



## Innovative $\alpha$ -Cryptoxanthin ( $\alpha$ -C) Anti-Aging Serum Based on Lecithin and Hyaluronic Acid in a Self-Emulsifying Delivery (SED) System

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Serum Anti-Aging;  
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### Abstract

Skin aging is not only due to complex biological processes but also affected by exposure to ultraviolet (UV) radiation. Exposure to UV radiation triggers the formation of Reactive Oxygen Species (ROS), hyperpigmentation, decreased elasticity, and collagen production.  $\alpha$ -cryptoxanthin ( $\alpha$ -C), one of the carotenoids with significant antioxidant, anti-inflammatory, and photoprotective properties. However, its use in serum preparations is still very limited.  $\alpha$ -C also has lipophilic properties and low solubility in water. Therefore, this study aims to develop an anti-aging serum  $\alpha$ -cryptoxanthin based on lecithin-hyaluronic acid using a self-emulsifying delivery (SED) system as an approach to improve delivery stability and potential effectiveness of active ingredients. The method used is a non-experimental study by collecting data, recording, and processing literature materials. Eligible studies were identified through searches on PubMed, Scopus, Google Scholar, Web of Science, Wiley, and ScienceDirect from 2016–2026. The results showed that  $\alpha$ -C provides indirect photoprotective by neutralizing ROS due to UV exposure, reducing hyperpigmentation and supporting skin structure through stimulation of collagen production. Hyaluronic acid also improves skin hydration and elasticity which all contribute to a younger skin appearance. This innovation also supports the Sustainable Development Goals (SDGs) point 3 (Good Health and Well-Being) through the development of skin care concepts and point 12 (Responsible Consumption and Production) by encouraging the use of natural active ingredients and sustainable cosmetic formulation innovations.

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## INTRODUCTION

Facial skin aging is a progressive biological process characterized by a decrease in the structure and function of skin tissue, such as reduced collagen, elasticity, and the appearance of hyperpigmentation. This process is influenced by intrinsic (chronological aging) and extrinsic factors, especially exposure to Ultraviolet (UV) radiation which plays a role in accelerating photoaging (Hussen, et al., 2025; Salminen, et al., 2025).

UV exposure increases the production of Reactive Oxygen Species (ROS) that trigger oxidative stress, thereby causing damage to DNA, lipids, and skin proteins (Hussen, et al., 2025). This condition also increases the expression of the enzyme Matrix Metalloproteinase (MMP) which plays a role in collagen degradation, thereby accelerating the appearance of signs of premature aging such as wrinkles and decreased skin elasticity (Xiao et al., 2020; Liu et al., 2024). Therefore, the use of antioxidants is one of the main approaches in preventing skin aging.

Antioxidants play a role in warding off free radicals and breaking off chain oxidative reactions, thus helping to maintain the cellular function of the skin (Hussen, et al., 2025). One potential source of natural antioxidants is  $\alpha$ -cryptoxanthin ( $\alpha$ -C), which is a carotenoid contained in Pandanus Conoideus (Papuan red fruit). Studies show that this fruit has a significant  $\alpha$ -C content with high antioxidant activity (Sarungallo, et al., 2015). This compound

has the potential to neutralize ROS, prevent hyperpigmentation, and increase collagen production and skin elasticity.

However, the use of  $\alpha$ -C in topical formulations is still limited due to its lipophilic properties, low solubility in water, and is susceptible to oxidative degradation (González-Peña, et al., 2023). On the other hand, hyaluronic acid (hyaluronic acid or HA) is known as a hydration agent that is able to increase skin moisture and elasticity and support the skin's biological function (Draeos, et al., 2021). The combination of  $\alpha$ -C and HA has the potential to provide a more optimal anti-aging effect, but the difference in physicochemical properties between  $\alpha$ -C (lipophilic) and HA (hydrophilic) is a challenge in formulation.

To overcome this, additional components such as amphiphilic lecithin are needed, so that they are able to connect the oil and water phases and form a stable emulsion system (Thy, et al., 2025). Lecithin is also known to increase the penetration of the active ingredient into the skin. The integration of  $\alpha$ -C, HA, and lecithin can be optimized through the Self-Emulsifying Delivery System (SEDs) approach, which is a system capable of spontaneously forming nanoemulsions to improve the stability and bioavailability of active ingredients (van Deventer, et al., 2025).

Based on this background, this study aims to analyze the potential of  $\alpha$ -cryptoxanthin as an anti-aging active ingredient contained in *Pandanus Conoideus*, evaluate the synergy of lecithin-hyaluronic acid-based  $\alpha$ -C combinations in the SED system, and develop an effective, stable, and sustainable anti-aging serum formulation concept.

The formulation of the problem in this study includes the potential of  $\alpha$ -cryptoxanthin ( $\alpha$ -C) derived from Papuan red fruit (*Pandanus conoideus*) as an active ingredient to slow down the aging of facial skin due to exposure to UV radiation, how the combination of lecithin-hyaluronic acid (L-HA) based  $\alpha$ -cryptoxanthin in the Self-Emulsifying Delivery (SED) system, and how the development of  $\alpha$ -cryptoxanthin, lecithin, and hyaluronic acid-based anti-aging serums in the system can be carried out. This study aims to analyze the potential of  $\alpha$ -cryptoxanthin as a natural anti-aging agent, examine the effectiveness of the combination of  $\alpha$ -cryptoxanthin with lecithin-hyaluronic acid in the SED system, and develop an innovative anti-aging serum formulation. The benefits of this research are to provide a deeper understanding of the potential of  $\alpha$ -cryptoxanthin from Papuan red fruits as an anti-aging active ingredient, expand studies related to the lecithin-hyaluronic acid combination in the Self-Emulsifying Delivery system, and open up opportunities for the development of safe, effective, and sustainable anti-aging serums.

### **Sinar Ultraviolet (UV)**

Ultraviolet (UV) rays are a form of high-energy electromagnetic radiation that is invisible and emitted by the sun. Based on the wavelength, UV can be divided into UVA (320 - 400 nm), UVB (280 - 320 nm), and UVC (100 - 280 nm). UVB has greater energy and is mainly absorbed by the cells of the epidermis compared to UVA. About 95% of UVB rays are absorbed by the ozone layer before reaching the skin and are mainly absorbed in the epidermis, while UVA rays can penetrate to the dermis. Strikingly, shorter wavelengths than UVB were found to cause more changes in key biological macromolecules (DNA and proteins) compared to longer wavelengths from UVA. UVB radiation causes direct DNA damage, especially in the form of (Xiao, et al., 2020) *dimer pyrimidine cyclobutane* (CPD) and *8-hydroxy-2'-deoxyguanosine* (8-OHdG), which is a key genetic marker for UVB-induced mutagenesis. In addition to

causing DNA damage, UVB radiation causes sunburns, cataracts, as well as triggering carcinogenic processes in the skin. (Emanuele, et al., 2014)(De Jager, et al., 2017)

### **Skin Aging caused by UV rays**

UVB radiation is mainly absorbed by the cells of the epidermis compared to UVA. Repeated exposure to UVB can cause changes in the skin's DNA as well as related proteins, making it one of the main factors in accelerating skin aging due to light exposure (*photoaging*). *Photoaging* and chronological aging are related to the process of *remodeling* of the immune system, which is characterized by the development of acute and chronic inflammatory responses and immune suppression. These opposing changes are pathological characteristics found in both accelerated aging processes and normal aging (Salminen, et al., 2025; De Jager, et al., 2017). The epidermis is constantly renewed and separated from the dermis by a layer of cells that continue to divide, namely keratinocytes and melanocytes. Epidermal melanocytes are susceptible to Reactive Oxygen Species (ROS) such as *superoxide anions*[ $O_2^-$ ]; *hydroxyl* [ $OH$ ]radicals and *hydrogen peroxide*[ $H_2O_2$ ], which are induced by excessive exposure to sunlight.

ROS-induced cellular oxidative stress can cause mitochondrial damage, which results in an imbalance of calcium ions and triggers the release of apoptosis proteins from cells, which triggers the process of apoptosis and accelerates the aging process of the skin. When homeostasis is disrupted by increased ROS production, the cell's malignant transformation process can increase, which further damages proteins, lipids, and nucleic acids; ROS is generally produced through intracellular metabolic processes such as electron transport chains. UV radiation also causes oxidative stress on the skin by triggering the release of inflammatory mediators. Leukocytes produce anion radicals, which are catalyzed by the enzyme NADPH oxidase. then undergo dismutation into oxygen and , which is catalyzed by (Xu, et al., 2025) (Xiao, et al., 2020)(De Jager, et al., 2017)(Hussen, et al., 2025)(Chen, et al., 2021) $O_2^-O_2^-H_2O_2$ *superoksida dismutase*. *Myeloperoxidase* then converts to hypochlorite. Another route of oxidative stress caused by UV is the removal of protons and electrons from lipid molecules, which produce lipid radicals. Lipid radicals can interact with molecular oxygen, producing lipid peroxide and new lipid molecules. Oxidative stress and the oxidative damage it produces can exacerbate skin pigmentation and aging, causing changes in skin tone homogeneity, wrinkles, sagging, dryness, and roughness. $H_2O_2$  (De Jager, et al., 2017)(Chen, et al., 2021)

### **$\alpha$ -C for Anti-Aging**

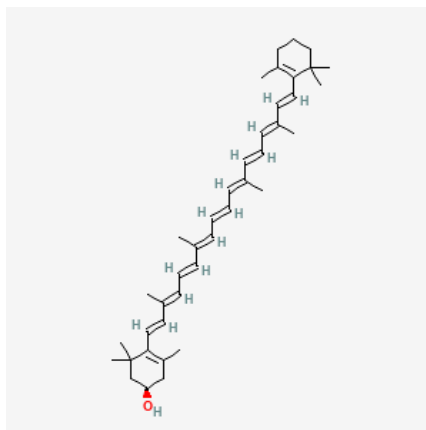
*Pandanus Conoideus* (Red Fruit) is a fruit native to the Papua region, Indonesia, which contains carotenoids, so it is included in the group *Xanthophylls*. *Pandanus Conoideus* Pregnant *Cryptoxanthin*, such as *A-C* and  *$\beta$ -C*. Studies show that *A-C* contained in *Pandanus Conoideus* have a much smaller amount than  *$\beta$ -C*, both in the form of oil directly and after drying. *A-C* only concentrated at about 6-27 ng/mg, while  *$\beta$ -C* concentrated at about 14-90 ng/mg. This causes (Sarungallo, et al., 2015) *$\beta$ -C* more widely used in cosmetics industry. Nevertheless, *A-C* has the potential to compete with  *$\beta$ -C*, mainly due to its high antioxidant content compared to other carotenoids. Antioxidant Activity of Oil *Pandanus conoideus* it is believed to be linked to its high content of carotenoids (pro vitamin A) and tocopherol (vitamin E), as well as their unsaturated fatty acids.



**Figure 1. Buah Merah (Pandanus Conoideus)**

Source: <https://investor.id/lifestyle/238460/manfaat-buah-merah-papua-untuk-merawat-tubuh-dan-rambut>

The antioxidant activity of carotenoids is closely related to their molecular structure: the number of conjugated double bonds and the properties of the terminal rings (e.g., *b*- vs *ε* ionone) affects both singlet oxygen suppression and free radical capture. Carotenoids with polar groups at the ends also attach to lipid interfaces, increasing protection against lipid peroxidation of membranes. The double bonding system of conjugation makes carotene highly susceptible to isomerization and oxidation by heat as well as high pressure and mechanical processing such as stirring or homogenization during processing. The *cis* isomer of (Charlton, et al., 2023) $\beta$  carotene has reduced provitamin A activity and altered antioxidant activity. (Sarungallo, et al., 2015)



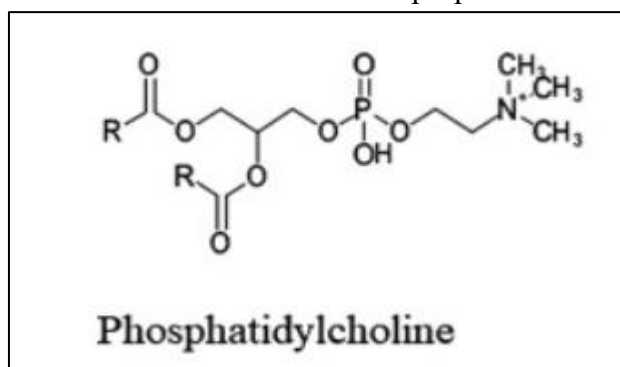
**Figure 2. Structure  $\alpha$ -cryptoxanthin**

Sources: <https://pubchem.ncbi.nlm.nih.gov/compound/Cryptoxanthin>

### ***Lecithin as an Emulsifier***

The skin is one of the easily accessible routes of drug administration, especially because it can avoid liver metabolism, thereby increasing the bioavailability of drugs, reducing side effects, allowing rapid discontinuation of therapy, and increasing patient adherence. However, the layered nature of the skin poses challenges in drug delivery due to the lipophilic outer layer of skin, followed by the hydrophilic layer of the skin underneath. Combinations (Van Steden, et al., 2020)(Van Steden, et al., 2020)*A-C* and *HA* face challenges because they dissolve in different ways; *A-C* is a fat-loving compound, while *HA* soluble in water. In this condition,

*lecithin* Acting as a *emulsifier*, support the combination. *Lecithin* It has a unique amphibious structure, with a hydrophilic polar head and two hydrophobic tails. This structure allows the lecithin to act as a *emulsifier* which is strong, facilitates the formation of homogeneous emulsions in many cosmetic products. *Lecithin* Able to retain moisture, protect the skin's natural lipid barrier, and aid in the penetration of active ingredients into the epidermis. *Lecithin* refers to a group of naturally occurring phospholipids extracted from a variety of sources, including plants (such as soybeans, sunflower seeds, seeds *rapeseed*, etc.) and animals (such as egg yolks, cheese, fish, etc.). (Xu, et al., 2025)*Lecithin* Sunflower exhibits a superior phospholipid content that is essential for its emulsification and stabilization properties.



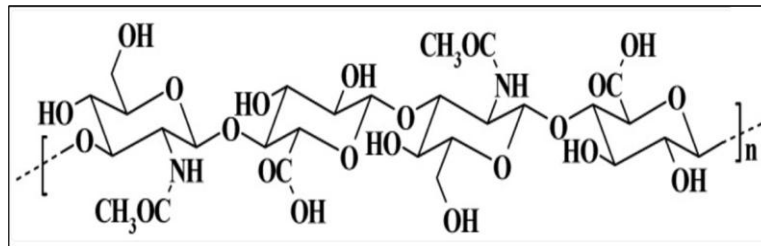
**Figure 3. Structure Lecithin (*phosphatidylcholine*)**

Sources: <https://www.sciencedirect.com/topics/chemical-engineering/lecithin>

### **Integration of L-HA in Serum**

Hyaluronic acid (HA), also known as hyaluronan, is a linear polysaccharide found in various living organisms and is highly hydrophilic. The human body contains about 15 g of hyaluronic acid (HA), with one-third of it found in the skin. HA has various functions in the skin, including in the regulation of cellular immunity, the regulation of intercellular interactions of the epidermis, as a component of the extracellular matrix, as well as its ability to absorb large amounts of water. Hyaluronic acid (HA) has an important role for skin health, especially in maintaining hydration by regulating water balance, osmotic pressure, and ion flow. In addition, HA serves as a filter that inhibits the penetration of certain molecules, increases the extracellular domain on the cell surface, as well as stabilizes the skin structure through electrostatic interactions. In addition to playing a role in maintaining skin hydration, hyaluronic acid (HA) also has antioxidant properties. The antioxidant activity of HA has been proven in various experimental models. For example, studies involving mechanical compression of cartilage showed that the administration of HA can significantly decrease ROS production. In addition, previous studies have shown a decrease in (Draeos, et al., 2021)*Nitric oxide* (NO) after the administration of HA, which further confirms the effectiveness of its antioxidant activity. HA provides significant advantages to serum formulations because it increases the viscosity of the formulation and improves the stability of the composition film when applied to the skin. HA helps the serum penetrate the skin's hydrophilic layers, supporting the serum's efforts to be better absorbed. Considering the advantages of HA and (Chmielewski & Lesiak, 2024)(Bravo, et al., 2022)*lecithin*, this will be beneficial for serum formulation when HA and *lecithin* integrated with A-C. Hyaluronic acid (HA) plays a role in providing hydration to the skin, while A-C neutralizes sources of oxidative stress through its high antioxidant content. The

combination of the two makes it easier to absorb the serum into the skin. In addition, lecithin supports this synergy by forming an optimal formulation for the skin.



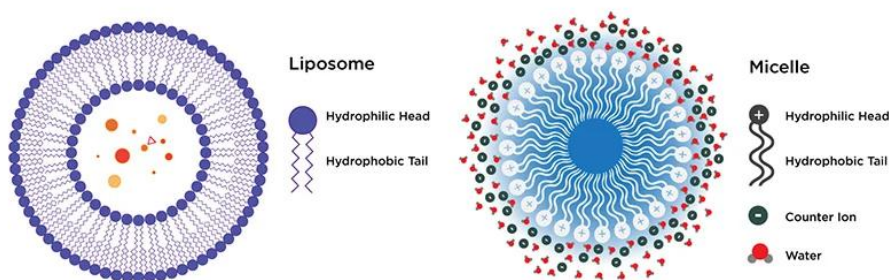
**Figure 4. Structure Hyaluronic Acid (HA)**

Source: (Valachová, et al., 2024)

### Sistem *Self-Emulsifying-Delivery (SED)*

*Self-Emulsifying-Delivery (SEDs)* systems are very promising treatment application systems and are suitable for the presence of lipophilic and hydrophilic components. This system combines both components through the oil phase (lipid solution) and surfactant. SEDs have also been widely used in drug formulations to improve the solubility and bioavailability of skin care products. SEDs are believed to be an affordable production method and are known to improve the stability of skincare emulsions that contain high lipophilic components.

SEDs are obtained by combining an oil or lipid phase containing a dissolved lipophilic component and a surfactant phase, which is usually a combination of surfactant and cosurfactant. After the addition of the water phase, oil-in-water emulsions (o/w) or water-in-oil (w/o) can be formed spontaneously without the addition of kinetic energy (increased temperature (>37 °C) and/or excessive stirring), and these emulsions can be further classified as microemulsions or nanoemulsions. For the formation of skincare formulations, a minimal amount of water is required to allow the formation of spontaneous emulsions due to the limited volume of water in the skin. In addition, when it wants to incorporate hydrophilic active ingredients, it is first dissolved in the water phase, which is then gradually introduced into the oil-surfactant concentrate to form a final emulsion (either an emulsion, microemulsion, or nanoemulsion) before application. Process *self-emulsification* is only used to form dermal formulations containing hydrophilic active ingredients.(van Deventer, et al., 2025)



**Figure 4. Structure Misel**

Source: <https://www.beckman.com/resources/sample-type/extracellular-vesicles/micelles>

## **METHOD**

The writing method used in this paper is Systematic Literature Review (SLR). This method aims to identify, evaluate, and synthesize relevant research results to answer research questions that have been formulated systematically. The literature search process is carried out through various scientific databases, including PubMed, Scopus, Google Scholar, Web of Science, Wiley, and ScienceDirect, with a publication year range of 2015-2025. The literature obtained is then selected and processed through a data reduction process to ensure the relevance and quality of the sources used.

### **Types of Writing**

This paper uses a systematic literature review approach with a descriptive-analytical method. This approach was used to comprehensively review various studies related to the development of  $\alpha$ -cryptoxanthin-based anti-aging serums with a Self-Emulsifying Delivery (SED) delivery system.

### **Data Collection Techniques**

The data used in this study are secondary data obtained from various scientific sources, such as national and international journals, proceedings, and relevant reference books. The literature search process is carried out using the following keywords:

- a. " $\alpha$ -cryptoxanthin"
- b. "Lecithin-Hyaluronic acid"
- c. "Self-Emulsifying Delivery"
- d. "Serum anti-aging"
- e. "Sustainable cosmetic"

### **Tahapan Systematic Literature Review**

#### **1. Research Question (RQ)**

At this stage, research questions are formulated as the basis for literature analysis, namely:

- a. RQ1: What is the potential of  $\alpha$ -cryptoxanthin (a-C) in the Papuan red fruit Pandanus Conoideus as an active ingredient in slowing down the aging of facial skin due to UV radiation?
- b. RQ2: How is the combination of lecithin-hyaluronic acid (HA) based  $\alpha$ -cryptoxanthin (a-C) in the Self-Emulsifying Delivery (SED) system?
- c. RQ3: How was the lecithin-hyaluronic acid-based  $\alpha$ -cryptoxanthin (a-C) anti-aging serum in the Self-Emulsifying Delivery (SED) system developed?

#### **2. Literature Identification**

The literature search process is carried out systematically to obtain sources that are relevant to the research question. The data used were secondary and came from previous research, without involving direct observation.

#### **3. Literature Selection (Screening)**

The selection stage is carried out to determine the feasibility of the literature used. The selection criteria include inclusion and exclusion criteria, which include aspects of population, intervention, comparison, outcomes. In addition, additional criteria are used in the form of publication year (2016-2026) and language to ensure the relevance and quality of data sources.

### **Data Analysis Techniques**

Data analysis was carried out descriptively and comparatively through several stages, namely:

1. Screening by title and abstract to eliminate irrelevant literature.
2. Evaluation of the feasibility of references.
3. Synthesis of data to identify key patterns, relationships, and findings in decision-making

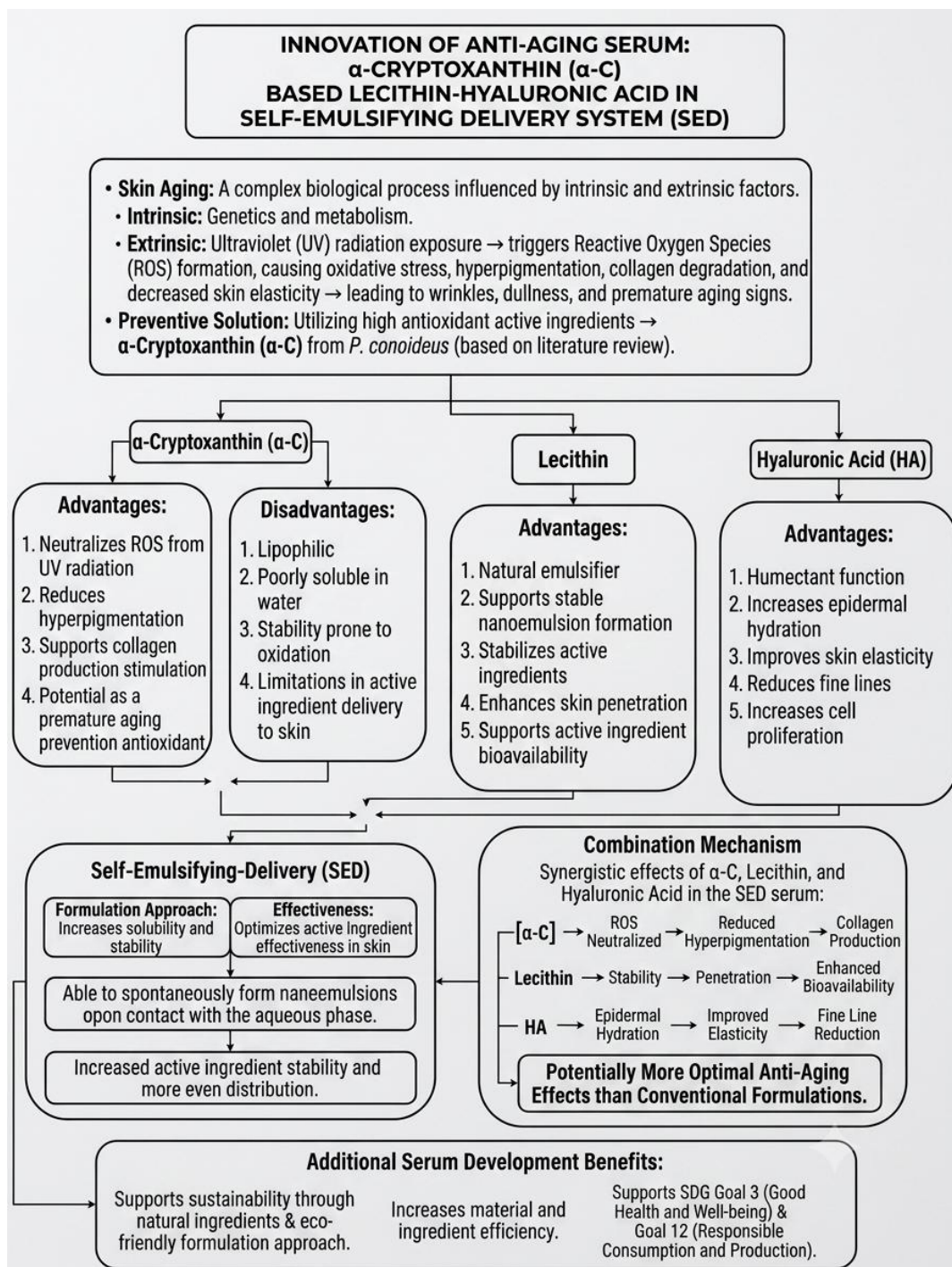
### **Frame of Mind**

Skin aging is a complex biological process that is influenced by intrinsic factors (genetic and metabolic) as well as extrinsic factors, especially exposure to UV radiation. UV exposure triggers the formation of Reactive Oxygen Species (ROS) which cause oxidative stress, collagen degradation, hyperpigmentation, and decreased skin elasticity, thereby accelerating the appearance of signs of premature aging. One approach to treat this condition is the use of antioxidants, such as  $\alpha$ -cryptoxanthin ( $\alpha$ -C) derived from *Pandanus Conoideus* (red fruit). This compound has a high potential in reducing the impact of oxidative stress. However, its lipophilic nature, low solubility in water, and easy oxidation are obstacles in transmission to the skin.

To overcome these limitations, a Self-Emulsifying Delivery (SED) approach is used which is able to increase the stability and distribution of active ingredients through spontaneous formation of nanoemulsions. Lecithin acts as a natural emulsifier that supports stability and penetration, while hyaluronic acid (HA) functions as a humectant that improves skin hydration and elasticity.

The combination of  $\alpha$ -cryptoxanthin ( $\alpha$ -C), lecithin, and hyaluronic acid (HA) in the SED system in the developed serum provides synergistic effects through several mechanisms.  $\alpha$ -C acts as an antioxidant that neutralizes Reactive Oxygen Species (ROS) due to UV exposure, thus helping to reduce hyperpigmentation and supporting the stimulation of collagen synthesis. Lecithin serves as a natural emulsifier that improves system stability, facilitates the penetration of active ingredients, as well as increases bioavailability. Meanwhile, HA acts as a humectant that increases epidermal hydration, improves skin elasticity, and reduces the appearance of fine lines.

Thus, this formulation has the potential to produce a more optimal anti-aging effect compared to conventional systems, while supporting the principle of sustainability through the use of natural ingredients that are in line with SDGs points 3 and 12.



**Figure 6. Thinking Framework Diagram**

Source: Researcher's Results, 2026

## RESULTS AND DISCUSSION

This chapter presents the results of a literature review that has been analyzed to answer the formulation of the problem and evaluate the scientific feasibility of α-cryptoxanthin-based (α-C)-based anti-aging serum innovation in the self-emulsifying delivery (SED) system.

### Photoaging Mechanism and Role of α-Cryptoxanthin

Based on the results of a literature review, skin aging due to exposure to UV radiation or photoaging is a complex biological process characterized by an increase in the production of Reactive Oxygen Species (ROS) (De Jager, et al., 2017). ROS accumulation triggers oxidative

stress that causes damage to DNA, membrane lipids, and skin proteins (Chen, et al., 2021), as well as increases the activity of the enzyme Matrix Metalloproteinase (MMP), specifically MMP-1 which plays a role in collagen degradation ((Liu, et al., 2024); (Salminen, et al., 2025)). This decrease in collagen quality has an impact on reduced skin elasticity and the appearance of wrinkles as a sign of premature aging.

In this context, the use of antioxidants is one of the main approaches to inhibit the photoaging process (Hussen, et al., 2025). One of the compounds that has this potential is  $\alpha$ -cryptoxanthin ( $\alpha$ -C), which is a bioactive carotenoid known to have high antioxidant activity ((González-Peña, et al., 2023); (Burri, et al., 2015)). Based on the results of the literature review,  $\alpha$ -C has the potential as an antioxidant through the following mechanisms:

1. Captures and neutralizes free radicals

$\alpha$ -C acts as a free radical scavenger by donating electrons to stabilize ROS, thereby preventing chain reactions that damage cellular components ((Hussen, et al., 2025); (Charlton, et al., 2023)).

2. Inhibits lipid peroxidation of cell membranes

$\alpha$ -C protects membrane lipids from oxidation due to ROS, thereby maintaining the integrity of the cell membrane and maintaining skin cell function (Chen, et al., 2021).

3. Suppresses increased expression of the enzyme Matrix Metalloproteinase (MMP)

UV exposure is known to increase the expression of MMP which plays a role in collagen degradation. Antioxidant compounds, including carotenoids such as  $\alpha$ -C, have the potential to suppress these pathways thereby slowing the breakdown of the extracellular matrix ((Xiao, et al., 2020); (Liu, et al., 2024)).

4. Supports fibroblast activity in maintaining collagen structure

By lowering oxidative stress,  $\alpha$ -C creates more optimal conditions for fibroblasts to remain active in collagen synthesis, thus helping to maintain skin elasticity and strength (Hussen, et al., 2025).

With this mechanism,  $\alpha$ -C not only acts as a protective agent against oxidative damage, but also contributes to maintaining the overall biochemical balance of the skin. This suggests that  $\alpha$ -C has strong potential as an active ingredient in anti-aging serum formulations, which further needs to be optimized through a proper delivery system approach.

### **The Benefits of $\alpha$ -Cryptoxanthin from *Pandanus Conoideus***

Based on the results of a literature review,  $\alpha$ -cryptoxanthin ( $\alpha$ -C) is one of the bioactive carotenoids that has high antioxidant activity and plays a role in protecting cells from damage due to oxidative stress (González-Peña, et al., 2023). This compound belongs to the group of xanthophyll that is naturally found in various food sources, including *Pandanus Conoideus* (Papuan red fruit), which is known to have significant carotenoid content (Sarungallo, et al., 2015).

Structurally,  $\alpha$ -C has a conjugated double bonding system that plays an important role in its antioxidant activity. This structure allows  $\alpha$ -C to interact with free radicals and stabilize them, thereby reducing the potential for oxidative damage to skin tissue (Charlton, et al., 2023). Compared to other sources of carotenoids, *Pandanus Conoideus* has several advantages as a source of  $\alpha$ -cryptoxanthin, including:

1. Relatively high antioxidant content

Pandanus Conoideus contains a wide variety of carotenoids, including  $\alpha$ -cryptoxanthin, which contribute to significant antioxidant capacity ((Sarungallo, et al., 2015); (González-Peña, et al., 2023)).

2. Contains supporting compounds such as tocopherols

The presence of compounds such as tocopherols has the potential to provide synergistic effects in increasing antioxidant activity, thereby strengthening protection against oxidative stress (González-Peña, et al., 2023).

3. It is Indonesia's local resource that supports sustainability

The use of Pandanus Conoideus as an active ingredient is not only scientifically relevant, but also supports sustainability through the use of local resources and opens up opportunities for the development of industries based on natural materials in Indonesia.

With these characteristics, the  $\alpha$ -C of Pandanus Conoideus not only has high bioactive potential, but also offers added value from the sustainability aspect. Nevertheless, its use in topical formulations still faces challenges related to physicochemical properties, especially solubility and stability, which will be discussed further in the next sub-chapter.

### **Challenges of $\alpha$ -C Formulation in Serum**

Although  $\alpha$ -cryptoxanthin ( $\alpha$ -C) has a high bioactive potential as an antioxidant, its use in topical formulations faces some limitations in terms of physicochemistry. One of the main challenges is its lipophilic nature, so it has a low solubility in aqueous media, as in serum preparations that are generally water-based (González-Peña, et al., 2023).

These differences in properties make it difficult for  $\alpha$ -C to disperse homogeneously in formulations, potentially degrading system stability as well as the effectiveness of delivering active ingredients to the skin. In addition, carotenoid compounds such as  $\alpha$ -C are also susceptible to oxidation-induced degradation, especially when exposed to light, oxygen, and ambient temperatures (Charlton, et al., 2023). These limitations can have an impact on several important aspects of topical formulation, including:

1. Unhomogeneous distribution of active ingredients
2. Low stability due to oxidation
3. Limited penetration into the skin layer

The structure of the skin itself consists of layers with hydrophilic and lipophilic characteristics, so a formulation approach is needed that is able to unite the two properties that  $\alpha$ -C has. In addition, the skin structure consisting of layers with hydrophilic and lipophilic characteristics requires a delivery system that is able to accommodate both properties simultaneously. Therefore, a formulation approach is needed that not only increases the solubility and stability of  $\alpha$ -C, but is also able to optimize its penetration and bioavailability on the skin.

Thus, the physicochemical limitations of  $\alpha$ -C are an important basis for the development of more adaptive formulation strategies, which in this study are proposed through the Self-Emulsifying Delivery System (SEDs) approach.

## Strategy and Effectiveness of Lecithin-Hyaluronic Acid-Based Formulations in Self-Emulsifying Delivery (SED)

To overcome the physicochemical limitations of  $\alpha$ -cryptoxanthin ( $\alpha$ -C), a formulation approach is needed that can improve the solubility, stability, and effectiveness of the delivery of the active ingredient into the skin. One of the approaches used in this study is the self-emulsifying delivery system (SEDs), which is a system that is able to form nanoemulsions spontaneously when in contact with the water phase (Van Steden, et al., 2020).

SED systems allow the formation of nano-sized droplets (<200 nm) that can increase the contact surface area, thereby supporting increased stability and penetration of active materials (Van Steden, et al., 2020); (van Deventer, et al., 2025)). In this formulation, lecithin and hyaluronic acid (HA) are selected as the main components that play a role in supporting system performance. The developed SED-based serum formulation approach is shown in Figure 7.



**Figure 7. Prototype Innovation Anti-Aging Serum a-CryptoXanthin (Lecithin – Hyaluronic Acid) in the Self-Emulsifying Delivery (SED) system**

Source: Researcher's Results, 2026

Figure 7 illustrates the integration between the active components and the delivery system designed to enhance the effectiveness of anti-aging through complementary mechanisms.  $\alpha$ -C encapsulated in the nanoemulsion system plays a role in neutralizing Reactive Oxygen Species (ROS) due to exposure to UV radiation, thereby reducing oxidative stress and supporting collagen synthesis.

To understand the working mechanism of the system more comprehensively, it is necessary to analyze the role of each component in the formulation. Each component in the SED system not only functions individually, but also contributes synergistically in improving the stability, penetration, and effectiveness of the active ingredients.

### 1. The Role of Lecithin

Lecithin is a natural phospholipid that is amphiphilic, which has hydrophilic and lipophilic groups in one molecular structure. This property allows lecithin to connect the oil

and water phases simultaneously, thus acting as an emulsifier in the SED system (Thy, et al., 2025).

In this formulation, lecithin facilitates the formation of small droplets (nanoemulsions), which contributes to increased system stability as well as a more even distribution of  $\alpha$ -C. Smaller droplet sizes also increase the surface area of contact, potentially increasing the penetration of the active ingredient into the skin layer.

## 2. Role of Hyaluronic Acid (HA)

Hyaluronic acid (HA) functions as a hydration agent that has a high ability to bind water, so it plays an important role in maintaining skin moisture (Bravo, et al., 2022).

The presence of HA in the formulation provides two main advantages:

- a. Increases skin moisture and elasticity, thus helping to improve the condition of aging skin.
- b. Supports an optimal microenvironment for cell proliferation and tissue regeneration, which contributes to the improvement of skin structure.

Thus, HA not only serves as a supporting component, but also as an active ingredient that strengthens the overall anti-aging effect.

## 3. Synergy Analysis in SED Systems

The combination of lecithin and HA in the SED system allows lipophilic  $\alpha$ -C to remain stable in a water-based serum medium. The system simultaneously improves:

- a. The stability of the active ingredient against oxidative degradation, thus maintaining the antioxidant activity of  $\alpha$ -C.
- b. Homogeneity of the formulation, which ensures a more even distribution of the active ingredients.
- c. Topical bioavailability, through increased penetration and retention of active ingredients on the skin.

Scientifically, this approach is considered rational because it is able to overcome the limitations of  $\alpha$ -C solubility while increasing its delivery effectiveness (Van Steden, et al., 2020).

## 4. The Relevance of Innovation to Indonesia's Conditions

As a tropical country, Indonesia has a high level of exposure to UV radiation throughout the year, which increases the risk of skin damage due to oxidative stress. Therefore, the development of anti-aging serums based on natural antioxidants is a contextual and relevant solution. This innovation integrates:

- a. The natural active ingredient ( $\alpha$ -cryptoxanthin) is Papuan red fruit (*Pandanus Conoideus*)
- b. Modern transmission technology (SED)
- c. A sustainable approach based on local resources

Overall, the results of the study show that the formulation of lecithin-hyaluronic acid-based  $\alpha$ -C serum in the SED system has a strong scientific basis, is relevant to the geographical conditions of Indonesia, and has the potential to be further developed through experimental research.

## CONCLUSION

Based on the results of the literature review that has been conducted, it can be concluded that the development of  $\alpha$ -cryptoxanthin ( $\alpha$ -C)-based anti-aging serum in the Self-Emulsifying Delivery (SED) system has strong scientific potential in overcoming skin aging due to exposure to UV radiation.  $\alpha$ -C derived from Papuan red fruit (*Pandanus conoideus*) shows antioxidant, anti-inflammatory, and photoprotective activity that plays a role in neutralizing the formation of Reactive Oxygen Species (ROS), preventing hyperpigmentation, and increasing elasticity and collagen production in the skin. The combination of  $\alpha$ -C with lecithin and hyaluronic acid (L-HA) in the SED system also provides a synergistic effect in increasing the stability, solubility, and bioavailability of lipophilic compounds, resulting in a more optimal distribution of active ingredients to the skin layer. Thus, the development of  $\alpha$ -C-based anti-aging serums in the SED system is an innovative formulative approach because it is able to overcome the limitations of the stability of active ingredients while supporting the development of effective, safe, and sustainable cosmetic products in accordance with SDGs point 3 (Good Health and Well-being) and point 12 (Responsible Consumption and Production).

This research also provides significant theoretical and practical implications in the field of cosmetic formulation and dermatology. Theoretically, this study strengthens the concept that the physicochemical limitations of bioactive compounds can be overcome through the right delivery system, while enriching the understanding of the synergistic mechanisms between  $\alpha$ -C, lecithin, and hyaluronic acid in increasing the effectiveness of anti-aging. In practical terms, the development of  $\alpha$ -C-based serums in the SED system opens up real application opportunities for the cosmetics industry through product formulations that are more stable, effective, and based on local natural ingredients. Therefore, further research through in vitro and in vivo tests, long-term safety and stability testing, and formulation optimization is needed to ensure the effectiveness and safety of the product before it is applied on an industrial scale. In addition, collaboration between researchers, educational institutions, and the cosmetics industry needs to be strengthened in order to accelerate the downstream of innovation into competitive, sustainable products, and be able to increase the responsible use of local resources such as *Pandanus conoideus*.

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