 months of this specific regimen, the SCORAD (SCORing Atopic Dermatitis) decreased by almost 50%.

Diet has also been described to play a key role in the etiology and pathogenesis of psoriasis, one of the most common chronic skin inflammatory disorders.¹⁹ Low energy diet could be an important adjuvant factor in the prevention and treatment of psoriasis.²⁰ Vegetarian diet as well as fasting periods may be also beneficial.²¹ These effects could be explained by a lack of arachidonic acid, limiting thus the inflammation cascade and a reduction of oxidative stress due to caloric restriction.

Furthermore some evidences exist about the influence of food on the development of UV-induced skin lesions. Indeed, a review of the results obtained in epidemiological studies suggests a positive relationship between fat intake and both basal and squamous cell carcinoma.²² A few years later, the same team demonstrated, in a cohort of 1,360 adults, that diet with high meat and fat intake significantly increases the risk of squamous cell carcinoma, particularly in persons with history of skin cancer.²³ In 2009, the results of a prospective study showed a moderate decrease of actinic keratosis among the highest consumers of fish oil.²⁴ In the same way, some dietary factors present in the Mediterranean diet might protect against skin melanoma.²⁵

Beneficial Effects of Nutritional Supplementation on Skin Health and Beauty

Many attempts have been made to improve skin health and beauty by changing or by supplementing the diet.²⁶ In 2001, Boelsma et al.²⁷ reviewed the effects of vitamins, carotenoids and fatty acids supplementation in optimizing skin condition and preventing skin diseases and concluded that nutritional factors show potential beneficial actions on the skin.

Specific nutritional interventions using probiotics are described in some studies to exert beneficial effects in the treatment and/or prevention of AD, with a decrease in SCORAD or a decrease of the frequency of AD in the first two years of life.²⁸ In a recent paper Koch et al. reported the beneficial effect (decrease of SCORAD) of docosahexaenoic acid supplementation in atopic eczema.²⁹ In the same way, oral evening primrose oil has shown to have a beneficial effect in eczema³⁰ and a dietary supplement with fish oil has shown beneficial effect in the management of psoriasis and eczema.³¹

Photoprotection obtained by nutrients is well documented. Skin exposure to ultra-violet (UV) leads directly or indirectly through the generation of reactive oxygen species to a large range of photodamage affecting cellular lipids, proteins and DNA. It is involved in erythema appearance, premature skin aging, photo-immunosuppression and skin cancer.³²⁻³⁴

The most frequent damage induced by UV exposure is sunburn, and evidence of nutritional supplementation in sunburns' prevention has been reported. β -carotene (from 15 to 180 mg/day) and lycopene (up to 10 mg/day), two efficient singlet oxygen quenchers, have been shown to prevent sunburn in humans.³⁵⁻³⁸ Systemic administration of antioxidants such as vitamins C (2 mg/day) and E (1,000 IU/day), as well as dietary fish oil (2 g/day) rich in omega-3 free fatty acids increased minimal erythema dose.^{39,40} The effect of fish oil on UV-induced inflammation may be partially explained by its ability to reduce prostaglandin E₂ levels.⁴¹ Polyphenol provided by the ingestion of high flavanol cocoa (326 mg/day) reduced UV-induced erythema.⁴² *Polypodium leucomotos* (7.5 mg/kg body weight), a tropical fern plant used traditionally in Central America for the treatment of anti-inflammatory disorders, has also been shown to counteract the erythemal effect of UV exposure.⁴³ Finally a specific association of a probiotic (*Lactobacillus johnsonii*, La1) with carotenoids (β -carotene: 4.8 mg/day; lycopene: 2 mg) was also shown to increase minimal erythema dose.⁴⁴

UV exposure can lead to both direct and indirect DNA damage. The major direct DNA damage is the release of cyclobutane pyrimidine dimers (thymine dimers and 6–4 photoproducts). Placzek M et al.⁴⁵ have shown that the oral administration of vitamins C (2 mg/day) and E (1,000 IU/day) during 3 months had a protective effect against UV-induced thymine dimers.

UV exposure also causes local and systemic immunosuppression, and several mechanisms are involved in this deleterious effect, among which UV-induced depletion of Langerhans cells (LC), the major antigen presenting cells in the skin.⁴⁶

A placebo controlled study demonstrated that β -carotene (30 mg/j) protects against photo-immunosuppression.⁴⁷ Oral administration of *Polypodium leucomotos* (1,080 mg) prior to UV exposure seemed to protect CD1a⁺ cell density and to preserve the dendricity of immune cells.⁴⁸ More recently, oral supplementation with the probiotic strain *Lactobacillus johnsonii* has been shown to accelerate the recovery of human skin immune homeostasis after UV-induced immunosuppression.⁴⁹ This specific strain associated with carotenoids (β -carotene: 4.8 mg/day; lycopene: 2 mg) was also able to counteract UV-induced decrease of LC density in human volunteers.⁴⁴

Increased life expectancy is associated with a need to appear healthy and handsome. Very recently, epidemiological study evidence that multivitamin use is associated with longer telomere length, a marker of biological aging, in women.⁵⁰ Skin, especially facial skin, is one of the most important factors in attractiveness. Two papers reported that food and nutrients intake can influence skin aging. In 2001, Purba et al. described that actinic damage especially skin wrinkling may be associated with food habits. In this study, high intake of vegetables, legumes and olive oil seem to be protective against cutaneous actinic damage.⁵¹ In another paper, higher intakes of vitamin C and linoleic acid and lower intakes of fat and carbohydrates were shown to be associated with better skin appearance.⁵² Beside the traditional use of topical care, nutritional supplements have emerged as a new strategy to improve skin beauty.

Yamakoshi et al.⁵³ investigated the effect of oral intake of a proanthocyanidine enriched-extract (201 mg a day, during 6 months) on facial hyperpigmentation in women and demonstrated that this extract was able to improved chloasma determined by clinical evaluation as well as by using colorimetric method. Oral fish polysaccharides (3 x 250 mg per day, during 8 weeks) associated with an antioxidant mix have been shown to improve dermal thickness, skin wrinkling, color and viscoelasticity after 2 months of supplementation.⁵⁴ Silicon (20 mg per day) taken during 20 weeks enhanced skin microrelief and mechanical properties in women with photo-damaged skin.⁵⁵ A combination of lycopene (6 mg), vitamin C (60 mg) and soy isoflavones (50 mg) has been shown to maintain skin density, improve skin firmness, microrelief, hydration and tone in menopausal women.⁵⁶ Hair loss is a very common problem for both men and women: it affects up to 80% of men and 50% of women in their life time.⁵⁷ It has been shown in both men and women that the association of

antioxidants with polyunsaturated fatty acids, zinc, taurine and plant polyphenols was able to restore a more balanced hair cycle leading to decreased hair loss and increased hair density together with an improvement of hair quality.⁵⁸

In recent decades, the incidence of subjects presenting reactive skin has considerably increased in industrialized countries. Reactive skin is characterized by marked sensitivity of the skin to physical (heat, cold, wind) or chemical (topical product application) stimuli and occasionally by impaired ability for skin barrier function recovery. A recent study demonstrated that after 43 days of supplementation, a specific probiotic called *L. paracasei* decreased significantly skin sensitivity compared to placebo, and also increased the recovery rate of the skin barrier function induced by mechanical disruption.⁵⁹

Conclusions

The data presented in this paper show evidence of a clear link between nutrition and skin condition demonstrating the impact of nutrition on skin health and beauty. Evidence from literature review as well as internal published or unpublished work show that appropriate nutritional supplementation is beneficial in the prevention of the harmful effect of UV exposure, in the management of skin aging and of reactive skin, as well as for limiting hair loss.

Altogether, the data show that a balanced diet associated with cosmetics and/or oral supplementation at nutritional dose and/or drugs could represent a globalized approach for improving skin health and beauty.

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References

- Roberfroid MB. Aliments fonctionnels: définitions, concepts et stratégies. In Roberfroid M, Coxam V, Delzenne N, eds. Aliments Fonctionnels, seconde édition. Paris: Lavoisier 2008; 53-72.
- Sarno Ryan A, Goldsmith LA. Nutrition and the skin. Clin Dermatol 1996; 14:32-4.
- Rushton DH. Nutritional factors and hair loss. Clin Exp Dermatol 2002; 27:396-404.
- Oumeish OY, Oumeish I. Nutritional skin problems in children. Clin Dermatol 2003; 21:260-3.
- Fuchs J. Alcoholism, malnutrition, vitamin deficiencies and the skin. Clin Dermatol 1999; 17:457-61.
- Vasantha L, Srikantia SG, Gopalan C. Biochemical changes in the skin in Kwashiorkor. Am J Clin Nutr 1970; 23:78-82.
- McKenzie CA, Wakamatsu K, Hanchard NA, Forrester T, Ito S. Childhood malnutrition is associated with a reduction in the total melanin content of hair scalp. Br J Nutr 2007; 98:154-9.
- Strumia R, Varotti E, Manzato E, Gualandi M. Skin signs in anorexia nervosa. Dermatology 2001; 203:314-7.
- Barthelemy H, Chouvet B, Cambazar F. Skin and mucosal manifestations in vitamin deficiency. J Am Acad Dermatol 1986; 15:1263-74.
- Niyama S, Mukai H. Reversible cutaneous hyperpigmentation and nails with white hair due to vitamin B12 deficiency. Eur J Dermatol 2007; 17:551-2.
- Malanin K, Telegdy E, Qazaq H. Hair loss and serum zinc values among Arab females in Al Ain region, United Arab Emirates. Eur J Dermatol 2007; 17:446-7.
- Yosipovitch G, DeVore A, Dawn A. Obesity and the skin: skin physiology and skin manifestation of obesity. J Am Acad Dermatol 2007; 56:901-16.
- MacKay D, Miller AL. Nutritional support for wound healing. Altern Med Rev 2003; 8:359-77.
- Danby FW. Diet and acne. Clin Dermatol 2008; 26:93-6.
- Smith RN, Braue A, Varigos GA, Mann NJ. The effect of low glycemic load diet on acne vulgaris and the fatty acid composition of skin surface triglycerides. J Dermatol Sci 2008; 50:41-52.
- Burks W. Skin manifestations of food allergy. Pediatrics 111:1617-24.
- Uenishi T, Sugiura H, Tanaka T, Uehara M. Role of foods in irregular aggravation of skin lesions in children with atopic dermatitis. J Dermatol 2008; 35:407-12.
- Tanaka T, Kouda K, Kotani M, Takeuchi A, Tabei T, Masamoto Y, et al. Vegetarian diet ameliorates symptoms of atopic dermatitis through reduction of the number of peripheral eosinophils and of PGE2 synthesis by monocytes. J Physiol Anthropol 2001; 20:353-61.
- Wolters M. Diet and psoriasis: experimental data and clinical evidence. Br J Dermatol 2005; 153:706-14.
- Rucevic I, Perl A, Barisi-Drusko V, Adam-Perl M. The role of the low energy diet in psoriasis vulgaris treatment. Coll Antropol 2003; 27:41-8.
- Lithell H, Bruce A, Gustafsson IB, Höglund NJ, Karlström B, Ljunghall K, et al. A fasting and vegetarian diet treatment trial on chronic inflammatory disorders. Acta Derm Venereol 1983; 63:397-403.
- McNaughton SA, Marks GC, Green AC. Role of dietary factors in the development of basal cell cancer and squamous cell cancer of the skin. Cancer Epidemiol Biomarkers Prev 2005; 14:1596-607.
- Ibibebe TI, van der Pols JC, Hughes MC, Marks GC, Williams GM, Green AC. Dietary pattern in association with squamous cell carcinoma of the skin: a prospective study. Am J Clin Nutr 2007; 85:1401-8.
- Hughes MCB, Williams GM, Fourtanier A, Green C. Food intake, dietary patterns, and actinic keratosis of the skin: a longitudinal study. Am J Clin Nutr 2009; 89:1246-55.
- Fortes C, Mastroeni S, Melchi F, Pilla MA, Antonelli G, Camaioni D, et al. A protective effect of the Mediterranean diet for cutaneous melanoma. Int J Epidemiol 2008; 37:1018-29.
- Burton JL. Diet and dermatology. BMJ 1989; 298:770-1.
- Boelsma E, Hendriks HFJ, Roza L. Nutritional skin care: health effects of micronutrients and fatty acids. Am J Clin Nutr 2001; 73:853-64.
- Betsi GI, Papadavid E, Falagas ME. Probiotics for the treatment or prevention of atopic dermatitis: a review of the evidence from randomized controlled trials. Am J Clin Dermatol 2008; 2:93-103.
- Koch C, Dölle S, Metzger M, Rashe C, Jungclas H, Rühl R, et al. Docosahexaenoic acid (DHA) supplementation in atopic eczema: a randomized, double-blind, controlled trial. Br J Dermatol 2008; 158:786-92.

30. Wright S, Burton JL. Oral evening primrose seed oil improves atopic eczema. *Lancet* 1982; 2:1120-2.
31. Burton JL. Dietary fatty acids and inflammation in skin disease. *Lancet* 1989; 1:27-31.
32. Matsumura Y, Ananthaswamy HN. Toxic effects of ultraviolet radiation on the skin. *Toxicol Appl Pharmacol* 2004; 195:298-308.
33. Fisher GJ, Kang S, Varani J, bata-Csorgo Z, Wan Y, Datta S, Voorhees JJ. Mechanism of photoaging and chronological skin aging. *Arch Dermatol* 2002; 138:1462-70.
34. Schwarz T. Photoimmunosuppression. *Photodermatol Photoimmunol Photomed* 2002; 18:141-5.
35. Stahl W, Heinrich U, Wiseman S, Eicher O, Sies H, Tronnier H. Dietary tomato paste protects against ultraviolet light-induced erythema in humans. *J Nutr* 2001; 131:1449-51.
36. Stahl W, Heinrich U, Aust O, Tronnier H, Sies H. Lycopene-rich products and dietary photoprotection. *Photochem Photobiol Sci* 2006; 5:238-42.
37. Sies H, Stahl W. Nutritional photoprotection against skin damage from sunlight. *Annu Rev Nutr* 2004; 24:173-200.
38. Köpcke W, Krutmann J. Protection from sunburn with β -carotene-A meta-analysis. *Photochem Photobiol* 2008; 84:284-8.
39. Eberlein-König B, Placzek M, Przybilla B. Protective effect against sunburn of combined systemic ascorbic acid (vitamin C) and d- α -tocopherol (vitamin E). *J Am Acad Dermatol* 1998; 38:45-8.
40. Rhodes LE, O'Farrell S, Jackson MJ, Friedmann PS. Dietary fish-oil supplementation in humans reduces UVB-erythral sensitivity but increase epidermal lipid peroxidation. *J Invest Dermatol* 1994; 103:151-4.
41. Rhodes LE, Durham BH, Fraser WD, Friedmann PS. Dietary fish oil reduces basal and ultraviolet B-generated PGE₂ levels in skin and increases the threshold to provocation of polymorphic light eruption. *J Invest Dermatol* 1995; 105:532-5.
42. Heinrich U, Neukam K, Tronnier H, Sies H, Stahl W. Long-term ingestion of high flavanol cocoa provides photoprotection against UV-induced erythema and improves skin condition in women. *J Nutr* 2006; 136:1565-9.
43. Middelkamp-Hup MA, Pathak MA, Parrado C, Goukassian D, Rius-Diaz F, Mihm MC, et al. Oral polypodium leucomotos extract decreases ultraviolet-induced damage of human skin. *J Am Acad Dermatol* 2004; 51:910-8.
44. Bouilly-Gauthier D, Jeannes C, Maubert Y, Duteil L, Queille-Roussel C, Piccardi N, et al. Clinical evidence of skin benefits of a dietary supplement containing probiotic and carotenoids on UV-induced damage. *Bn J Dermatol*, (submitted).
45. Placzek M, Gaube S, Kerkmann U, Gilbertz KP, herzinger T, Haen E, Przybilla B. Ultraviolet B-induced DNA damage in human epidermis is modified by the antioxidants ascorbic acid and d- α -tocopherol. *J Invest Dermatol* 2005; 124:304-7.
46. Schwarz T. Mechanisms of UV-induced immunosuppression. *Keio J Med* 2005; 54:165-71.
47. Fuller J, Faulkner H, Bendich A, Parker RS, Roe DA. Effect of β -carotene supplementation on photosuppression of delayed-type hypersensitivity in normal young men. *Am J Clin Nutr* 1992; 56:684-90.
48. Gonzales S, Pathak MA, Cuevas J, Villarrubia VG, Fitzpatrick TB. Topical or oral administration with an extract of *Polypodium leucomotos* prevents acute sunburn and psoralen-induced phototoxic reactions as well as depletion of Langerhans cells in human skin. *Photodermatol Photoimmunol Photomed* 1997; 13:50-60.
49. Peguet-Navarro J, Dezutter-Dambuyant C, Buetler T, J Leclaire, Smola H, Blum S, et al. Supplementation with oral probiotic bacteria protects human cutaneous immune homeostasis after UV exposure-double blind, randomized placebo controlled clinical trial. *Eur J Dermatol* 2008; 18:504-11.
50. Xu Q, Parks CG, De Roo LA, Cawthon RM, Sandler DP, Chen H. Multivitamin use and telomere length in women. *Am J Clin Nutr* 2009; 89:1-7.
51. Purba M, Kouris-Blazos A, Wattanapenpaiboon N, Lukito W, Rothenberg EM, Steen BC, Walquist ML. Skin wrinkling: can food make a difference? *J Am Coll Nutr* 2001; 1:71-80.
52. Cosgrove MC, Franco OH, Granger SP, Murray PG, Mayes AE. Dietary nutrient intakes and skin-aging appearance among middle-aged women. *Am J Clin Nutr* 2007; 86:1225-31.
53. Yamakoshi J, Sano A, Tokutake S, Saito M, Kikuchi M, Kubota Y, et al. Oral intake of proanthocyanidin-rich extract from grape seeds improves chloasma. *Phytotherapy Research* 2004; 18:895-9.
54. Distanto F, Scalise F, Rona C, Bonfigli A, Fluhr JW, Berardesca E. Oral fish cartilage polysaccharides in the treatment of photoaging: biophysical findings. *Int J Cosmet Sci* 2002; 24:81-7.
55. Barel A, Calomme M, Timchenko A, De Paep K, Demester N, Rogiers V, et al. Effect of oral intake of choline-stabilized orthosilicic acid on skin, nails and hair in women with photodamaged skin. *Arch Dermatol Res* 2005; 297:147-53.
56. B Dréno. New assessment methods applied to a patented lacto-lycopene, soy isoflavones and vitamin C in the correction of skin aging. *Nouv Dermatol* 2003; 22:1-6.
57. Tosti A, Piraccini M, Lorizzo M, Voudouris S. The natural history of androgenetic alopecia. *J Cosmet Dermatol* 2005; 4:41-3.
58. Bouilly-Gauthier D, Jeannes C, Dupont N, Piccardi N, Manissier P, Heinrich U, Tronnier H. A new nutritional supplementation is effective against hair loss and improves hair quality. *EADV* 2008; 1003.
59. Benyacoub J, Gueniche A, Bureau-Franz I, Castiel I. Probiotiques et peau. In Roberfroid M, Coxam V, Delzenne N, eds. *Aliments Fonctionnels*, seconde édition. Paris: Lavoisier 2008; 633-43.