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FORMULATION AND EVALUATION OF SACHA INCHI OIL-BASED SERUM AS AN ANTI-AGING COSMETIC

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ABSTRACT

Skin aging is a complex biological process influenced by intrinsic factors (genetic, hormonal, and metabolic) and extrinsic factors (UV exposure, pollution, and lifestyle), characterized by decreased collagen and elastin production and increased oxidative stress. Sacha Inchi seed oil is known for its high content of polyunsaturated fatty acids and bioactive compounds such as tocopherols and phenolics, which exhibit antioxidant activity beneficial to skin health. This study aimed to formulate and evaluate the physical stability of a facial serum containing Sacha Inchi seed oil (*Plukenetia volubilis* L.) as a natural anti-aging agent. The formulation was assessed through physical quality tests, including organoleptic properties, homogeneity, spreadability, viscosity, pH, and a cycling stability test over six cycles at 4°C and 40°C to simulate extreme storage conditions. The results showed that the serum maintained its physical stability after the cycling test. No significant changes were observed in organoleptic properties (color, odor, texture), and the formulation remained homogeneous with no phase separation. Viscosity slightly decreased from 3920 to 3643 mPa·s, while spreadability decreased from 13.6 to 9.4 g·cm/s, yet both remained within acceptable cosmetic limits. The pH remained stable between 5.44 and 5.47, aligning with the physiological skin pH range (4.5–6.5). These findings indicate that Sacha Inchi oil can be effectively formulated into a physically stable serum and holds promise for development as a natural active ingredient in anti-aging skincare products.

Key words: Serum, Sacha Inchi Oil, Anti-Aging, Evaluation

INTRODUCTION

Skin aging is a natural biological process that occurs with increasing age and is characterized by structural and functional changes in skin tissue. Physiologically, this condition is caused by a decline in fibroblast activity, which plays a crucial role in the synthesis of collagen and elastin two major proteins responsible for maintaining skin firmness and elasticity (Iskandar et al., 2021). As a result, the skin becomes drier, thinner, and more prone to

wrinkle formation. In general, skin aging is influenced by two main mechanisms: intrinsic and extrinsic factors. Intrinsic or chronological aging is associated with genetic and hormonal factors as well as cellular processes such as telomere shortening, reduced DNA repair capacity, and increased oxidative stress. These changes lead to decreased collagen production, reduced blood flow, and lower lipid content in the skin, causing the skin to appear dry, pale, and finely wrinkled (Karim & Pakadang, 2022). Extrinsic aging is triggered by environmental factors such as excessive ultraviolet (UV) radiation exposure, pollution, stress, smoking, and unhealthy lifestyle habits. Prolonged UV exposure generates reactive oxygen species (ROS), which accelerate collagen and elastin degradation, induce photoaging, and reduce skin strength and elasticity (Yusharyahya, 2021). One effective approach to counteract the harmful effects of free radicals that contribute to skin aging is the use of antioxidants in skin care.

Antioxidants are compounds capable of donating one or two electrons to free radicals, thereby inhibiting oxidative reactions within cells and reducing cellular damage. Antioxidants are found in various forms, including vitamins, minerals, and secondary metabolites derived from plants (Hernani & Raharjo, 2005). One plant-derived material that can be utilized as an antioxidant active ingredient is Sacha Inchi seed oil (*Plukenetia volubilis* L.). Traditionally, Sacha Inchi seed oil has been used in Peru as a topical skin treatment applied regularly to maintain skin softness and health. This traditional use is supported by research conducted by Thuanthong et al. (2021), which reported that Sacha Inchi seed oil exhibits strong antioxidant activity, with IC_{50} values of DPPH = 0.007 ± 0.001 mg/mL, ABTS = 1.4065 ± 0.0505 mg/mL, and FRAP = 74.4960 ± 2.6067 mg/g extract, categorizing it as a potent antioxidant. Furthermore, studies by Hadzich et al. (2020) and Chirinos et al. (2016) revealed that Sacha Inchi seed oil contains various bioactive compounds with antioxidant potential, including omega-3, omega-6, and omega-9 fatty acids, vitamins E and A, tannins, phytosterols, terpenoids, and phenolic compounds (Thuanthong et al., 2021; Hadzich et al., 2020; Chirinos et al., 2016).

Facial serum is a topical cosmetic preparation in liquid or semi-liquid form with low viscosity, designed to deliver high concentrations of active ingredients effectively to the skin. Its lightweight physical characteristics and smaller molecular size, compared to creams or lotions, allow for faster and more efficient penetration into the epidermal layers, enhancing the bioavailability of active compounds and accelerating their biological effects on

the skin. Moreover, the non-occlusive texture and quick absorption profile of serums contribute to user comfort and reduce the risk of greasiness, making them suitable for various skin types. In modern cosmetic development, serums are frequently selected as a delivery system for antioxidant and anti-aging agents due to their ability to optimize the stability, efficacy, and application sensorial attributes of topical products (Zhang et al., 2021). The incorporation of bioactiverich natural substances, such as Sacha Inchi seed oil known for its high content of polyunsaturated fatty acids, tocopherols, and phenolic compounds further supports the role of serums as an effective and rational delivery system in functional cosmetic formulations (Thuanthong et al., 2021; Chirinos et al., 2016).

Although the potential of Sacha Inchi oil as an anti-aging cosmetic ingredient has been widely reported, studies evaluating the formulation and physical characteristics of facial serums based on Sacha Inchi oil remain limited. Previous studies have demonstrated the strong antioxidant activity of this oil and its potential anti-aging effects in topical formulations; however, more detailed investigations on physical characteristics, stability, homogeneity, and cosmetic performance are required to support the development of effective and safe products (Tanjung, 2025).

Therefore, this study aims to evaluate the physical characteristics of a facial serum formulated using Sacha Inchi oil (*Plukenetia volubilis* L.) as an anti-aging active ingredient. Through this research, it is expected that scientific data can be generated to support the utilization of Sacha Inchi oil as an effective, stable, and safe natural cosmetic ingredient, as well as to contribute to the development of plant-based cosmetic products with anti-aging claims.

MATERIAL AND METHODS

Material

The materials used in this study included Sacha Inchi oil, glycerin, propylene glycol, carbomer 980, polysorbate 20, Span 80, aqua (distilled water), rose oil fragrance, disodium EDTA, panthenol, ascorbyl glucoside, triethanolamine (TEA), and a preservative blend of phenoxyethanol and ethylhexylglycerin. The instruments used included an Ohaus Pioneer analytical balance with an accuracy of ±0.0001 g and a SH Scientific hotplate magnetic stirrer. The glassware consisted of Pyrex graduated cylinders (100 mL ±0.2 mL and 50 mL ±1.0 mL), volumetric pipettes (5 mL and 10 mL ±0.05 mL), dropper

pipettes, glass stirring rods, spatulas, and rubber bulbs. All glassware was pre-calibrated to ensure measurement accuracy.

Methods

Serum Formulation

The serum formulation presented in Table 1 incorporates 3% *Sacha Inchi Oil* as the antioxidant active ingredient, combined with excipients such as Tween 20, Span 80, carbomer, humectants, and additional antioxidants, selected based on their pharmaceutical functions as referenced in the *Handbook of Pharmaceutical Excipients* (Rowe et al., 2009). The facial serum was formulated using Sacha Inchi seed oil (*Plukenetia volubilis* L.) as the primary active ingredient, functioning as both an antioxidant and emollient. Glycerin and propylene glycol were incorporated as humectants to help retain skin moisture. Carbomer 980 was used as a gelling agent, while Polysorbate 20 (Tween 20) and Span 80 served as non-ionic surfactants to form and stabilize the emulsion between the oil and aqueous phases. Disodium EDTA was added as a chelating agent to enhance formulation stability by binding metal ions. Rose fragrance was used as a perfume component, and a combination of phenoxyethanol and ethylhexylglycerin served as the preservative system. Ascorbyl glucoside, a stable derivative of vitamin C, was included for its additional antioxidant activity. pH adjustment was carried out by adding triethanolamine (TEA). All ingredients were dissolved or dispersed in distilled water as the primary solvent, and the final serum preparation was subsequently subjected to physical characterization tests.

Tabel 1. Formula Composition of Sacha Inchi Oil-Based Facial Serum

Ingredient	Formula (%)	Function
SIO (Sacha Inchi Oil)	3.0	Active
Tween 20	1.5	Emulsifier
Span 80	1.5	Emulsifier
Carbomer 980	0.3	Thickener
Glycerin	4.0	Emulsifier
Distillate water	81.63	Solvent
Phenoxyethanol	0.8	Preservative
Ascorbyl Glucoside	2.0	Antioxidant
Rose Fragrance Oil	0.1	Essential Oil
EDTA	0.05	Chelating Agent

Ingredient	Formula (%)	Function
Propylene Glycol	3.0	Co-solvent
BHT	0.02	Antioxidant
TEA	0.1	pH Adjuster

Physical Evaluation of Serum Preparation

The physical evaluation of the serum formulation was conducted to ensure that the prepared serum met the required characteristics for topical cosmetic products. The parameters evaluated included the following:

Organoleptic Test

Organoleptic evaluation was carried out through direct visual observation of the serum preparation, assessing parameters such as color, odor, and overall appearance of the facial serum (Suleman et al., 2023).

Homogeneity Test

The homogeneity test was performed by applying the serum onto a transparent glass slide. The serum was then spread evenly by gently touching and rubbing the surface. A good formulation was indicated by a homogeneous appearance without visible coarse particles or granules (Liandhajani et al., 2022).

Spreadability Test

A total of 1 g of serum was placed between two glass plates with a diameter of 7 cm. The upper glass plate of the same size was then loaded with an additional weight of 5 g. After removing the upper plate, the time required for it to slide until reaching the full length of the plate was recorded as the measurement parameter. The spreadability value was calculated using the equation $S = m \cdot l/t$, where S represents spreadability (g·cm/s), m is the applied load (g), l is the length of the glass plate (cm), and t is the time required for the upper plate to move across the plate (s) (Mohini et al., 2025).

Viscosity Test

Viscosity measurement was conducted by placing the serum sample into a viscometer until the spindle was fully immersed. The spindle was set at a rotational speed of 30 rpm using spindle number 4. The viscosity of the serum formulation was considered acceptable if it fell within the range of 200–5000 dPa·s, as specified by SNI 16-4399-1996.

pH Measurement

Prior to measurement, the pH meter was calibrated using standard buffer solutions of pH 4 and pH 7. The electrode was rinsed and dried with tissue paper between calibrations. Subsequently, the pH meter was immersed into the serum sample, and the pH value was recorded. The serum formulation was required to have a pH range compatible with human skin, namely 4.5–6.5 (Fauzah et al., 2024).

Stability Test

The physical stability of the serum was evaluated using a cyclic test method for six cycles. Each cycle consisted of storing the serum at 4°C for 24 hours, followed by storage at 40°C for another 24 hours. One cycle was considered complete after the serum underwent both low- and high-temperature storage conditions. Physical changes in the serum, including appearance, phase separation, and consistency, were observed and compared with the initial formulation throughout the testing period (Suleman et al., 2023).

RESULT AND DISCUSSION

The serum formulation based on Sacha Inchi seed oil (*Plukenetia volubilis* L.) in this study was developed as a topical cosmetic product with antioxidant and anti-aging properties, attributed to its high content of polyunsaturated fatty acids and bioactive compounds such as tocopherols and phenolics (Thuanthong et al., 2021; Chirinos et al., 2016). The physical evaluation of the Sacha Inchi oil-based facial serum was conducted to ensure the stability of the formulation during storage and to determine its compliance with standard characteristics of topical cosmetic preparations. Based on the results presented in Table 2, the serum demonstrated good stability across various physical parameters both before and after undergoing cyclic stability testing. The evaluated parameters included organoleptic properties, homogeneity, spreadability, viscosity, and pH, each of which provides important insight into product quality, user acceptability, and the overall stability of the emulsion system. The following discussion examines each parameter in detail and compares the findings with relevant literature and established standards in cosmetic formulation.

Table 2. Results of Stability Testing of Serum Formulation

Parameter	IPC (In Process Control)	After Cycling Test
Organoleptic	Aroma: Rose, Tekstur: Light, Color: Milky White	Aroma: Rose, Tekstur: Light, Color: Milky White
Stability	Stable	Stable
Homogeneity	Homogeneous	Homogeneous
Spreadability	13.6 g·cm/s	9.4 g·cm/s
Viscosity	3920 mPa·s	3643 mPa·s
pH	5.44	5.47

The study by Tanjung et al. (2025) investigated the formulation and antioxidant activity of facial serum based on Sacha Inchi (*Plukenetia volubilis* L.) seed oil at concentrations of 3%, 4%, and 5%. The physical evaluation included organoleptic tests, homogeneity, pH, viscosity, spreadability, adhesiveness, as well as antioxidant activity assessment. The results showed that all formulas met the physical evaluation requirements. However, this study did not compare the physical properties before and after stability testing, which is essential to ensure the quality and safety of the formulation during storage and distribution. A formulation is considered stable if there is no significant difference in the observed parameters before and after the cycling test (Slamet et al., 2020).

The organoleptic evaluation results presented in Table 2 show that the serum maintained consistent aroma, color, and texture both during In Process Control (IPC) and after the cycling test. This consistency indicates that no degradation occurred in volatile components such as fragrance, nor were there any structural changes in the emulsion system. Organoleptic characteristics are critical in cosmetic formulation as they directly affect user comfort and consumer perception of product quality. The stability of these sensory attributes throughout storage also reflects the overall formulation quality (Suleman et al., 2023).

The homogeneity test results demonstrate that the formulation remained physically stable without the presence of coarse particles, agglomerates, or phase separation, both before and after the stability test. This suggests that the non-ionic surfactants used Tween 20 and Span 80 were effective in maintaining emulsion stability under temperature fluctuations. Homogeneity is a key indicator of the even distribution of active ingredients and the physical integrity of emulsions. Poor homogeneity can result in uneven

performance and undesirable product texture (Liandhajani et al., 2022; Zhang et al., 2021; Sutariya et al., 2016).

The spreadability test revealed a decrease from 13.6 g·cm/s to 9.4 g·cm/s after the cycling test. Although a decline was observed, the values remained within an acceptable range for topical application. This reduction is likely associated with increased viscosity due to temperature changes during the test. Spreadability is essential for determining ease of application and the distribution of active ingredients across the skin. According to Mohini et al. (2025), spreadability is strongly influenced by the formulation's viscosity and consistency higher viscosity generally leads to lower spreadability, and vice versa.

Viscosity values slightly decreased from 3920 mPa·s to 3643 mPa·s after the stability test. Despite this reduction, the values remained within the ideal range for semi-solid topical formulations, namely 200–5000 mPa·s, as stipulated by the Indonesian National Standard SNI 16-4399-1996. Viscosity plays a vital role in determining application comfort, spreadability, and the stability of emulsions. A formulation with too low a viscosity may be excessively runny and prone to separation, while overly viscous products may hinder the even application of active ingredients (Zhang et al., 2021).

The serum's pH increased slightly from 5.44 to 5.47 after the cycling test, though it remained within the physiologically acceptable skin pH range of 4.5–6.5. This slight shift is not considered significant and does not indicate degradation or interaction among the active ingredients that could affect the chemical stability of the formulation. pH stability is crucial for maintaining product safety and effectiveness. A product with an inappropriate pH can disrupt the skin's natural barrier or cause irritation (Liandhajani et al., 2022; Maya, 2024).

Overall, the results of the cycling test indicate that the Sacha Inchi oil-based facial serum retained good physical stability despite exposure to temperature fluctuations. The test simulates suboptimal storage conditions to assess the formulation's resistance to potential degradation, phase separation, or physical changes. The tested parameters organoleptic properties, homogeneity, viscosity, spreadability, and pH showed minimal variation and remained within acceptable cosmetic standards. These findings are consistent with existing literature stating that such parameters are essential for evaluating the long-term stability and safety of topical cosmetic products (Maya, 2024). Therefore, the Sacha Inchi oil-based serum formulation

developed in this study shows promising potential as a stable, topical anti-aging cosmetic product.

CONCLUSION

The topical serum formulated with Sacha Inchi seed oil demonstrated good physical stability after undergoing the cycling stability test. There were no significant changes in organoleptic properties, the formulation remained homogeneous without any phase separation, and the viscosity and spreadability values were within acceptable limits for topical cosmetic products. The serum's pH remained stable and within the physiological skin pH range. These findings indicate that Sacha Inchi seed oil can be effectively formulated as a natural active ingredient in a physically stable anti-aging serum that is safe and suitable for topical application.

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