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Potential of β-carotene as anti-aging serum: A narrative review

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Abstract

β-Carotene is known to have antioxidant activity, the ability to scavenge free radicals and reduce oxidative stress that occurs in the body. However, researchers have paid a little attention to the potential of β-Carotene as an anti-aging agent. The aim of this study was to describe the potential of β-Carotene from natural sources as anti-aging agent via antioxidant mechanism. Literature study was conducted on 28 publications associated with natural sources of β-Carotene, mechanism of anti-aging and antioxidant in the body. The results showed that the best antioxidant activity of β-carotene in scavenging free radicals was at low concentrations while taking into account antioxidant activity, dose, and half-life. UV exposure and air pollution can be a source of free radicals that cause aging of the skin. High antioxidant activity of β-carotene has the potential as anti-aging agent in the form of a beauty serum to treat premature aging of the skin.

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INTRODUCTION

Almost everyone has to do outdoor activities in the exposure of sunlight and pollution released to the air from engine exhaust, cigarette smoke, or industrial activities. There is a reported increase of pollutant particles concentration in the air near the threshold that is 180 $\mu g/m^3$ in June 2019 (BMKG, 2019). Air pollution is proven to be the cause of respiratory diseases and also have serious consequences on skin condition if it's being neglected. Free radicals resulting from exposure to pollution and sunlight could trigger damage to the cells of the skin that leads to the event of premature aging, making the skin less elastic, prone to acne, blackheads, dark spots, and wrinkles (Maris, 2009). The synthesis of Anti-aging products from plant sources could be the solution to those problems. Over the years the most popular method used to slow down aging is the use of antioxidants due to the inhibitory potential to oxidation caused by oxidants which leads to the slowing down of the production of free radical activities that are dangerous to tissues and cells. β-carotene is a plant secondary metabolite that has antioxidant activities (Ardhie, 2011). The development of an anti-aging product from natural sources has been done by previous researchers, like the use of *manalagi* mango fruit concentrate to produce the anti-aging serum. The fruit is believed to contain a high level of β-carotene, potassium, and vitamin C that act as an antioxidant to neutralize free radicals in the body and slow down aging process (Satria and Siahaan, 2017). Here we reviewed current research articles focused on studying β-carotene as an anti-aging agent. This review article is aimed to explain the activity of β-carotene as an anti-aging agent via the mechanism of antioxidant and to give a deeper and comprehensive understanding about the potential of β-carotene as an anti-aging agent.

MATERIALS AND METHODS

The method used in this research is a literature study presented as a narrative review. A narrative review is an alternative in doing research to add to the existing knowledge of the antioxidant activity of β-carotene. This review is also aimed to reevaluate previous studies on the same topic that is considered important to look into more deeply. Previous studies on the effectiveness of β-carotene as an anti-aging agent were gathered from search results by Google Scholar, and databases like Science Direct, *neliti*, National Library of Medicine, and Reserarchgate, using these keywords: "source natural of beta-carotene", "reactive oxygen species and stress oxidative", "antioxidant activity of beta-carotene", "Mechanism of anti-aging", and "serum" with only publications that are relevant to this study and meeting our criteria are selected.

RESULTS AND DISCUSSION

β-Carotene Benefits

β-carotene is a member of various compounds in the carotenoids group and is a precursor of vitamin A widely found in vegetables, flowers, and fruits. β-carotene acts as an antioxidant that can damage oxidative damage that occurs in cellular lipids, proteins or DNA that causes erythema, premature aging, photodermatitis or skin cancer. Besides, β-Carotene is the main carotenoid in the skin to give protective effect from UV light radiation and prevent the formation of reactive oxygen species. The β-carotene structure showed in Figure 1.

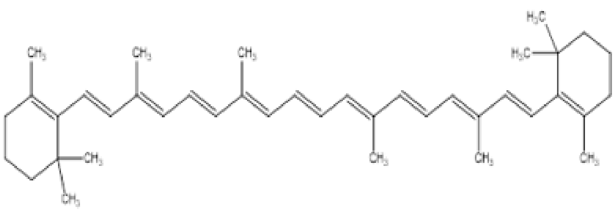

Figure 1: β-carotene structure.

Epidemiological studies showed antioxidant property of β-carotene could have a significant benefit in the treatment of lead poisoning (Kasperczyk *et al.*, 2014), it also acts as potential chemotherapy reagent in neuroblastoma treatment (Lim *et al.*, 2014) β-carotene have anti-keratopathy and could improve condition of cornea in rats with diabetes mellitus via hypoglycemic and antioxidant mechanism (Abdul-Hamid and Moustafa, 2014). Pritwani and Mathur (2017) identified β-carotene content in vegetables, fruits, and tubers collected from four markets in New Delhi, India, using HPLC and the data of β-carotene content from each source showed in Table 1. Mean value, standard deviation and range of β-carotene content were analyzed using SPSS software version 22, with statistically significant p-value $p<0.05$. The average content of β-carotene in orange carrot was reported at 1906 $\pm$ 52 μg/100 g, while at red carrot this value was 1187 $\pm$ 188 μg/100 g. Mazzeo *et al.* (2011) reported in their research that average β-carotene concentration contained in fresh carrot was 128 $\pm$ 0.8 μg/100 g, far lower than what is reported by Pritwani and Mathur (2017). Average β-carotene content in the sweet potatoes sample from Table 1 was 708 $\pm$ 145 μg/100 g. Islam *et al.* (2016) reported values that differ significantly from the value mentioned before, a difference that can be explained by the difference in the variety of the sweet potato being tested.

Islam *et al.* found as much as 4500 μg/100 g β-carotene in sweet potato sample from Kamala Sundari variety and 270 μg/100 g from kuning tripti variety. Based on Table 1, spinach has the highest concentration of β-carotene at 3468 $\pm$ 297 μg/100 g sample. This result is almost similar to the data published by the US Department of Agriculture (USDA), where there is 5600 μg β-carotene in every 100g of fresh spinach. Meanwhile, Longvah *et al.* (2017) reported the β-carotene content in 100g spinach is about 2605$\pm$ 521 μg. Average β-carotene content of Pumpkin tested by Pritwani and Mathur (2017) at 470 $\pm$ 52 μg/100 g differs significantly from the value reported by Koh and Loh (2018) with average β-carotene content in the fresh pumpkin at 4340 $\pm$ 0.04 μg/100 g. Differences in those values can be explained by differences in color intensity of the samples. Color intensity is affected by the maturity level of the samples, and thus the harvest time of the samples is a significant factor that determines the β-carotene level in every sample (Octaviani *et al.*, 2014).

β-Carotene antioxidant activity

Carotenoids could have a protective effect on the skin from damages caused by UV irradiation, especially UV A. Its position and orientations in the cell membrane are important factors that define its relative effectiveness to fight against free radicals. Both α- and β-carotene in the body are able to protect cells from lipid peroxidation induced by oxidants and are known to be more efficient than other antioxidants to overcome singlet oxygen molecules (Gupta and Ghosh, 2013).

Table 1: β-carotene content in various sources.

Sources	Number of Samples	Range of Concentration (μg/100g)	β-Karoten (μg/100g) Mean $\pm$ SD
Red Carrot (Daucus carota)	4	913 - 1331	1187 $\pm$ 188
Orange Carrot (Daucus carota)	4	1845 - 1970	1906 $\pm$ 52
Sweet Potato (Ipomea batatas)	4	605 - 1810	708 $\pm$ 145
Spinach (Spinacia oleracea)	20	2966 - 3967	3468 $\pm$ 297
Pumpkin (Cucurbita maxima)	6	405 - 520	470 $\pm$ 52

Table 2: Formulations of serum from plant extracts.

Research	Best Formulations	Source
Antioxidant facial serum from green robusta coffee bean extract	Coffee bean extract: 0.5% Natrosol (coagulant): 0.75%	(Mardhiani *et al.*, 2018)
Facial serum from temu giring fermented with *Lactobacillus bulgaricus*	Fermented temu giring juice: 15% Xanthan gum (coagulant): 0.5%	(Kurniawati *et al.*, 2018)

Gupta and Ghosh (2013) conducted a test on the antioxidant activity of β-carotene isolated from palm oil. The sample was assayed for its DPPH radical scavenging activity, reducing capacity, and superoxide radical scavenging activity. β-carotene will reduce the reagent 1,1-diphenyl-2-picrylhydrazyl (DPPH) by donating its hydrogen atom, consequently faints the color of the reagent. It was reported that β-carotene works optimally in reducing free radicals at a concentration as low as 0.001%. Reducing the capacity of β-carotene is measured based on its activity to reduce Fe^{3+} to Fe^{2+}. The higher the concentration of antioxidant the higher the reducing activity. β-carotene donates its electrons efficiently to free radicals, turns it into a more stable form, and stops the free radical chain reaction. In this case, a low concentration of β-carotene showed the highest activity.

In the research conducted by Gupta and Ghosh (2013), pyrogallol was used to initiate free radical formation by capturing free oxygen, then turning it into superoxide anion. Superoxide anion will then react with protons from the water and hydrogen peroxide will form subsequently, hydrogen peroxide will further be reactant in the formation of hydroxyl radicals and singlet oxygen. At 0.001% concentration, β-carotene can capture superoxide anions with maximum efficiency and suppress peroxides formation. β-carotene can switch from its reduced and oxidized form, so it shows both antioxidant and prooxidant properties depending on the administered dose and its half-life (Teow *et al.*, 2007). Therefore, to achieve the high activity, carotenoids should be given at low concentration while observing its antioxidant activity.

Aging and anti-aging mechanisms

Aging process of the skin happens because of age-dependent degeneration of cells function (intrinsic factor) or because of the cumulative effect from environmental exposure (extrinsic factor). Intrinsic aging is the result of physiological and genetical processes like cell proliferation, lower hormone secretion, telomers shortening, keratinocytes accumulation, metabolic disorders, and so on. Those disorders cause disturbance of water distribution on the skin, making it dry, increase its pH value, and produce more reactive oxygen species (ROS) that counteract with the antioxidant system (Kohl *et al.*, 2011; Poljšak *et al.*, 2012).

Melanogenesis is an important process to neutralize free radicals from UV irradiation and act as a defense mechanism against damages caused by the radiation. Damages on skin induce an increase of inflammation cells, reduction of the extracellular matrix of the skin cells, and disruption of collagen fiber that leads to wrinkles. UV radiation also caused shortenings of telomers by producing ROS on the skin (Kim and Park, 2016). The summary aging mechanism presented in Figure 2.

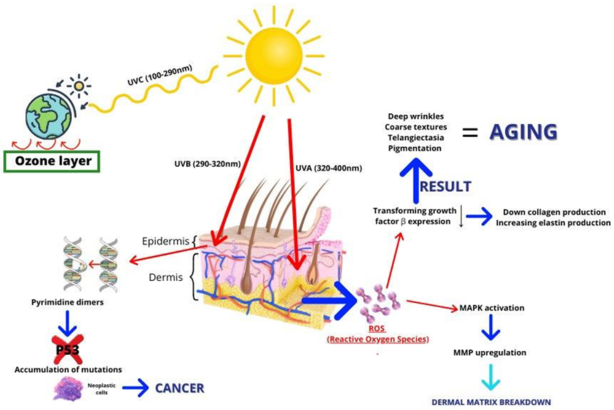

Figure 2: Aging mechanism.

Smoke from cigarettes can also act as free radical that will accumulate in the body, increasing ROS formation and production of enzyme Matrix Metalloproteinase (MMP). It's the enzyme required in the degradation of extracellular matrix protein that constitutes the connective tissues of the skin. Increase in MMP leads to degradation of collagen and elastic fiber. Morita *et al.* (2009) showed that topical application of tobacco on rats back skin caused the loss of collagen fiber. Furthermore, smoke from tobacco could induce MMP-1 expression via the signaling pathway of the Aryl hydrocarbon receptor (AhR) of the human fibroblast and keratinocytes (Ono *et al.*, 2013). Excessive free radicals in the body will potentially be an agent of skin destruction with clinical features like wrinkles, dryness, even melanoma (Pandel *et al.*, 2013).

Antioxidant can stabilize or deactivate free radicals before disrupting the cell functions. It is also able to inhibit oxidation reactions, thus act preventively and protectively against degenerative diseases (Zalukhu *et al.*, 2016). Oral and topical retinoids like vitamin A, β-carotene, lycopene, lutein and others contribute as UV blockers and also act as an antioxidant (Evans and Johnson, 2010). Some molecules from natural product whether it's extracted from plants, fruits, and/or tubers have the ability to activate nuclear factor erythroid derived 2-like 2 (NFE2L2), that is a transcription factor that regulates genes involved in defense mechanism against damage caused by ROS, thus those molecules are regarded as anti-aging agents (Schäfer and Werner, 2015). Wahyono *et al.* (2011) claimed that giving tomato juice to rats with a dosage of 11g/kg body weight could prevent the increase of malondialdehyde (MDA) level, expression of activator protein-1 (AP-1) protein, ROS activity, and prevent the decrease of type-1 collagen expression after 150 mJ/cm^2 UV-B irradiation. The juice contains compounds like lycopene, β-carotene, and vitamin C. Sweet potato contain a high concentration of β-carotene with different antioxidant activity. Kourouma *et al.* (2019) tested 25 cultivars of sweet potato which contain β-carotene and different antioxidant activities. Sweet potato from Pushu 32 cultivar are orange-coloured and has highest β-carotene that is 208.11 μg/g, with highest antioxidant activity at 18.98 mg AAE per g DW tested with DPPH assay. Figure 3 showed several aspects related to aging factors and antioxidant performance.

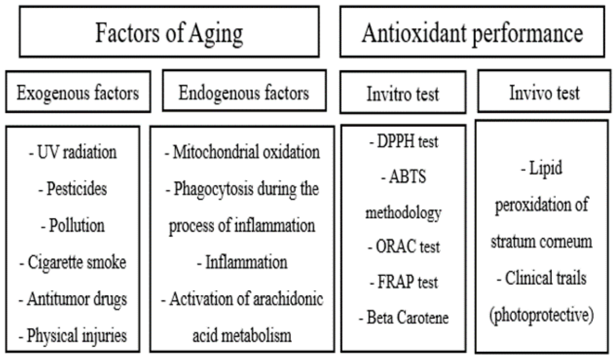

Figure 3: Aspects related to oxidative stress, aging of the skin, invivo and invitro methods to investigate the effects of antioxidant.

Anti-aging Serum from Natural Sources

Serum is a form of cosmetic preparation and has an advantage of containing high concentration of active compound, making it easier to be applied on skins (Noorviana, 2014). Because of its antioxidant properties, active compounds from plant like carotenoids and polyphenols, especially flavonoids, are widely used to formulate as oral preparation like vitamin and topical preparation like many skin treatment products. Plant extracts containing antioxidant is gaining interest in the field of phytocosmetics for it has the ability to inactivate ROS, restore skin homeostasis so as to prevent erythema and premature aging in skins (Calderon-Montano *et al.*, 2011; Mansur *et al.*, 2012). Some previous research has been conducted on the production of anti-aging serum from plant extract. But, none of those researches used β-carotene as the ingredient, so there is no information about the best formulation to make a β-carotene anti-aging serum from plant extract. Best serum formulation was devised by testing various ratios of the extract and the coagulant by antioxidant assays, serum stability assay, and organoleptic assay. Coagulant is used to adjust the viscosity of the serum. Serums with high viscosity tend to be more condensed (Mardhiani *et al.*, 2018). Serum is designed to have low viscosity, so it can thoroughly spread on and be absorbed by the skin (Noorviana, 2014). Table 2 shows several formulations as reference for β-carotene anti-aging serum production from plant extracts.

CONCLUSIONS

This review shows that, at low concentration, β-carotene, which is also a member of carotenoid substances have maximum efficiency to scavenge superoxide anions and thus can reduce the production of peroxides in vitro. Due to its chemical mechanism as an antioxidant, β-carotene holds the potential as an anti-aging agent and as a natural ingredient in the production of anti-aging serum. Although, much research is still needed on the basis of optimal anti-aging agent serum formulation from β-carotene.

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Conflict of Interest

The authors declare that they have no conflict of interest for this study.

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