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Formulation and Antioxidant Testing of Gold Nanoparticles Serum from Arabica Coffee Husk Extract (Coffea arabica L.) as an Anti-Aging Agent

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ABSTRACT

Arabica coffee bean husks (Coffea Arabica L.) are known to contain polyphenols, one of which is flavonoids, which have the potential to act as bioreductive agents in the biosynthesis of gold nanoparticles. Gold nanoparticles are widely used in cosmetics because they can increase skin elasticity, improve skin metabolism, and have anti-aging properties. The purpose of this study was to formulate a gold nanoparticle serum using coffee bean skin extract and determine its antioxidant effectiveness. The gold nanoparticle biosynthesis method used in this study was the green synthesis method, while the method used to test antioxidant activity was the DPPH (2,2-diphenyl-2-picrylhydrazyl) method. Characterization results of gold nanoparticles from Arabica coffee fruit peel extract showed a color change from yellow to purple. The results of the physical quality evaluation of gold nanoparticle serum from Arabica coffee fruit peel extract at F1 with a pH of 6.45 ± 0.05, viscosity 933.75 ± 13.77 cP, and spreadability 6.20 ± 0.08. F2 with pH 6.20 ± 0.08, viscosity 917.50 ± 11.90 cP, and spreadability 6.43 ± 0.05. F3 with pH 5.90 ± 0.08, viscosity 987.50 ± 6.55 cP, and spreadability 6.6 ± 0.08. The antioxidant activity results of Arabica coffee fruit peel extract nanoparticles showed an IC50 value of 9.826, Vitamin C at 1.653, both of which have very strong antioxidant activity, while the gold nanoparticle serum from Arabica coffee fruit peel at 53.239 has strong antioxidant activity because it has an IC50 value in the range of 50–100.

Keywords: consist Gold nanoparticles; Arabica coffee fruit skin; Serum; Antioxidant

Introduction

Premature aging is a process of skin aging that occurs faster than normal, characterized by facial wrinkles, dullness, and sagging skin. Skin aging is caused by two factors: intrinsic and extrinsic factors. Intrinsic factors are influenced by age, which causes aging in body tissues. Extrinsic factors are caused by exposure to ultraviolet rays, infrared rays, pollution, and smoking. Anti-aging compounds function to prevent skin damage, thereby preventing the appearance of signs of aging on the skin. (Mardhiani et al., 2018). The benefits of anti-aging products include preventing degenerative damage to the skin that causes it to look dull and wrinkled, making the skin healthier, brighter, and more youthful, supple, elastic, and free from signs of premature aging. To protect the skin from cell damage caused by UV radiation or sun exposure, antioxidants are needed. (Mangiwa & Maryuni, 2019).

Antioxidants are molecules that can inhibit the oxidation of other molecules, which can protect the skin from various cell damage caused by UV radiation, anti-aging, and protection from reactive oxygen species (ROS). The antioxidant defense mechanism in the skin can be affected by ROS. When the defense mechanism is imbalanced, oxidative stress can damage cell membranes, proteins, carbohydrates, and nucleic acids, triggering oxidation (Ajhar & Meilani, 2020). The use of natural ingredients as antioxidants is still rare, even though many plants in Indonesia contain compounds that have antioxidant activity, one of which is the coffee plant.

Coffee fruit skin is part of the coffee plant that contains antioxidant compounds such as anthocyanins, beta carotene, polyphenols, and vitamin C. The polyphenol compounds found in coffee skin are flavan-3-ol, hydroxymatic acid, flavonol, anthocyanidin, catechin, epicatechin, rutin, tannin, and ferulic acid (Arpi et al., 2018). In previous studies, ethanol extracts from Arabica coffee fruit peel exhibited antioxidant activity with an IC50 value of 12.739 ppm (Ekawati & Hariningsih, 2023). Until now, coffee fruit waste has only been used as animal feed, so innovation is needed to maximize its use.

Technological development in the world is becoming increasingly sophisticated with the aim of providing beneficial impacts for the wider community. One example is nanotechnology, which has a scale of less than 100 nm, so that the development of nanotechnology has been extensively tested by scientists. (Singh et al., 2025). One type of nanotechnology that has many advantages is gold nanoparticles. The combination of gold nanoparticles with natural ingredients in cosmetics offers several advantages, including better absorption, smaller gold nanoparticle size with a larger surface area that enables them to cross cell membranes, and good stability and biocompatibility. Gold nanoparticles are widely used in cosmetics because they can improve skin elasticity, enhance skin metabolism, and have anti-aging properties. (Suryani et al., 2017). Previous syntheses of gold nanoparticles have mostly used top-down (physical) and bottom-up (chemical) methods (Hammami et al., 2021). However, both methods are costly and have an impact on the environment. Therefore, the application of gold nanoparticle biosynthesis using the green synthesis energy method is necessary because it is low-cost and environmentally friendly (Dewi et al., 2020). This study used gold nanoparticles with bioreduction of Arabica coffee fruit peel extract. In order to develop anti-aging cosmetic products, this study created a gold nanoparticle Arabica coffee fruit extract facial serum.

Facial serum is a preparation with active ingredients that have a high concentration and low viscosity, enabling it to deliver a thin film of active ingredients to the skin's surface (Firmansyah et al., 2022). The serum is formulated with low viscosity and is clear or less clear (semi-transparent) and has a higher active ingredient content than other topical preparations. (Febriani et al., 2022). This study used Carbopol 940 as a gelling agent, triethanolamine as an emulsifier, propylene glycol as a humectant, propyl paraben and methyl paraben as preservatives, and sodium metabisulfite as an antioxidant. To determine the physical quality of the

serum preparation, organoleptic testing, homogeneity testing, pH testing, and viscosity testing were conducted. Serum preparations are easier to apply to containers as antioxidants that can prevent premature aging. To determine the extent of antioxidant activity, antioxidant activity tests need to be carried out on nanoparticle serum preparations of coffee fruit skin extract.

The antioxidant testing method used on gold nanoparticle serum preparations extracted from coffee fruit peel was the 2,2-diphenyl-2picrylhydrazyl (DPPH) method. This method was chosen because it is easy and quick to perform to determine the antioxidant activity, namely IC50, in gold nanoparticle serum preparations extracted from Arabica beans (Atun et al., 2010). The positive control used in the antioxidant activity test is ascorbic acid.

Based on the above description, researchers have reason to conduct research aimed at formulating a gold nanoparticle serum preparation extracted from Arabica coffee fruit skin that meets quality standards and testing its antioxidant activity, with the title "Formulation and Efficacy Testing of Antioxidant Facial Serum Containing Gold Nanoparticles and Arabica Coffee Bean Skin Extract (Coffea arabica L.) as an Anti-Aging Agent". The urgency of this research is motivated by the increasing use of anti-aging products, leading to the innovation of gold nanoparticle anti-aging serum with smaller particles and a larger surface area, enabling it to cross cell membranes and offering good stability and biocompatibility..

Methodology

This study was conducted using an experimental quantitative research method. The tool used in this study was an analytical balance (OHAUS), Rotary Evaporator, water heater (FAITHFULL), mortar dan stamper, porcelain dish, pH meter. Viscometer, micropipet, microsyringe, ultrasonic, Spektrofotometer UV vis, Particle Size Analyzer (PSA).

the materials used in this study were Arabica coffee fruit peel, 96% ethanol, gold powder, polyvinyl alcohol (PVA), carbopol 940, TEA, propylene glycol, methyl paraben, propyl paraben, sodium metabisulfite, distilled water, glycerin, and DPPH.This study used samples of ethanol extracts from Arabica coffee (Coffea arabica L.) fruit skins. Sample collection in this study used random sampling, a sampling technique that gives each sample an equal chance of being selected for the study. The stages of the study were as follows:

1. Plant Determination

The purpose of plant identification is to determine the species of the plants being studied. In this study, plant identification was carried out at the Mathematics and Natural Sciences Laboratory, UIN Siber Syekh Nurjati Cirebon

2. Production of Ethanol Extract from Arabica Coffee Fruit Skin (Coffea arabica L.)

The production of ethanol extract from Arabica coffee (Coffea arabica L.) fruit peel was carried out using the maceration extraction method, in which dried Arabica

coffee fruit peel samples were ground into powder, then 1000 grams of powder was placed in a maceration vessel. Next, 96% ethanol was added at a ratio of 1:10 and soaked. The soaking process lasts for 5 days in a place protected from light and moisture, and is stirred occasionally. After the soaking period is complete, the solution is filtered using flannel cloth. The extract obtained is then thickened using a rotary evaporator and evaporated through heating to produce a thick extract, then the percentage yield is calculated.

3. Phytochemical testing of Arabica coffee bean skin extract (Coffea arabica L.)

The purpose of conducting phytochemical tests is to determine the secondary metabolite content found in Arabica coffee bean skin extract (Coffea arabica L.), especially the flavonoid, saponin, and tannin content, which have antioxidant activity

Flavonoid test

Add 0.3 g of extract to sufficient hot water, then boil for 10 minutes and filter. Add 0.05 mg of Mg powder and 6-7 drops of concentrated HCL to 5 mL of filtrate. A positive test is indicated by the formation of a brown to red, yellow, or orange color.

Tannin test

Add 1 mL of extract with a few drops of 3% iron (III) chloride solution. If the color changes from cloudy brown to black, this indicates the presence of tannins.

Saponin test

Add 2–3 mL of extract to a test tube, then add 10 mL of hot water and cool. Shake vigorously for ±10 seconds, then add 1 drop of 2N HCl. A positive test is indicated by the presence of stable foam 1–10 cm high for 10 minutes

Alkaloid test

A total of 0.1 grams of sample was extracted with 5 mL of KI and 5 mL of glacial CH3COOH was added. Then, 10 drops were placed in a test tube. Next, Dragendorff's reagent was added to the test tube. Dragendorff's reagent will form a precipitate, indicating the presence of alkaloids.

4. Gold Nanoparticle Formulation from Arabica Coffee Fruit Skin Extract

0.5 mM $HAuCl_4$ gold solution can be made by dissolving 0.0493 grams of gold powder in 4mL of aquaregia solvent, then placing it in a 500mL beaker. Through a heating process at 70˚C, the solution has the following characteristics: (a) clear brass color. In this study, ethanol extract from Arabica coffee fruit peel was added to $HAuCl_4$ gold solution and PVA solution, producing a clear yellow color. The gold nanoparticle formula is as follows:

Table 1. Gold Nanoparticle Formula from Coffee Fruit Skin Extract

Fomulas	Coffee Fruit Skin Extract (µL)	Gold solution $HAuCl_4$ (µL)	PVA Solution (µL)
F1	90	1400	50
F2	120	1400	50
F3	150	1400	50

5. Characteristics Test of Gold Nanoparticles from Arabica Coffee Fruit Skin Extract

The gold nanoparticle formula that was formed underwent gold nanoparticle characteristic testing, including:

Visual observation

In this study, formulations 1 to 3 showed the formation of gold nanoparticles, indicated by a color change from yellow to purple. These results indicate the formation of gold nanoparticles. The color change to purple occurred at 30 minutes and remained stable during 24 hours of storage.

Wavelength observation

The formation of gold nanoparticles is considered successful when there is a color change in the sample solution from clear yellow to purple. The formation of gold nanoparticles occurs due to the oxidation-reduction reaction of gold (Au) from Au3+ to Au0 with the help of flavonoids from plants that act as bioreductors. In this study, the three formulas were analyzed using a UV Vis spectrophotometer in the range of 400 nm to 600 nm.

Observation of gold nanoparticle size

The formation of gold nanoparticles can also be seen based on particle size and can be observed using a Particle Size Analyzer (PSA). The size range of gold nanoparticles is between 1-100 nm.

6. Formulation of Gold Nanoparticle Serum from Arabica Coffee Fruit Skin Extract

The formulation of the gold nanoparticle serum used in this study is as follows:

Table 2. Formulation of Gold Nanoparticle Serum from Arabica Coffee Fruit Skin Extract

Ingredient	Concentration (%)				Function
	FO	F1	F2	F3	
Gold Nanoparticle from Arabica Coffee Fruit Skin Extract	-	1	5	10	Active ingredient
Carbopol 940	0.4	0.4	0.4	0.4	Gelling agent
Propilenglikol	5	5	5	5	Humectant
Trietanolamin	2	2	2	2	pH regulator
Gliserin	2	2	2	2	Humectant
Metil paraben	0.018	0.018	0.018	0.018	Preservative
Propil paraben	0.02	0.02	0.02	0.02	Preservative
Sodium metabisulfit	0.1	0.1	0.1	0.1	Antioxidant
Aquadest (ad)	100	100	100	100	Solvent

The production of nanoparticle serum from Arabica coffee bean skin extract is carried out by developing carbopol with distilled water mixed with TEA as a pH neutralizer in carbopol, then sprinkling carbopol over the solution, then stirred using a stirrer until the base was formed. Methyl paraben and propyl paraben were dissolved in glycerin, then added to the carbopol base mixture and stirred until homogeneously dissolved. The Arabica coffee bean skin nanoparticle extract was then added to the serum base and stirred until homogeneous.

7. Evaluation of Serum Physical Quality Tests

The evaluation of the physical quality test of coffee fruit skin serum includes:

Organoleptic Test

Organoleptic testing is conducted by observing the shape, color, and smell of the serum preparation. This observation is done using sight and smell. (Febriani et al., 2016).

Homogeneity Test

Homogeneity testing is performed by spreading the serum preparation on a glass slide or watch glass to check for the presence of coarse particles. If none are found, the preparation can be declared homogeneous (Febriani et al., 2016).

pH Test

Weigh 1 gram of the serum formulation, then dissolve it in distilled water until the volume reaches 100 ml to obtain a sample with a concentration of 1%. Next, use a pH meter to measure the pH of the solution (Febriani et al., 2016).

Spread Power Test

1 g of gel preparation on the test device, then cover it with a glass slide and apply weights of 0 g, 50 g, 100 g, and 150 g for 1 minute, then measure the diameter. (Febriani et al., 2020). A good spread test ranges from 5 to 7 cm (Voight, 1994 dalam Febriani et al., 2016).

Viscosity Test

Viscosity testing was conducted by preparing 100 ml of serum and testing it with a Brookfield LVT viscometer equipped with a number 7 spindle at 20 rpm. The scale was read by observing the red needle when its position had stabilized. (Febriani et al., 2020).

8. Antioxidant Activity Test

Preparation of DPPH stock solution

Weigh 10 mg of DPPH powder, then dissolve it in p.a ethanol to a volume of 100 mL using a measuring flask to produce a stock solution with a concentration of 100 ppm. This solution is stored in a dark-colored, tightly closed glass bottle to avoid exposure to light.

Determination of Maximum Wavelength

To determine the maximum wavelength (λmax), a 20 ppm DPPH solution was prepared by pipetting 10 mL of stock solution into a 50 mL volumetric flask, then diluted to the mark using p.a. ethanol. The solution was incubated for 30 minutes at 25^{o}C temperature in the dark, then its absorbance was measured using a UV-Vis spectrophotometer in the wavelength range of 500–600 nm (at 5 nm intervals) to obtain the λmax value used in subsequent measurements.

Antioxidant Activity Test

Antioxidant testing using the DPPH method involves a reaction between DPPH radicals and antioxidant compounds in the sample. The sample used was nanoparticle

serum extracted from Arabica coffee fruit skin. From a standard solution with a concentration of 100 ppm, a standard curve was created with concentrations of 20 ppm, 30 ppm, 40 ppm, and 50 ppm of nanoparticle extracted from Arabica coffee fruit skin. One milliliter of 1000 ppm DPPH and 10 ml of PA methanol were added, and the absorbance was read using UV-Vis spectrophotometry. The antioxidant value was determined by IC50 (Inhibition Concentration) by measuring the absorbance of the blank, sample, and reference. The formula for determining the percentage of inhibition is

$$\%\ Inhibition\ = \frac{Blank\ absorbance\ - Sample\ absorbance}{Blank\ absorbance}\ x\ 100\ \%$$

where the blank absorbance is the absorbance of the DPPH solution without the sample, and the sample absorbance is the absorbance of the DPPH solution plus the sample. The % inhibition data from each concentration is used to create a calibration curve (concentration vs. % inhibition), then linear regression analysis is performed to determine the IC_{50} value, which is the concentration that can inhibit 50% of free radicals. This is then entered into the equation obtained from the calibration curve y = a + bx, where the value of y is 50 and the value of x indicates the IC_{50}.

Result and Discussion

1. Plant Determination

To ensure that the samples to be used for research are indeed Arabica coffee (Coffea arabica L.), it is necessary to determine the plant. Plant determination is carried out at the Mathematics and Natural Sciences Laboratory Unit, UIN Siber Syekh Nurjati Cirebon. The results of plant determination indicate that the plants to be used in the research are indeed Arabica coffee of the species Coffea arabica L. from the Rubiaceae family.

2. Extraction Results of Arabica Coffee Fruit Skin (Coffea arabica L.) Using the Maceration Method

The results obtained from the extraction process using the maceration method on 1000 grams of coffee husk powder with 96% ethanol using a 1:10 ratio. The yield obtained based on the formula:

$$\text{Rendemen: } = \frac{Weight\ of\ extract\ obtained\ (gr)}{weight\ of\ crude\ drug\ before\ extraction\ (gr)}\ x\ 100\%$$

Table 3. Results of Arabica Coffee Skin Extraction Using the Maceration Method

Simplified powder (g)	Concentrated extract (g)	Rendemen (%)	Referral results
1000	110,9	11,09	>10 %

Based on Table 1, the results of coffee fruit skin powder extraction yielded 110.9 grams of thick extract with a yield of 11.09%, thus meeting the requirement of >10% (Saerang et al., 2023).

3. Results of Phytochemical Testing of Coffee Fruit Skin Extract

The identification of chemical compounds in coffee fruit peel extract was conducted to determine the content of compounds in the extract that have antioxidant activity. The results of the identification of chemical compounds in coffee fruit peel extract are as follows:

Table 4. Results of Phytochemical Testing of Coffee Fruit Skin Extract

Test	Result	Information
Flavonoid	The appearance of a brick-red or orange discoloration	+
Tanin	Blackish-green in color	+
Saponin	Foam forms	+
alkaloid	It is red in color and has sediment	+

Information:
+ : Positive results

Based on phytochemical test results, it was found that coffee fruit peel contains flavonoids, tannins, saponins, and alkaloids. These compounds are also found in Arabica coffee beans. The compounds contained in coffee beans and peel have very strong antioxidant activity .

4. Results Characteristics Gold Nanoparticles from Arabica Coffee Fruit Skin Extract

Visual observation of gold nanoparticles extracted from Arabica coffee fruit skin was conducted to qualitatively determine the formation of gold nanoparticles. Gold nanoparticles can form when there is an oxidation-reduction reaction of gold (Au) from Au3+ to Au0 with the help of flavonoids in plants that act as bioreductors. The formation of gold nanoparticles is considered successful if there is a color change in the sample solution from clear yellow to purple. In this study, formulations 1 to 3 showed the formation of gold nanoparticles, indicated by a color change from yellow to purple. These results indicate the formation of gold nanoparticles. The color change to purple occurred at 30 minutes and remained stable during 24 hours of storage.

UV-Vis spectrophotometer is an instrument that can be used to observe the formation time of gold nanoparticles. In this study, the UV-Vis spectrophotometer scale used was in the range of 400–600 nm (Rashid et al., 2025). In addition to wavelength, the UV-Vis spectrophotometer can also determine the absorbance of the sample. The expected absorbance of the gold nanoparticle sample is in the range of 0.2–1.2. The absorbance of gold nanoparticles is directly proportional to the storage time. The longer the storage time, the higher the absorbance of the sample.

Table 5. Wavelength Observation Results

Fomula	Coffee Fruit Skin Extract (µL)	Gold solution HAuCl4 (µL)	PVA Solution (µL)	wavelength	absorbance
F1	90	1400	50	504	0,935

F2	120	1400	50	516	0,965
F3	150	1400	50	520	1,032

From the results of observations using a UV-Vis spectrophotometer, it can be concluded that the results obtained were good for all three formulations. This is because the values obtained for the three formulations fell within the range, both for wavelength and absorbance of Arabica coffee bean skin gold nanoparticles.
The formation of gold nanoparticles can also be seen based on particle size and can be observed using a Particle Size Analyzer (PSA). The size range of gold nanoparticles is between 1-100 nm. In this study, the size range was not met, but it still met the nanoparticle size range of between 1 nm and 1000 nm (Chanida et al., 2024). The results of nanoparticle measurements observed particle size and polydispersity index with the following results:

Table 6. Particle Size Observation Results

Fomula	Coffee Fruit Skin Extract (µL)	Gold solution HAuCl4 (µL)	PVA Solution (µL)	Particle Size (nm)	Polidispersi index (D)
F1	90	1400	50	146,7	0,299
F2	120	1400	50	158,9	0,313
F3	150	1400	50	262,1	0,472

Based on particle size analysis using Particle Size Analyzer (PSA), the results showed that all coffee fruit peel extract gold nanoparticle formulations—namely F1, F2, and F3 had particle sizes that met the requirements for nanoparticles, which are in the range of 1 nm to 1000 nm.

5. **Results of the Evaluation of the Physical Properties of Nanoparticle Serum from Arabica Coffee Fruit Skin Extract**

Quality tests conducted on gold nanoparticle serum preparations extracted from Arabica coffee fruit skin included:

Organoleptic Test Results

The results of organoleptic testing covered the shape, color, and smell of the nanoparticle serum preparation extracted from Arabica coffee fruit peel. From the results of observing the texture, color, and smell of the serum preparation, it was found that it met the serum criteria. Therefore, it can be concluded that the preparation has good organoleptic physical quality. The results of the organoleptic testing can be seen in the following table 7:

Table 7. Result Organoleptic Test

Organoleptic	**F0**	**F1**	**F2**	**F3**
Texture	Slightly thick	Slightly thick	Slightly thick	Slightly thick
Color	Clear	Light purple	Light purple	Light purple

Smell	odorless	Coffe	Coffe	Coffe

The organoleptic test results for the Arabica coffee bean skin nanoparticle serum preparations in the table above show that F0 has a slightly thick texture, clear color, and no odor, while F1, F2, and F3 have a slightly thick texture, light purple color, and the characteristic aroma of coffee bean skin.

Homogeneity Test Results

Homogeneity testing of preparations was conducted to observe the absence of coarse particles in serum preparations and preparations mixed evenly. Homogeneity testing was conducted on glass slides. The results of homogeneity testing can be seen in the following table:

Table 8. Homogeneity Test Result

Formula	Replication			
	1	**2**	3	4
F0	Homogeneous	Homogeneous	Homogeneous	Homogeneous
F1	Homogeneous	Homogeneous	Homogeneous	Homogeneous
F2	Homogeneous	Homogeneous	Homogeneous	Homogeneous
F3	Homogeneous	Homogeneous	Homogeneous	Homogeneous

The results of the homogeneity test conducted on F0, F1, F2, F3, and F4 showed that all formulations were homogeneous and there were no coarse particles in the preparations, which is in accordance with the requirement that serum preparations must be homogeneous.

pH Test Results

Physical quality testing of pH was conducted to determine the degree of acidity of the serum preparation so as not to cause skin irritation. pH measurements were replicated three times for each formulation. The results of the pH test can be seen in the following table:

Table 9. pH Test Results

Formula	Replication				$\bar{x}$±SD	Requirements pH
	1	**2**	3	**4**		
F0	6,8	6.9	6.8	6.8	6.83 **±** 0.05	pH 4,5-8.0
F1	6.4	6.5	6.4	6.5	6.45 **±** 0.05	
F2	6.1	6.2	6.2	6.3	6.20 **±** 0.08	
F3	5.9	5.9	5.8	6.0	5.90 **±** 0.08	

Based on the results shown in the table, all serum preparation formulas, starting from F0, F1, F2, and F3, have a pH range of 5.8 to 6.9, which means that all serum preparation formulas meet the pH requirements for serum preparations, which are in the range of 4.5–8.

Viscosity Test

Viscosity testing needs to be carried out on cosmetic products because knowing the viscosity of a preparation can reveal the spreadability of the product, its ability to flow out of the container, and how easy it is to apply. The higher the viscosity, the greater the resistance to flow, making it more difficult for the preparation to flow out of its

container and apply. Viscosity measurements are carried out using a Brookfield viscometer. The viscosity measurement results can be seen in the following table:

Table 10. Viscosity Test Result

Formulasi	Replication				$\bar{x}$±SD	Requirements viscosity
	1	2	3	4		
F0	955	965	980	970	967.50 ± 10.41	800-3000 cP
F1	940	920	925	950	933.75 ± 13.77	
F2	930	905	925	910	917,50 ± 11.90	
F3	900	890	905	895	987.50 ± 6.55	

The viscosity test results in this study showed that F0, F1, F2, F3, and F4 had good viscosity ranging from 890 to 980 cP, which means that all formulas met the viscosity requirements for serum preparations, which are in the range of 800 to 3000 cP.

Spread Power Test Results

Spreadability testing was conducted to determine the ability of the serum preparation to spread on the skin surface. The results of the spreadability testing in this study can be seen in the table below:

Table 11. Spread Power Test Results

Formula	Replication				$\bar{x}$±SD	Requirements
	1	2	3	4		
F0	5.9	6.0	6.1	6.0	6.95 ± 0.07	5-7 cm
F1	6.2	6.1	6.2	6.3	6.20 ± 0.08	
F2	6.4	6.5	6.4	6.4	6.43 ± 0.05	
F3	6.6	6.7	6.6	6.5	6.6 ± 0.08	

The results of the spreadability test conducted in this study showed that formulas F0, F1, F2, F3, and F4 had spreadability values between 5.9 and 6.7. These results indicate that all serum preparation formulas met the serum preparation requirements, which range from 5 to 7 cm .

Antioxidant Activity Test using the DPPH Method

The results of the maximum wavelength measurement for DPPH show that the maximum wavelength is 517 nm with an absorbance of 0.690, which meets the criteria of 0.2–0.8 and can therefore be used for testing.The antioxidant value is determined by IC50 (Inhibition Concentration) by measuring absorbance, blank, sample, and reference. The IC50 values obtained for Arabica coffee bean skin nanoparticles are shown in the following table:

Table 12. The IC50 Values Obtained For Arabica Coffee Bean Skin Nanoparticles

Formula	IC50	Category
Gold Nanoparticles from Arabica Coffee Fruit Skin Extract	9.826	Very strong
Ascorbic Acid	1.653	Very strong

Arabica coffee fruit peel extract gold nanoparticle serum (F1)	83.439	Strong
Arabica coffee fruit peel extract gold nanoparticle serum (F2)	65.250	Strong
Arabica coffee fruit peel extract gold nanoparticle serum (F3)	53.239	Strong

The IC50 value of gold nanoparticles extracted from Arabica coffee husks was 9.826 ppm, indicating that gold nanoparticles extracted from Arabica coffee husks have very strong antioxidant activity, as indicated by an IC50 value <50. The antioxidant activity of gold nanoparticles extracted from Arabica coffee fruit skin is stronger than the antioxidant activity of Arabica coffee fruit skin extract at 12.739 ppm (3).

Conclusion

Based on the results of this study, it can be concluded that the gold nanoparticle formula extracted from coffee fruit skin meets the requirements for gold nanoparticles, namely a color change from yellow to light purple, a maximum wavelength of 504-520 with an absorbance of 0.935-1.032, and a particle size of 146.7-262.1 nm. The most stable formula in storage is F1 because no black particles formed during storage.

The Arabica coffee fruit peel extract serum formulation meets the physical requirements based on organoleptic testing, homogeneity, pH, spreadability, and viscosity.

The IC50 value of gold nanoparticles from coffee fruit peel extract is 9.826, indicating very strong antioxidant activity, while vitamin C has an IC50 value of 1.653, also classified as very strong. The serum formulation with the best antioxidant activity is F3, with an IC50 value of 53.239, classified as strong.

Declaration of Competing Interest

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