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Mini review: the effects of coenzyme Q10 on skin functions and health

KEYWORDS: Coenzyme q10, CoQ10, skin, anti-aging, dietary supplements.

Abstract Coenzyme Q10 (CoQ10) is a natural substance found in all human cells that plays a fundamental role in cellular bioenergetics. It is also a very effective antioxidant with a range of possible benefits for human health. Due to its perceived ability to protect the skin from free radical damage and reduce signs of ageing, CoQ10 has become a very popular ingredient in cosmetics and so-called beauty foods. In the paper, we review in vitro and in vivo studies regarding its influence on the skin.

INTRODUCTION

Coenzyme Q10 (CoQ10), also known as ubiquinone 10, is an important lipid soluble compound, a coenzyme present in all human cells. It plays a fundamental role in cellular bioenergetics as an electron carrier in the oxidative phosphorylation process in mitochondria, which convert energy from carbohydrates and fatty acids into adenosine triphosphate (ATP) to drive cellular machinery and synthesis (1). In addition, for over three decades CoQ10 has been known as an effective antioxidant capable of functioning synergistically with other antioxidants, and with several possible benefits for human health (2-4).

In humans, CoQ10 is chiefly found in the most active organs like the heart, kidney and liver. About 50% of total CoQ10 is located in mitochondria, making it very accessible to free radicals that form during the oxidative phosphorylation process (5). Coenzyme Q10 is distributed in all membranes throughout a cell (6). The presence of CoQ10 in the membranes of eukaryotic cells suggests its potential to act as a free radicals scavenger, preventing the activation of inflammatory signalling pathways (7). There is also increasing evidence of CoQ10 playing a role in the control of cell functions and growth (1). Several potential health benefits of CoQ10 supplementation have been reported. Its beneficial role has been shown in various clinical conditions such as cardiovascular conditions (8-10), mitochondrial conditions and neurodegenerative conditions (11-13), diabetes (14), periodontal disease (15) and male infertility (16). Since most of those studies were not performed on healthy population groups, such evidence cannot be used to substantiate health claims on foods (17). Consequently in the European Union there are no authorised health claims regarding CoQ10 as a functional food ingredient.

CoQ10 is an endogenous compound, but its synthesis reduces progressively with age, resulting in a decline of endogenous CoQ10 levels in all tissues (18, 19). CoQ10 is also supplied to the organism by exogenous sources, e.g. meat, migratory fish, dairy products, nuts and some vegetable oils as major sources in the human diet, yet the average dietary intake of CoQ10 is only 3–5 mg in the diet of populations of Western countries (20).

CoQ10 LEVELS IN SKIN DECLINE WITH AGE

Covering the entire outer surface of the body, human skin is constantly exposed to external stress factors, e.g. UV irradiation. Within the skin, the highest levels of CoQ10 are found in the epidermis (21) and in skin surface lipids (SSL), a constituent of the stratum corneum (SC). There it acts, in combination with other compounds, as the skin's outermost barrier to oxidant assault, protecting the deeper layers of the skin from environmental stress factors (21, 22). CoQ10 is able to protect cells against reactive oxygen species (ROS) insult by keeping cells' antioxidative system working (23).

Cutaneous ageing is characterised by a drop of energy metabolism in skin cells due to changes in mitochondrial respiration, a consequence of the harmful effects of free radicals induced by exogenous (e.g. UV irradiation) and endogenous factors. The alternations in mitochondrial respiration are both the reason for ageing as well as its outcome. Since CoQ10 is crucial for maintaining mitochondrial activity in cells, it is able to retain proper energy levels and alleviate ROS formation, maintaining mitochondrial energy metabolism (23). It has been shown that CoQ10 levels in the skin and skin surface lipids decline with age (18, 22, 24).

Although without authorised health claims, CoQ10 can commonly be found in the marketplace in food supplements (25) and functional foods (26), particularly in products intended to support heart health. It is also frequently a cosmetic ingredient, mostly due to its perceived ability to protect the skin from free radical damage and reduce signs of ageing.

In relation to this, CoQ10 has also become an ingredient in so-called *beauty foods* formulated to support skin health, but until recently the evidence for such use was scarce.

EFFECTS OF CoQ10 ON SKIN – *IN VITRO* EXPERIMENTS AND ANIMAL STUDIES

As shown by a range of *in vitro* experiments or animal studies, CoQ10 is also able to reduce the formation of oxidative stress in human skin connected with increasing age (27). It positively influences the age-affected cellular metabolism in keratinocytes (24, 28), retains activities of superoxide dismutase (SOD) and glutathione peroxidase (GPx) in UVA-irradiated fibroblasts (29, 30) and reduces lipid peroxidation and DNA damage induced by UVA irradiation, thereby protecting cells against apoptosis induced by oxidative stress (31, 32). It also prevents UVR-induced inflammation by decreasing inflammatory mediators and prevents UV-R induced expression of matrix metalloproteinase-1 (MMP-1) – enzymes that degrade extracellular matrix components (33, 34). In addition, it is able to enhance dermal, epidermal and basement membrane components expression, i.e. laminin 332 and type IV and VII collagens, in keratinocytes and fibroblasts, respectively; however, it has no effect on type I collagen production in fibroblasts (31, 35). CoQ10 is also able to suppress melanin synthesis (35, 36).

These results suggest that protection of the epidermis against oxidative stress and enhancement of the production of epidermal basement membrane components may be involved in the anti-ageing properties of CoQ10 in skin. Further, some *in vivo* studies also investigated the effects of CoQ10 on human skin parameters and condition – either with topical or oral CoQ10 application.

Despite very promising results of *in vitro* studies, reports of *in vivo* effects of CoQ10 on human skin condition and function with proper control and statistical evaluation are scarce.

EFFECTS OF CoQ10 ON SKIN – HUMAN *IN VIVO* EXPERIMENTS

Topical application of CoQ10

It has been shown that topically applied CoQ10 in a proper formulation is able to penetrate the skin and reach the vital layers of the skin; its levels were raised in skin surface lipids as well as in deeper layers of the epidermis (24, 29). Concurrent elevation of epidermal ubiquinol levels suggested the metabolic transformation of ubiquinone due to increased energy metabolism (24). Topically applied CoQ10 also improves the antioxidant potential of skin (24, 37) and may reduce the effects of skin photoageing (32). In a study carried out on 20 women, six months of daily application of CoQ10 (0.3% in vehicle) reduced the depth of wrinkles around the eyes in aged human skin for 27% (mean peak to valley depth determined by profilometry), but no statistical data for these effects and for comparison with control were provided (32). Similarly, in another experiment involving 31 women, the beneficial effect on wrinkle reduction was observed after 5 months of topical CoQ10 (1% cream) application as wrinkle grade score was reduced, but there was no statistical difference in efficacy between CoQ10 and placebo group (34). In a further trial on 50 subjects with photoaged skin, 0.5% or 1% idebenone (synthetic CoQ10 analogue) lotion was applied daily for six weeks (38). The results showed an increase of collagen I expression and decrease of MMP-1 enzymes activity in treated skin. Both products improved skin hydration and according to expert assessments also skin roughness, wrinkles/fine lines and the overall global assessment of photoaged skin were improved with both idebenone lotions. However, a vehicle control group was lacking and it seemed that moisturising effects and some other related effects e.g. skin roughness improvement were associated more with the lotion base than idebenone.

Although *in vitro* studies have shown that CoQ10 is able to decrease UV-induced damage and inflammatory response, photoprotective effects of CoQ10 or its synthetic analogue idebenone were not observed for *in vivo* topical applications (39).

Oral application of CoQ10

Only a few studies have investigated the effects of CoQ10 supplementation on the skin. Passi et al. tested a combination of topical and oral application of CoQ10 together with other antioxidants (40). For 60 days, 50 subjects were daily treated with cream containing 0.05% CoQ10, 0.1% vit. E, 1% squalene (SQ) and half of them also received a food supplement with 50 mg CoQ10, 50 mg vit. E and 50 µg selenium. Topical application resulted in increased CoQ10, vit. E and SQ in the sebum, but not in plasma or stratum corneum. The concomitant oral administration of antioxidants produced a significant rise in CoQ10 and vitamin E in both plasma and stratum corneum, but sebum levels of CoQ10 and vit. E were not additionally elevated. Using profilometry, a significant reduction of wrinkle depth compared to the baseline condition was observed and, according to self-assessments, skin softness, smoothness and brightness were also improved. However, to be able to attribute those anti-ageing effects to antioxidants in formulations, a proper placebo control is needed, thus results should be interpreted with care.

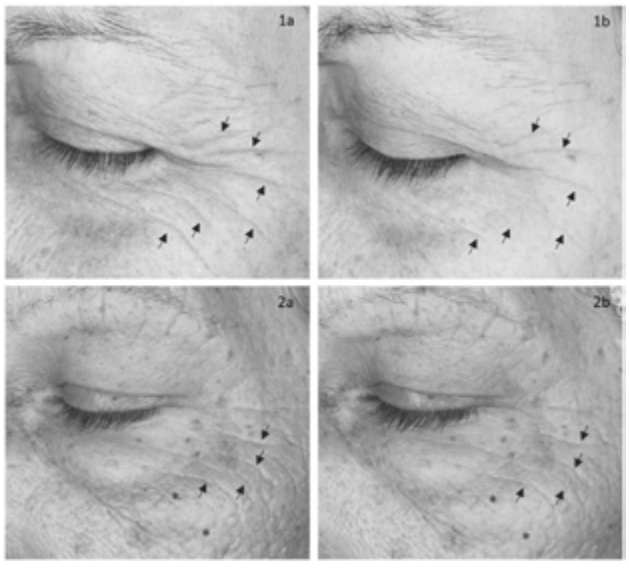

Figure 1. Reproduced with the permission of *John Wiley & Sons Ltd*. from Zmitek et al. 2017 (41). The images show the periorbital area of two subjects (both 60 years old) from the LD group (1a, b) and HD group (2a, b) before supplementation with syrup containing water-soluble CoQ10 (week 0, images 1a and 2a) and after 12 weeks of supplementation (images 1b and 2b). Arrows mark the wrinkles that visibly improved; * marks the area where an improvement in smoothness and microrelief lines can be observed.

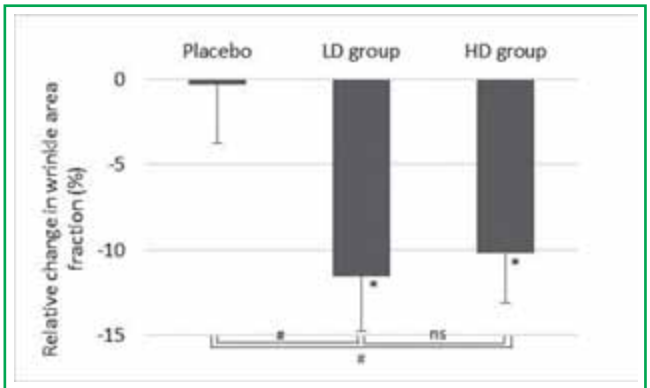

Figure 2. Reproduced with the permission of *John Wiley & Sons Ltd.* from Zmitek et al. 2017 (41). The figure shows relative changes in periorbital wrinkle area for the placebo, LD and HD groups after 12 weeks of CoQ10 supplementation. Data shown as relative change of wrinkle area fraction (± SE) in comparison to baseline values. *p< 0.05 significant difference for a comparison of week 12 to week 0; #p < 0.05 significant difference between groups; ns no significant difference between groups.

Very recently, the effect of oral administration of CoQ10 on skin parameters was tested in a double-blind, placebo-controlled trial (41). Thirty-three subjects were divided into three groups, receiving 0 mg (placebo), 50 mg or 150 mg CoQ10 daily for 12 weeks. The study was conducted with a syrup containing water-soluble form of CoQ10 with superior bioavailability (42). While the results of the previously mentioned *in vitro* studies showed possible CoQ10 protection in UVB response, no important photoprotective effects were observed for CoQ10 supplementation; changes in the minimal erythema dose (MED) were used as an indicator for UVB-induced inflammation. However, the intake of water-soluble form of CoQ10 considerably limited seasonal deterioration of viscoelasticity and had beneficial effects on visible signs of ageing as it was able to significantly reduce wrinkles and microrelief lines and improve skin smoothness. Some of those changes can be observed in Figure 1 and relative changes in periorbital wrinkle area fraction are shown in Figure 2. The influence of the CoQ10 dose on the response magnitude was observed in the expert assessment of wrinkles only. While the improvement of periorbital wrinkles was comparable for both CoQ10 groups, an additional improvement of wrinkles in other facial parts (nasolabial folds, corner of the mouth lines and upper radial lip lines) was observed in the 150 mg group. The CoQ10 supplementation did not significantly affect skin hydration, dermis thickness or density.

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