Indonesian Journal of Global Health Research
Volume 6 Number 3, Juni 2024
e-ISSN 2715-1972; p-ISSN 2714-9749
http://jurnal.globalhealthsciencegroup.com/index.php/IJGHR

THE ROLE OF HYDROLYZED ORAL COLLAGEN SUPPLEMENTATION ON PREMATURE AGING IN WOMEN AGED 30-60 YEARS

Louis Rianto*, Moonly Hong, Olivia Margaretha, Edward Edwin
Faculty of Medicine, Universitas Tarumanagara, Jl. Letjen S. Parman No.1, Tomang, Grogol Petamburan, Jakarta Barat, Jakarta 11440, Indonesia
*louis.rianto@rocketmail.com

ABSTRACT

Collagen is an important substance in the body to compose connective tissue. One of the important roles of collagen is to keep the skin strong and elastic so that the skin does not look old. However, with age, the body's collagen production will decrease and have an effect on skin aging, so external collagen supplementation is often used to prevent premature aging. This study was conducted to review more deeply the role and effectiveness of oral hydrolyzed collagen supplementation in preventing premature aging of the skin of women aged 30-60 years and to compare the effectiveness and benefits of topical collagen compared to oral collagen so that the results of this study are expected to be useful in considering the use of oral collagen for prevention of premature aging. A literature search was conducted from journal articles with a time span of 2012-2022 using databases in the form of Pubmed, Ebsco, Google Scholar, Hindawi, Medline and Science Direct (28 articles). We included 28 research articles that met the inclusion and exclusion criteria by analyzing the abstract and full text through tables together. A literature search was conducted from journal articles with a time span of 2012-2022 using databases in the form of Pubmed, Ebsco, Google Scholar, and Science Direct. Research shows that hydrolyzed oral collagen has a fairly high level of effectiveness in inhibiting the premature aging process, in the form of increasing skin hydration and elasticity and reducing wrinkles in several areas of the face. The use of oral and topical collagen also has almost the same effect and will provide a more satisfying effect if consumed together.

Keywords: aging; collagen supplements; oral collagen; skin health

First Received	Revised	Accepted
01 March 2024	14 March 2024	15 March 2024
Final Proof Received		**Published**
29 March 2024		01 June 2024

How to cite (in APA style)
Rianto, L., Hong, M., Margaretha, O., Edwin, E., & Tjahyanto, T. (2024). The Role of Hydrolyzed Oral Collagen Supplementation on Premature Aging in Women Aged 30-60 Years. Indonesian Journal of Global Health Research, 6(3), 1187-1196. https://doi.org/10.37287/ijghr.v6i3.3116.

INTRODUCTION

Collagen is the main structural protein in the body's connective tissues such as skin, tendons, cartilage and bones, accounting for 25-30% of total body protein and representing up to 75% of the total weight of the extracellular matrix of skin tissue. Collagen forms a supporting network for fibroblasts, keratinocytes, melanocytes, and special cells of the skin immune system (de Miranda et al., 2021; Tak et al., 2021). Skin aging is a degenerative process that cannot be avoided along with a decline in a person's physiological function. This process is influenced by a combination of intrinsic and extrinsic factors. Intrinsic factors involve age-related inherited factors, neuroendocrine aspects, while extrinsic factors are the result of external factors such as exposure to ultraviolet A (UVA) and ultraviolet B (UVB) radiation, pollution, and lifestyle factors including nutritional status, smoking, and drinking. alcohol can accelerate the aging process due to increased ROS production in chronic inflammatory processes. (Aguirre-Cruz et al., 2020a; Bolke et al., 2019; Jhawar et al., 2020; Morgado-Carrasco et al., 2022a). The dermal collagen fiber network becomes increasingly fragmented with age due to increased formation of metalloproteinases which can degrade collagen fibers.

This results in a decrease in collagen density and dermis thickness so that the skin becomes sagging and wrinkled due to a decrease in integrity and elasticity. (de Miranda et al., 2021; Jhawar et al., 2020). As we age, hyaluronic acid, which plays a role in retaining water in the skin's extracellular matrix, can decrease, causing structural and functional changes in the dermis, decreased volume and thickness of the epidermis, loss of skin elasticity and moisture, and decreased skin moisture (de Miranda et al., 2021). Oral collagen supplements are believed to help reduce skin aging. The main bioactive ingredient in this supplement is collagen peptides. This peptide is obtained from the enzymatic hydrolysis of natural collagen which is generally sourced from pork, beef and marine products which are rich in the amino acid peptides proline (Pro), glycine (Gly), and hydroxyproline (Hyp). In the digestive tract, these peptides will be metabolized into di- and tri-peptides then transported through the blood vessels and accumulated in the skin to form new collagen tissue (Barati et al., 2020; de Miranda et al., 2021; Jhawar et al., 2020). Apart from that, previous research demonstrated that Gly-Pro-Hyp and Pro-Hyp are stable in gastrointestinal fluids and plasma, without being degraded by gastric acid and enzymes, pancreatin, or plasma peptides. These results suggest that oral intake of hydrolyzed collagen supplements may be an efficient approach to take bioactive peptides due to the enzymatic stability and intestinal permeability of Gly-Pro-Hyp and Pro-Hy (Aguirre-Cruz et al., 2020 ; Evans et al., 2021 ; Tak et al., 2021).

Scientists believe that these protein peptides can help maintain and increase collagen in the skin. Apart from that, these protein peptides can also increase the production of hyaluronic acid in skin fibroblasts, induce fibroblast migration, increase stronger collagen fibrils, and increase the water content in the stratum corneum. Regular intake of hydrolyzed collagen supplements can inhibit the action of matrix metalloproteinases which are responsible for collagen destruction. This makes the skin smoother, softer, and improves skin texture (Aguirre-Cruz et al., 2020; Jhawar et al., 2020). Since 1985, hydrolyzed collagen has been considered a safe ingredient for use in cosmetic formulations. However, one of the main problems for topical application is its low permeability to penetrate the skin. The larger the peptide (more than six or seven amino acids), the less likely it is to reach deeper layers. In contrast to topical application, oral supplements are a practical approach for the prevention of skin aging because they can reach the dermis through blood circulation. With the increasing number of scientific publications and clinical studies evaluating collagen supplementation worldwide, therefore, we summarize several studies from various literatures regarding the evidence for the application of oral collagen supplementation in inhibiting the skin aging process. The aim of this research is to find out how much influence oral collagen has on reducing aging conditions.

METHOD

The author searched, sorted and analyzed scientific literature using keywords such as Aging, skin health, oral collagen, collagen supplements.The literature sources used are Pubmed, Ebsco, Google Scholar, and science direct with a period of the last 10 years (2012-2022). After carrying out the results of a literature search using keywords. Then, from the search results, journal selection was carried out using open access criteria and those that met the criteria were 28 journals. Writing begins by reviewing the complete contents of the journal, holding group discussions, and cross-checking other primary sources. The results of the discussion are arranged in a structured form in the form of the definition and physiology of skin collagen formation, the role and types of collagen use, implementation of the use of hydrolyzed oral collagen, side effects, and the safe limits of oral collagen.

RESULTS

Role and Effectiveness of Hydrolyzed Oral Collagen

Oral collagen is believed to inhibit the aging process of the skin. Giving 1 g of collagen peptides for 12 weeks to women aged 40-60 years showed a significant increase in skin hydration (Tak YJ et al, 2020). Collagen peptides themselves contain bioactives such as Pro-Hyp and Hyp-Gly which can increase hydration, elasticity and skin density so that they can reduce areas of wrinkles (Sugihara et al, 2015). Apart from inhibiting the aging process, administering collagen hydrolyzate 2.5g/day to 10g/day for 8-24 weeks is also useful for treating decubitus ulcers, xerosis, skin aging, and cellulite which plays a role in increasing skin elasticity and hydration significantly (Franchesca et al , 2019). The effects of collagen peptides also become more visible with increasing age, such as a study of administering collagen peptides to women aged 35-55 years for 8 weeks where the effect was more visible in women aged over 50 years (Proksch et al, 2014). Oral collagen also has variations in administration dosage. By administering 3g and 5g of collagen peptides from tilapia fish scales for 8-12 weeks, it is effective in reducing periorbital wrinkles and increasing hydration of the stratum corneum and dermis, as well as skin elasticity over 12 weeks (Koizumi et al., 2018; Miyanaga et al., 2021). Oral collagen supplementation also had an effect on skin Transepidermal Water Loss, double-blind RCT in 99 Japanese women, aged 35-50 years receiving 1 or 5g of CP or placebo once daily for 12 weeks. The results showed an increase in water content in the stratum corneum and epidermis and reduced Transepidermal Water Loss (TEWL) (Miyanaga et al., 2021).

Collagen has also been proven to play a role in skin aging due to UVA and UVB rays, clinical trials conducted on 64 women aged 40-60 years who were diagnosed with skin photoaging were given a daily oral dose of 1000mg LMWCP for 12 weeks. showed that oral intake of LMWCP significantly increased skin hydration after 6 weeks and improved elasticity and reduced wrinkles after 12 weeks thereby improving the condition of skin photoaging (Kim et al., 2018). The effectiveness of oral collagen also has quite satisfactory figures for several antiaging parameters. A meta-analysis study in 1,125 participants aged between 20 and 70 years (95% women) showed good effectiveness of hydrolyzed collagen supplementation at a daily dose of 2.5–5g over a period of 8–12 weeks, with improved skin density ($z=0.48$, $P=.002$), elasticity ($z=2.31$, $P=.02$), and hydration ($z=2.58$, $P=.010$) and a significant reduction in facial wrinkles ($z=-1.11$, $P=.009$). And the benefits persist for approximately 30 days after the end of treatment (de Miranda et al., 2021; Morgado-Carrasco et al., 2022b). Meanwhile, administering 10 grams of collagen peptide consumed for 8 weeks provided significant effectiveness in antiaging through increasing stratum corneum hydration and skin elasticity ($p = 0.049$) (Nomoto & Iizaka, 2020a).

The level of effectiveness of oral collagen against Transepidermal Water Loss (TEWL) also shows high figures. In a randomized controlled trial study, in 84 women aged between 40-60 years who took 1,000mg CTP (collagen tripeptide) every day for 12 weeks, the level of Transepidermal Water Loss (TEWL) was reduced more in the CTP group ($P < 0.05$). Statistical results remained significant after adjustment for humidity, temperature, and UVA (adjustment rate for humidity and temperature, $P = 0.024$; adjustment rate for UVA, $P = 0.032$; adjustment rate for temperature, high temperature, and ultraviolet A, $P = 0.031$) (Tak et al., 2021). Oral collagen also plays a role in the postmenopausal female population. Wich and Pravit conducted an RCT study with 36 post-menopausal female participants who were given 10 grams of oral supplements collagen for 4 weeks. Skin elasticity measurements on participants' left and right cheeks increased compared to placebo ($p=0.006$, 0.03 respectively). After 4 weeks of discontinuation of the study agent (week 8), skin elasticity measured from

both left and right cheeks remained different between the groups receiving oral collagen supplements versus the placebo group (p=0.01, 0.004 respectively) (Sangsuwan & Asawanonda, 2021).

Topical Collagen and Oral Collagen

Topical Formulations

Topical collagen formulations that are applied to the skin surface are designed to have maximum penetration of the active ingredients into the skin. Topical collagen can penetrate through three pathways, first through the sweat glands, second through the sebaceous glands, and third directly through the stratum corneum. 1 The formulation of topical cosmetics is usually complete with natural moisturizers whose sources come from plants or animals. Topical collagen has high moisturizing content that acts on the stratum corneum.1,2 Topical hydrolyzed collagen in the form of moisturizing lotion shows maximum effect against aging. A study on subjects of 40 women with sensitive skin who were given a moisturizing lotion containing hydrolyzed collagen for 4 weeks, showed an increase in hydration, smoothness, and brightness of the skin surface. The effect of topical formulated hydrolyzed collagen also reduces the level of transepidermal water loss (TEWL) and relieves symptoms of sensitive skin (Lupo et al). 3 The use of topical collagen tripeptide does not show any side effects. Such as a single arm prospective study for 4 weeks of 22 Asian women using topical CTP. Results showed significant improvements in wrinkles, elasticity, and skin density with reduced skin accumulation of advanced glycated end products (AGEs) at week 4 (Young In Lee, et al.).2

Oral Formulation

Hydrolyzed collagen with oral formulations can be called a "nutricosmetic" because of its role as a nutrient and works from within the body to slow the skin aging process. After consuming oral collagen (hydrolyzed collagen), collagen peptide levels in the blood will increase significantly and will be absorbed into the plasma (Aguirre-Cruz et al., 2020a). Hydrolyzed collagen in oral formulations is considered safe for consumption. as in detailed experimental studies characterizing hydrolyzed collagen, it was found that hydrolyzed collagen is safe and non-toxic for consumption (López-Morales et al., 2019). The effects of oral collagen peptide supplements provide satisfactory effects to inhibit aging such as delaying and improving signs of skin aging, reducing facial wrinkles and increasing skin hydration and elasticity (Barati et al., 2020).

Relationship between topical and oral formulations

Topical collagen formulations that work from outside the body can produce maximum effects if they are complemented by hydrolyzed oral collagen formulations that work from inside the body. This hydrolysis process makes collagen more available and easier to absorb (Aguirre-Cruz et al., 2020a). An RCT study conducted primarily in high- to middle-income countries highlighted that oral and topical collagen supplements helped delay the aging process, with no differences arising between the two types of collagen. Evidence from the studies reviewed shows that both collagen supplements improve skin moisture, elasticity, and hydration when administered orally. Additionally, collagen reduces wrinkles and skin roughness, and existing research has not found any side effects from its oral supplementation (Al-Atif, 2022). Maia et al conducted an innovative study with a combination of topical application of peptides extracted from rice and an oral supplement of hydrolyzed collagen mixed with vitamins A, C, D, and Zinc. This study was conducted on 60 healthy female subjects by applying biophysical and skin imaging techniques. The hydration level in the deeper layers of the epidermis increases after one month according to the application of cosmetic formulations with peptides. And the results after 90 days skin elasticity and viscoelasticity increased significantly (Maia

Campos et al., 2019a). The combination of both shows better results when compared to using either one.

DISCUSSION

Collagen fibers in the epidermis affect skin elasticity. As we age, collagen metabolism in the skin is disturbed, causing thinning of the skin and reduced skin elasticity. In addition, skin that becomes drier and thinner is susceptible to damage due to friction. Vulnerable skin is at risk of skin problems such as skin tears, dermatitis and pressure sores. Oral collagen peptides containing hydroxyproline can induce the growth of skin fibroblasts and increase the production of hyaluronic acid. This shows that this peptide is the active ingredient of the supplement which can increase stratum corneum hydration and skin elasticity (Nomoto & Iizaka, 2020b). The specific mechanism of action of collagen's influence on skin health is not yet known. However, there are three possible mechanisms in this case: (a) Collagen fragments can be precursors of collagen synthesis in the skin; (b) collagen fragments can stimulate the production of collagen and proteoglycans in the skin; and (c) collagen and its fragments can increase skin turnover by induction of regulatory T cells and M2 macrophages (Barati et al., 2020).

The role of collagen in antiaging effects in terms of molecular and cellular aspects is reviewed through examination of fibroblast cells given oral collagen supplementation showing the function of inhibiting ROS, facilitating extracellular matrix (ECM) protein synthesis, increasing mitochondrial activity, and increasing gene expression regarding correct protein folding. DNA mismatch repair (MMR) and base excision repair (BER). The synergistic effect of collagen drinks can not only reduce oxidative damage but also improve cell function to compensate for the negative effects caused by UVA (Lin et al., 2020). The demand for anti-aging skin therapies among the general public is expected to increase. The use of oral supplements and systemic drugs to combat skin aging is an attractive option, because it will eliminate or reduce the need for topical treatments or invasive or minimally invasive procedures that are not only expensive but also not without side effects. Hydrolyzed collagen used in oral supplements is obtained through enzymatic hydrolysis of natural collagen from various sources, such as fish, pork, and chicken. When digested, this collagen is broken down into dipeptides and tripeptides, which are absorbed into the bloodstream through the gastrointestinal tract and then mostly stored in the skin. This dipeptide stimulates the metabolism, migration and proliferation of fibroblasts and results in increased production of collagen and hyaluronic acid (Morgado-Carrasco et al., 2022b).

Meanwhile, from collagen preparation sources, marine collagen sources which have a low molecular weight are more easily absorbed and have lower inflammatory reactions and contaminants than land collagen sources. Meanwhile, its biocompatibility and amino acids are similar to land animals, and it has higher type I collagen (Lupu et al., 2020). An example of its application is that fish gelatin hydrolyzate is more easily absorbed by the body than pork gelatin hydrolyzate, which shows that low molecular collagen from fish gelatin can increase bioavailability and skin health parameters to a greater extent. Its use is getting better in society because there is no risk of disease transmission, lack of religious barriers, and cost savings (Tak et al., 2021). Topical skin care products (creams, lotions, and serums) often have difficulty reaching the dermis layer of the skin which is important for restoring collagen synthesis (Bolke et al., 2019). So it requires a combination with oral collagen to work optimally. Several studies have found that consuming hydrolyzed oral collagen for 4 weeks can reduce the area of dark spots caused by UV-B rays on the skin. Collagen peptides inhibit UV-B induced pigmentation due to their antioxidant activity and tyrosinase inhibition. The Gly-Pro and Pro-Hyp content in oral collagen also inhibits the formation of wrinkles due to UV-B exposure. Another benefit of

oral collagen supplementation which contains a combination of hydrolyzed collagen from fish skin with soy peptides and water extract of Flos Chrysanthemi Alba has proven to be safe and useful for melasma therapy (Kim et al., 2018). Meanwhile, High-Collagen Peptide with bioactive peptides such as Pro-Hyp and Hyp-Gly shows better skin repair effects than Low-Collagen Peptide. Where is the role of Pro-Hyp and Hyp-Gly in skin dermal fibroblasts as signal transducers that can stimulate metabolism, migration, fibroblast proliferation, and the production of hyaluronic acid (Inoue et al., 2016; Jhawar et al., 2020; Sugihara, 2012).

H-CP contains free-form bioactive peptides such as Pro-Hyp and Hyp-Gly, which show a much better facial skin condition improvement effect than L-CP which has a lower bioactive peptide content. Previous studies have shown the role of Pro-Hyp and Hyp-Gly in skin dermal fibroblasts as signal transducers, which can stimulate metabolism, migration, proliferation of fibroblasts, and the production of hyaluronic acid. After consumption, these dipeptides will be absorbed into the blood by peptide transporters from the intestinal epithelium in the digestive process, so that increasing the concentration of free form bioactive peptides in HC products is believed to increase the absorption of Pro-Hyp and Hyp-Gly. (N Inoue, F Sugihara, X Wang, 2016). Several studies have found that consuming oral HC for 4 weeks can reduce the area of dark spots caused by UV rays on the skin. According to the wavelength, UV is divided into three, namely UV-A (400–315 nm), UV-B (315–280 nm), and UV-C (<280). Continuous exposure to UV-B can accelerate skin aging by forming wrinkles. Benefits of an oral supplement containing a combination of fish skin HC with soy peptides and Flos Chrysanthemi Alba aqueous extract in clinical studies evaluating the safety and efficacy of CP for treating melasma. The authors reported decreased hyperpigmentation with lighter facial skin color after oral CP supplementation. Their results showed that CP inhibited UV-B-induced pigmentation due to the antioxidant activity and tyrosinase inhibitory effects of CP. Lee et al. conducted research to study the effect of oral administration of fish scales containing collagen peptide on skin protection when exposed to UV-B. They concluded that consumption of dipeptides in the form of Gly-Pro and Pro-Hyp attenuated UV-B-induced wrinkle formation.

Research on the combination of amino acids (hydrolyzed collagen peptides: glycine, proline and hydroxyproline) with water-soluble vitamins (A and C) and fat-soluble vitamins (E) and zinc is believed to be more effective in improving the condition of aging skin by increasing skin elasticity . This increase may be due to the mechanism of the dual role of collagen bioactive peptides in the dermis: (1) free amino acids support the formation of collagen fibers; (2) bioactive peptides bind to fibroblast membrane receptors and stimulate their proliferation and the production of new collagen, elastin, and hyaluronic acid. (Genovese L et al, 2017). In addition, combining three types of amino acids (glycine, proline and hydroxyproline) with vitamins and zinc has an antioxidant effect that can provide protection against ROS. (Campos et al, 2015).

Topical Collagen and Oral Collagen

The use of topical collage inhibits skin aging with active ingredients and bio-mimetic molecules (Aguirre-Cruz et al., 2020b). In fact, administering collagen peptides, both topically and orally, is very useful for preventing skin aging. Such as the ingredients hydroxyethylcellulose, methylphenyl polysiloxane, cyclomethicone and crosspolymer dimethicone in topical collagen and the oral collagen administration dose of 10g combined with vitamins A (600 µg), C (45 mg), E (10 mg), and zinc (7 .0 mg) which is used to maximize anti-aging on the skin. The administration of collagen also increases the water content in the stratum corneum which is measured using the CorneometerTM 825, which indicates an increase in skin hydration (Serup et al., 2006).

Skin elasticity and viscoelasticity parameters also increased significantly after 90 days of topical and oral collagen use, especially in the periorbital area. Meanwhile, the echogenicity of the dermis also improved and skin evaluation using high resolution photography showed improvement in wrinkles in the frontal and facial areas. The use of collagen supplementation is recommended to combine the use of both preparations. Due to the use of topical collagen, the effects of hydration, skin elasticity and reduction of wrinkle parameters are only temporary. Meanwhile, the use of hydrolyzed oral collagen with vitamins has an effect on skin elasticity and density (dermis), and reduces the formation of wrinkles progressively and in the long term. So combination therapy with both preparations can cause significant benefits in several parts of the body (Maia Campos et al., 2019b).

Taking collagen supplementation orally can trigger the development of fibroblasts and stimulate the formation of type 1 collagen in the dermis and make the skin softer, smoother and improve skin texture. The bioactive content in collagen also improves dermis health and prevents aging. Topical collagen administration also has the effect of increasing hydration of the deepest layers of the skin's epidermis after 90 days. And provides the effect of increasing skin elasticity and viscoelasticity. So for optimal results, it is recommended to provide collagen supplementation in oral or topical form. The use of oral collagen also does not show any side effects and tends to be safe for long-term consumption (Aguirre-Cruz et al., 2020b). In a clinical study of 120 subjects who were given 50 mL of a nutricosmetic formulation for 90 days, it was shown that oral collagen supplementation improved the structure and stratification of the epidermis so that the skin became more elastic, strong and thick (Genovese et al., 2017). A clinical study of 120 healthy volunteers conducted over 90 days. In this study they were instructed to ingest 50 mL of a nutricosmetic formulation (hydrolyzed collagen, hyaluronic acid and N-acetylglucosamine, borage oil, and other ingredients such as vitamins, minerals, antioxidants, and additional bioactive ingredients) or 50 mL of placebo (water and other ingredients such as flavors, organic acids, and soy polysaccharides). From the research results, it was found that oral collagen supplementation resulted in improvements in the structure and stratification of the epidermis layer, which made the skin more elastic, strong and thick. (Genovese et al., 2017). Another clinical study was conducted on 85 Chinese female subjects treated with low and high ratios of free forms of Pro-Hyp and Hyp-Gly derived from fish sources (Inoue et al., 2016). A five gram sample is consumed for eight weeks. Three physiological measurements were evaluated on the skin; Skin moisture showed significant improvement compared to placebo. With regard to skin elasticity, a significant increase in facial skin elasticity after oral consumption of collagen hydrolyzate was produced. The higher the ratio of Pro-Hyp and Hyp-Gly shows the best results in skin elasticity. This treatment also appears to obtain the best results for surface skin measurements due to a significant reduction in the number of wrinkles, wrinkle area, wrinkle depth, and roughness. Other works by this author also found that oral consumption of HC reduced the area of UV spots on the skin after four weeks of oral consumption (Sugihara, 2012).

CONCLUSION

Hydrolyzed oral collagen is effective in inhibiting the aging process by increasing hydration, elasticity and skin density, especially in women aged 30-60 years and can provide maximum effects if used regularly with the right dose and duration. The use of oral collagen does not cause side effects so it can be an effective prevention option in inhibiting the aging process and works more optimally when combined with topical collagen. Further research is needed to examine the minimum dose and duration recommendations to show optimal results on the skin. There are limited data regarding comparisons between ethnicities and ages, further research is needed to see the effects of using oral collagen between ethnic groups and ages.

REFERENCES

Aguirre-Cruz, G., León-López, A., Cruz-Gómez, V., Jiménez-Alvarado, R., & Aguirre-Álvarez, G. (2020). Collagen hydrolysates for skin protection: Oral administration and topical formulation. Antioxidants, 9(2), 181. doi:10.3390/antiox9020181

Al-Atif, H. (2022). Collagen supplements for aging and wrinkles: A paradigm shift in the field of dermatology and Cosmetics. Dermatology Practical & Conceptual. doi:10.5826/dpc.1201a18

Barati, M., Jabbari, M., Navekar, R., Farahmand, F., Zeinalian, R., Salehi-Sahlabadi, A., … Davoodi, S. H. (2020). Collagen supplementation for skin health: A mechanistic systematic review. Journal of Cosmetic Dermatology, 19(11), 2820–2829. doi:10.1111/jocd.13435

Bolke, L., Schlippe, G., Gerß, J., & Voss, W. (2019). A collagen supplement improves skin hydration, elasticity, roughness, and density: Results of a randomized, placebo-controlled, Blind Study. Nutrients, 11(10), 2494. doi:10.3390/nu11102494

Concentrated fortified collagen protein hydrolysate liquid supplement. (2020). Definitions. doi:10.32388/w82wl8

de Miranda, R. B., Weimer, P., & Rossi, R. C. (2021). Effects of hydrolyzed collagen supplementation on skin aging: A systematic review and meta-analysis. International Journal of Dermatology, 60(12), 1449–1461. doi:10.1111/ijd.15518

Evans, M., Lewis, E. D., Zakaria, N., Pelipyagina, T., & Guthrie, N. (2020). A randomized, triple-blind, placebo-controlled, parallel study to evaluate the efficacy of a freshwater marine collagen on skin wrinkles and elasticity. Journal of Cosmetic Dermatology, 20(3), 825–834. doi:10.1111/jocd.13676

Genovese, L., Corbo, A., & Sibilla, S. (2017). An insight into the changes in skin texture and properties following dietary intervention with a nutricosmeceutical containing a blend of collagen bioactive peptides and antioxidants. Skin Pharmacology and Physiology, 30(3), 146–158. doi:10.1159/000464470

GONZÁLEZ-ARRIAGADA, W. A., LUQUE-MARTÍNEZ, I., MUÑOZ, M. Á., & COUVE, E. (2020). Influence of radiation dose in collagen degradation, collagen-MMP immunoexpression and immediate adhesive properties. Oral Surgery, Oral Medicine, Oral Pathology and Oral Radiology, 129(1). doi:10.1016/j.oooo.2019.06.590

Hall, C. (2023). Reviewing collagen supplements. Plastic and Aesthetic Nursing, 43(1), 41–46. doi:10.1097/psn.0000000000000488

Inoue, N., Sugihara, F., & Wang, X. (2016). Ingestion of bioactive collagen hydrolysates enhance facial skin moisture and elasticity and reduce facial ageing signs in a randomised double-blind placebo-controlled clinical study. Journal of the Science of Food and Agriculture, 96(12), 4077–4081. doi:10.1002/jsfa.7606

Jhawar, N., Wang, J. V., & Saedi, N. (2019). Oral collagen supplementation for skin aging: A fad or the future? Journal of Cosmetic Dermatology, 19(4), 910–912. doi:10.1111/jocd.13096

Kim, D.-U., Chung, H.-C., Choi, J., Sakai, Y., & Lee, B.-Y. (2018). Oral intake of low-molecular-weight collagen peptide improves hydration, elasticity, and wrinkling in

human skin: A randomized, double-blind, placebo-controlled study. Nutrients, 10(7), 826. doi:10.3390/nu10070826

Koizumi, S., Inoue, N., Shimizu, M., Kwon, C., Kim, H., & Park, K. S. (2017). Effects of dietary supplementation with fish scales-derived collagen peptides on skin parameters and condition: A randomized, placebo-controlled, double-blind study. International Journal of Peptide Research and Therapeutics, 24(3), 397–402. doi:10.1007/s10989-017-9626-0

Lin, P., Hua, N., Hsu, Y.-C., Kan, K.-W., Chen, J.-H., Lin, Y.-H., … Kuan, C.-M. (2020). Oral collagen drink for antiaging: Antioxidation, facilitation of the increase of collagen synthesis, and improvement of protein folding and DNA repair in human skin fibroblasts. Oxidative Medicine and Cellular Longevity, 2020, 1–9. doi:10.1155/2020/8031795

Lupu, M., Gradisteanu Pircalabioru, G., Chifiriuc, M., Albulescu, R., & Tanase, C. (2019). Beneficial effects of food supplements based on hydrolyzed collagen for skin care (review). Experimental and Therapeutic Medicine. doi:10.3892/etm.2019.8342

López-Morales, C. A., Vázquez-Leyva, S., Vallejo-Castillo, L., Carballo-Uicab, G., Muñoz-García, L., Herbert-Pucheta, J. E., … Medina-Rivero, E. (2019). Determination of peptide profile consistency and safety of collagen hydrolysates as quality attributes. Journal of Food Science, 84(3), 430–439. doi:10.1111/1750-3841.14466

Maia Campos, P. M., Melo, M. O., & Siqueira César, F. C. (2019). Topical application and oral supplementation of peptides in the improvement of skin viscoelasticity and density. Journal of Cosmetic Dermatology, 18(6), 1693–1699. doi:10.1111/jocd.12893

Miyanaga, M., Uchiyama, T., Motoyama, A., Ochiai, N., Ueda, O., & Ogo, M. (2021). Oral supplementation of collagen peptides improves skin hydration by increasing the natural moisturizing factor content in the stratum corneum: A randomized, double-blind, placebo-controlled clinical trial. Skin Pharmacology and Physiology, 34(3), 115–127. doi:10.1159/000513988

Morgado-Carrasco, D., Gil-Lianes, J., Jourdain, E., & Piquero-Casals, J. (2023). [translated article] oral supplementation and systemic drugs for Skin aging: A narrative review. Actas Dermo-Sifiliográficas, 114(2). doi:10.1016/j.ad.2022.09.021

Nomoto, T., & Iizaka, S. (2020). Effect of an oral nutrition supplement containing collagen peptides on stratum corneum hydration and skin elasticity in hospitalized older adults: A multicenter open-label Randomized Controlled Study. Advances in Skin & Wound Care, 33(4), 186–191. doi:10.1097/01.asw.0000655492.40898.55

Sangsuwan, W., & Asawanonda, P. (2020). Four-weeks daily intake of oral collagen hydrolysate results in improved skin elasticity, especially in sun-exposed areas: A randomized, double-blind, placebo-controlled trial. Journal of Dermatological Treatment, 32(8), 991–996. doi:10.1080/09546634.2020.1725412

Seidenari, S., Giusti, F., & Pellacani, G. (2006). Non-invasive methods and assessment of skin diseases. Handbook of Non-Invasive Methods and the Skin, Second Edition, 37–46. doi:10.3109/9781420003307-8

CHIFU, C. (2023). Oral supplementation of hydrolyzed fish collagen, acerola and sodium

hyaluronate on facial skin: A double-blind, randomized, placebo-controlled trial. JFN, 9(1). doi:10.17303/jfn.2023.9.101

Tak, Y. J., Shin, D. K., Kim, A. H., Kim, J. I., Lee, Y. L., Ko, H.-C., … Lee, S. Y. (2021). Effect of collagen tripeptide and adjusting for climate change on skin hydration in middle-aged women: A randomized, double-blind, placebo-controlled trial. Frontiers in Medicine, 7. doi:10.3389/fmed.2020.608903.