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Optimization of nanoemulsion hair serum from chia seed oil using the Simplex Lattice Design method

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ABSTRACT

Hair loss is a hair problem that men and women often experience. Chia seed oil (*Salvia hispanica* L.) contains linolenic acid, which can stimulate the sebum glands. This research aims to determine the composition of the optimum formula for chia seed oil nanoemulsion hair serum using the Simplex Lattice Design (SLD) method to prove that the characteristics and physical stability of the optimum formula meet the requirements for good preparation. The optimization method was carried out with the help of Design Expert 13 software to optimize the formula by varying Tween 80 (X1) and propylene glycol (X2). The characteristic parameters observed include organoleptic parameters such as pH, viscosity, homogeneity, emulsion type, particle size, zeta potential, polydispersity index, and percent transmittance. The physical stability test was carried out using a 6-cycle test method for organoleptic parameters, pH, and homogeneity. Optimization results show that the optimum composition consists of Tween 80 33.52% and propylene glycol 46.48%. The preparation meets all physical characteristic tests. Physical stability did not significantly change in the pH test, with a significance value of 0.027 in the paired t-test. Based on the research results, it can be concluded that the optimum surfactant and cosurfactant composition in the optimum formula based on optimization using SLD is Tween 80 (33.52%) and propylene glycol (46.48%) with a desirability value of 0.947. The optimum formula for preparing chia seed oil nanoemulsion hair serum meets good physical characteristics and stability requirements.

Keywords: chia seed oil, nanoemulsion, *Salvia hispanica* Linn, Simplex Lattice Design

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INTRODUCTION

Hair loss is one of the most common hair problems. Hair loss does not pose a severe threat to human life, but it impacts self-confidence and the function of hair on the skin, especially the scalp. Hair loss is caused by abnormalities in the hair shaft cycle, which cause damage to the hair follicles, thereby causing hair growth failure. Hair loss problems can occur in both men and women (Magfirah et al., 2022).

Technological advances to overcome hair problems and research that continues to be studied increase knowledge and innovation in the use of herbal plants in cosmeceutical hair care products. Hair serum, or hair serum, is a product used to style and coat the hair's surface and has a thicker consistency than air (Vakhariya et al., 2022). Consumer interest in herbal products continues to increase globally (Gamage et al., 2022). The chia plant (*Salvia hispanica* L.) originates from northern Guatemala and is widely cultivated in Mexico. Chia seeds contain 39% oil and have the highest α-linolenic acid content at 68%; this level is higher than the content in flax seeds, namely 57% (Segura-Campos et al., 2014). Linolenic acid, or omega 3, is a polyunsaturated fatty acid that can be absorbed into the skin and stimulate hair growth through its mechanism as a sebum gland stimulant (Sofwan et al., 2017).

According to research by (Rahmayanti et al., 2023), chia seed oil hair emulsion is weak as an active ingredient, making it less stable during storage. Hence, it needs to be reformulated into a more stable dosage form. Nanoemulsions are kinetically and thermodynamically more stable. An optimization process is undoubtedly needed to create the best formula for a cosmetic product. Optimization can be done using several methods, including a mixture. The method in mixture design is simplex lattice design (SLD). This method is considered more effective in time and can minimize the costs used (Hidayat et al., 2020).

Several previous studies have been carried out regarding the optimization of nanoemulsion formulas using the SLD method, one of which is research on the optimization of eel fish oil nanoemulsion formulas using the SLD method, where in this study, good significant results were obtained. Namely, there was no significant difference between the results of direct observation of the preparation and the value predictions of the Design expert software version 10.0.1.0 (Az-Zahra et al., 2022); however, from several existing studies regarding the optimization of nanoemulsion formulas, there has been no research regarding the optimization of chia seed oil nanoemulsion hair serum formulas. Hence, this research needs to be developed. Based on the description above, it is necessary to conduct research on optimizing the halal nanoemulsion hair serum formula from chia seed oil (*Salvia hispanica* L.) using the Simplex Lattice Design (SLD) method.

MATERIALS AND METHOD

Materials

The ingredients used in the research were chia seed oil (*Salvia hispanica* L.) (CV. Happy Green), Tween 80 (Chimica Panzeri), propylene glycol (Bratachem), methylparaben (Golden Era), propylparaben (Golden Era), span 80 (Bratachem), sodium metabisulfite (Purolanssss), and distilled water (Bratachem). The tools used in the research were software Design Expert 13-trial, UV-Vis spectrophotometry (Shimadzu), Particle Size Analyzer (PSA) (Microtac Nanotrac Wave II), oven (Memmert UN30), Refrigerator (Samsung), benchtop pH meter (Metler Toledo), Brookfield spindle viscometer number 40 (Ametek).

Methods

Formula rationalization

The method used in the formula rationalization process is to look for literature studies regarding what materials are suitable for use in this research, compatibility between materials is seen from the characteristics of the materials through handbooks of pharmaceutical excipients, journals that support the use of materials, and also other literature studies. The basis for selecting materials is related to compatibility, solubility, toxicity, and also the range of use and usefulness of the material. Active ingredient used in optimizing this formula is chia seed oil. The linolenic acid content in chia seed oil is a stimulant agent for the sebaceous glands that stimulates hair growth (Rahmayanti et al., 2023). The combination of Tween 80 and Span 80 surfactants was chosen to produce HLB 12 with an O/W emulsion type; besides, both are nonionic surfactants, so toxicity and side effects are lower. Propylene glycol was chosen as a cosurfactant to help reduce interfacial tension and help increase the diffusion rate of topical preparations. The combination of propylparaben and methylparaben preservatives was chosen to increase efficacy and reduce side effects. The antioxidant Sodium Metabisulfite was used in this research to prevent oxidation processes that may occur during heating.

Formula optimization using design expert 13

The chia seed oil nanoemulsion hair serum preparation formula was optimized using Design Expert software version 13. The research direction used in this research was optimization to optimize the formula with the best characteristics. One method in mixture design is simplex lattice design (SLD). This method is an optimization method used to determine the best formula for a mixture of ingredients that have been determined, with the proportion of the total amount of different ingredients having to be 1 (Hidayat et al., 2020). Formula optimization was carried out by varying variable X which was the independent variable, Tween 80 (X1) and propylene glycol (X2) while variable Y was the physical characteristics test response. This method is carried out by entering data on the upper and lower limits for the use of variable After the data is entered into the software via the new design menu, then optimization, mixture and simplex lattice. The software will provide an overview of the test results of various combinations of variable X and their influence on variable Y mathematically. Then the software will provide an initial recommendation formula and predictions of quantitative physical evaluation data test results. Every 2 ingredients that are varied will produce 8 formulas, of which 3 are the same formula. This formula equation functions to support the accuracy of the data predicted by the Design Expert software.

Validation and verification

The nanoemulsion hair serum preparation was validated to ensure the preparation complies with the optimum formula results from the Design Expert software by repeating the preparation in triplicate three times. Verification is carried out by comparing the predicted results with the results.

The experiment uses a parametric one sample t-test if the data is distributed normal and non-parametric Wilcoxon tests if the data is not normally distributed. Normality testing is carried out for each preparation evaluation result. The software used for the verification process is SPSS software (Noor, 2018).

Procedure for making nanoemulsion hair serum

In the chia seed oil nanoemulsion hair serum formulation, the concentration of chia seed oil used is 7.5%, methyl paraben 0.18%, propyl paraben 0.02%, sodium metabisulfite 0.075%, distilled water ad 100%. For the use of optimized materials, the concentration is written in the range, namely Tween 80 5-80% and propylene glycol 1-10%, while for the use of Span 80 the amount of use adjusts the results of the HLB calculation to produce an HLB value of 12 when combined with Span 80. The selection of range and concentration has been adjusted to the literature and the reasons for selecting ingredients at the formula rationalization stage. All ingredients needed in the formulation are weighed, then dissolve the propyl paraben and methyl paraben in propylene glycol (mixture 1). Mixture 1 was added with chia seed oil and then homogenized using a magnetic stirrer at 1000 rpm for 30 minutes. A mixture of 2, namely the water phase, was made by heating Tween 80 and distilling water at a temperature of 50^{o}C, then homogenizing using a stirrer at 1000 rpm for 30 minutes at a temperature of 50^{o}C. then homogenized using a stirrer at 1000 rpm for 30 minutes at 50oC. The oil and water phases were mixed using a magnetic stirrer at a speed of 1000 rpm for 70 minutes. Then, it was sonicated using a bath-type sonicator for 90 minutes.

Physical evaluation of hair serum nanoemulsion preparations

Organoleptic test

The organoleptic test was performed by visually observing the hair serum nanoemulsion preparation. Good organoleptic results include precise, transparent preparations and no phase separation (Collins et al., 2023).

Homogeneity test

The homogeneity test is carried out to see whether less homogeneous particles or coarse particles are scattered in the preparation. A good preparation has homogeneous characteristics and does not contain scattered coarse particles (Collins et al., 2023).

pH test

The pH test is carried out so that the preparation has a pH that matches the skin's pH and does not cause irritation. The pH range of good topical preparations is between 4.5 and 7.0 (Sanaji & Liananda3, 2019). pH testing is carried out using a benchtop pH meter, by calibrating the pH meter with a standard buffer of pH 4.00; 7.00; and 9.00 then rinsed the electrode with distilled water and dry using tissue. After that, pH measurements are carried out by: dip the pH into the nanoemulsion preparation until the pH value appears on the screen pH meter (Handayani et al., 2018).

Viscosity test

The viscosity test is carried out to determine the viscosity level of the resulting preparation. A suitable dosage viscosity range is between 10 and 2000 cPs (Nicolini et al., 2021). This test uses tools Brookfield spindle viscometer number 40 with a rotation speed of 1 rpm. Then, the measurement results visible on the viscometer are viewed and analyzed meets the requirements for good viscosity acceptance or not (Az-Zahra et al., 2022).

Particle size test, zeta potential test, and polydispersity test

This test was carried out using a PSA apparatus with a dilution of 1:250 using Aqua Pro injection to determine whether the nanoemulsion preparation met the requirements for a good nanoemulsion, namely 10-1000 nm (Handayani et al., 2018). The particle size test, zeta potential test, and polydispersity tetst uses a Particle Size Analyzer (PSA) tool. The method is to dilute 1 mL of the nanoemulsion preparation in 250 mL of Aqua Pro injection, the diluted preparation is placed in a cuvette and the data coming out of the PSA device is observed. (Az-Zahra et al., 2022).

Emulsion type test

This test is carried out to determine the type of emulsion formed, including the type of oil in water (O/W) or water in oil (W/O). This test was carried out using a painting method using methylene blue.

Percent transmittance test

This test was carried out using UV-vis spectrophotometry with a dilution of 1:100 using aqua deion solvent. The aim is to see the clarity of the nanoemulsion; the acceptance range is 90–100% (Aprilya et al., 2021).

Physical stability test

The physical stability test was carried out using the cycling test method. The test was carried out by storing the preparation at a low temperature of 4ºC and a high temperature of 40ºC. With six cycle repetitions, each storage time is 48 hours (Ma'arif et al., 2023). The chia seed oil nanoemulsion hair serum formulation was stored at a low temperature of 4º C in the refrigerator and a high temperature of 40º C in the oven. The cycle was repeated for 6 cycles where each cycle was stored for 48 hours and observed whether there were any changes or instability that occurred in the nanoemulsion preparation.

After the preparation was stored for 6 cycles, the preparation was observed organoleptically, pH, and homogeneity to determine the stability of the preparation (Pratiwi et al., 2018).

Data Analysis

Data were analyzed using SPSS with one sample t-test to verify the predicted and experimental data if the data is usually distributed and the Wilcoxon if it is not normally distributed. Further data analysis was carried out on stability data using paired t-test samples. The p-value>0.05 indicates that the data is not significantly different. Based on the results of the pH response normality test, particle size, zeta potential, polydispersity index and percent transmittance data normally distributed so it uses a one sample t-test. Whereas for viscosity response data is not normally distributed in the normality test so Wilcoxon test was used. The results of data analysis show the significance value of the pH response 0.500; particle size response 0.500; viscosity response 0.276; zeta potential response 0.500; polydispersity index response 0.500; and the percent transmittance response is 0.500. The p value>0.05 indicates that there is no significant difference between prediction results with experimental results (Taufik et al., 2023).

RESULT AND DISCUSSION

Results of formula rationalization

Rationalization, in this case, means designing the ingredients used in the dosage formulation based on valid and relevant literature (Illu, 2020). The results of the rationalization of the formula are shown in Table 1.

Table 1. Nanoemulsion hair serum formula

Raw Material	Function
Chia Seed Oil	Active ingredients
Tween 80	Surfactant
Span 80	Surfactant
Propylene glycol	Cosurfactant
Methylparaben	Preservative
Propylparaben	Preservative
Sodium metabisulfite	Antioxidant
Aquadest	Solvent

Simplex Lattice Design (SLD) method formula optimization results

The simplex lattice design method requires researchers to enter the material components to be optimized by determining the upper and lower limits for each material. The mixed designs can contain anywhere from 2 to 30 materials or components where all components must have the same range. The results of the expert design formula are shown in Table 2.

The material components used in this research are compound X1, Tween 80, with a lower limit of 1 and an upper limit of 35%. Component X2 is propylene glycol, with a lower limit of 5% and an upper limit of 80% (Rowe et al., 2009). The total used for these two materials was 80. The determination of the total of these materials was adjusted to the researcher's wishes. Every two materials or components entered will produce eight runs of the prediction formula, as presented in Table 2. In addition, in these 8 formulas there are 3 similar formulas, this formula equation serves to increase the accuracy of the formulas produced by Design Expert. The responses entered will be coded with the letter Y. The value of each response is obtained from the laboratory experiments' results.

Table 2. Formula design expert results

Run	X1	X2	Y1	Y2	Y3	Y4	Y5	Y6
	Tween 80 (%)	Propylene glycol (%)	pH	Particle size (nm)	Viscosity (cPs)	Zeta potential (mV)	Polydis-persity index	Transmittance (%)
1	1	79	4.48	374.88	68.57	5.8	0.1181	25.508
2	35	45	6.40	104.40	157.27	16.5	0.1231	95.423
3	18	62	6.16	807.95	102.07	53.7	0.0233	69.039
4	9.5	70.5	5.62	172.70	96.16	9.6	0.1172	30.716
5	1	79	4.48	374.88	68.57	5.8	0.1181	25.508
6	35	45	6.40	104.40	157.27	16.5	0.1231	95.423
7	18	62	6.16	807.95	102.07	53.7	0.0233	69.039
8	26.5	53.5	6.26	307.26	117.20	5.9	0.3440	59.245

Design expert prediction optimum formula recommendation results

The optimum formula results were obtained after the selected model was significant, and analysis was carried out on each response. Determining the optimum formula is based on the formula that has the highest desirability value. The desirability value refers to the value of the optimization objective function. This value shows the program's ability to determine the formula according to the parameters set by the researcher. A desirability value close to 1 indicates that the formula is increasingly optimal. The results of the Design Expert's optimal prediction formula are presented in Table 3. In the optimization results, the optimum formula is shown in the gray area where the resulting desirability value is 0.947, which indicates that the desirability value is close to 1, which means the formula is the most optimal predicted formula result.

Optimum formula validation and verification results

Validation was carried out on the optimum hair serum nanoemulsion formula by preparing three replications, and the results were obtained, as shown in Table 4. Then, the stage continued with verification by comparing the predicted results with experimental results using the parametric one-sample t-test if the data was distributed normally and the Wilcoxon test if the data was not normally distributed. The test was carried out with the help of SPSS version 20 software. The results of the data analysis showed a significant value for the pH response of 0.500, particle size response of 0.500, viscosity response of 0.276, potential zeta response of 0.500, polydispersity index response of 0.500, and the percent transmittance response of 0.500. In the viscosity response test, the data obtained in the replication was not normally distributed, so the test was carried out using the Wilcoxon method. The p-value> 0.05 indicates no significant difference between the predicted and experimental results (Taufik et al., 2023). The optimum formula verification results are shown in Table 4.

Table 3. Design Expert 13 optimal prediction formula

Material Components (X)		Predicted Value of Response Variable (Y)						
Tween 80 (%)	Propylene glycol (%)	pH	Particle size (nm)	Viscosity (cPs)	Zeta potential (mV)	Polydis-persity index	Trans-mittance (%)	Desirability Value
33.52	46.48	6.37	176.958	147.14	17.125	0.287	90.00	0.947 (suggested)
26.50	53.50	6.29	454.576	116.00	32.079	0.344	75.85	0.626
13.26	66.74	5.92	605.654	99.37	33.635	0.023	49.18	0.325

Table 4. Optimum formula verification results

Response Parameters (Y)	Prediction	Experiment Results ($\bar{X}$ ± SD)	*p-value*	Information
pH	6.37	6.43 ± 0.015	0.500	Not significant difference
Particle size (nm)	176.96	130.29 ± 19.542	0.500	Not significant difference
Viscosity (cPs)	147.14	145.20 ± 1.617	0.297	Not significant difference
Zeta Potential	17.13	36.70 ± 29.444	0.500	Not significant difference
Polydispersity Index	0.287	0.274 ± 0.148	0.500	Not significant difference
Percent Transmittance (%)	90.00	95.16 ± 3.314	0.500	Not significant difference

Note: $\bar{X}$ = average
SD = Standard Deviation

Optimum formula characteristic results

Physical characteristics were carried out to compare the physical parameter values of the optimum hair serum nanoemulsion chia seed oil formula obtained with the predetermined acceptance range. Observation data are presented in Table 5.

Based on the results of physical characteristic tests on the optimum formula for chia seed oil nanoemulsion hair serum preparations, the optimum formula meets all physical characteristic tests for each parameter. In the organoleptic test, the light yellow color of the preparation was due to the composition of ingredients, which were mostly yellow, including chia seed oil, which had a clear yellow color, Span 80, which had a yellow color, and Tween 80, which had a yellow color. Adding propylene glycol as a cosurfactant can make the preparation more straight forward. The addition of appropriate surfactants and cosurfactants plays a role in reducing the interfacial tension between the oil and water phases so that phase separation does not occur and a homogeneous preparation is obtained in the homogeneity test (Figure 1).

Figure 1. Observation results of homogeneity and organoleptic tests of preparations

Table 5. Optimum formula characteristic test results

Parameter	Optimum Formula ($\bar{X}$ ± SD)	Acceptance
Organoleptic	Light yellow, liquid, characteristic smell of chia seed oil, clear, and no phase separation	-
Homogeneity	Homogeneous	Homogeneous
pH	6.43 ± 0.015	4.5 – 7
Particle size (nm)	130.29 ± 19.542	10 – 1000
Emulsion type	Oil in water (O/W)	Oil in water (O/W)
Viscosity (cPs)	145.20 ± 1.617	10 – 2000 cPs
Zeta potential (mV)	36.70 ± 29.444	(-30 mV) – (+30 mV)
Polydispersity Index	0.274 ± 0.148	0 – 1
Transmittance (%)	95.160 ± 3.314	90 %-100%

Note: $\bar{X}$ = average
SD = Standard Deviation

The physical appearance of the preparation is shown in Figure 2. The results obtained in the organoleptic test meet the characteristics of nanoemulsion, namely clarity and transparency. The organoleptic characteristics of a preparation can influence consumer acceptance of the product (Xu et al., 2022). In the optimum formula formulation, the preparation is replicated three times to increase the accuracy of the formula created and show that the test results obtained are not biased. As shown in Figure 2, the first bottle is the optimum formula for replication 1, then the next bottles are the optimum formula for replication 2 and 3.

In the pH test, it is known that the preparation meets the required pH range, namely by the topical pH of the skin. The Tween 80 surfactant used in this research has a pH that tends to be alkaline, namely (6–8), so increasing the concentration of Tween 80 surfactant tends to increase the pH value of the preparation. Meanwhile, the cosurfactant used, namely propylene glycol, tends to have an acidic pH (3-6), so the optimum composition between the use of surfactant and cosurfactant can produce a pH that meets the requirements (Bagiana et al., 2017).

Figure 2. Physical appearance of the optimum hair serum nanoemulsion chia seed oil formula

In the test using the Particle Size Analyzer (PSA) instrument, three test data were obtained, namely the particle size test, polydispersity index test, and zeta potential test. In the particle size test, it was discovered that the preparation had nano-sized particles by the standardized acceptance criteria. Tween 80 surfactants play a role in reducing particle size by reducing the amount of free energy between surfaces and forming a mechanical barrier that prevents particle aggregation (Pratiwi et al., 2018). Propylene glycol cosurfactant itself functions to prevent nanosized particles from recombining through a steric barrier formation mechanism so that the right combination of surfactant and cosurfactant will produce a nanoemulsion preparation with a stable nanometer size. The polydispersity index value in this preparation is classified as monodisperse because it has a polydispersity index value of <0.3, which means the particle size is uniform. The particle size distribution is narrow, so the preparation will be more stable in storage (Handayani et al., 2018). The polydispersity index tends to be influenced by the stirring speed, where the right stirring speed will produce a dosage value with a good polydispersity index (Faizatun et al., 2020). The zeta potential value of the chia seed oil nanoemulsion preparation meets the required criteria, namely >30 mV; this indicates that the preparation has good electrostatic stability (Handayani et al., 2018). The use of surfactants and cosurfactants does not influence the negative charge on the zeta potential value; this is because Tween 80 and propylene glycol are nonionic compounds (no charge); the negative charge is produced from the collision of droplets with the dispersing phase containing hydroxyl ions (OH-), thus creating preparations tend to have a negative charge.

In the emulsion type test, the preparation was an O/W emulsion type. For topical use, the O/W emulsion-type nanoemulsion was more suitable because it was not sticky and, as a hair serum, did not leave crusts on the scalp (Rahmayanti et al., 2023). The type of O/W emulsion is influenced by the highest concentration of nanoemulsion constituents, which tend to be polar, namely Tween 80, a hydrophilic nonionic surfactant, and propylene glycol, which is polar. The correct surfactant and cosurfactant composition influences the HLB value, so the oil phase can be dispersed evenly in the distilled water because the surface tension can be reduced. This makes methylene blue, which is polar, completely soluble to produce an O/W emulsion type (Dzakwan & Priyanto, 2019). The HLB value used in this research is HLB 12, which can produce O/W type nanoemulsions.

In the viscosity test, the chia seed oil nanoemulsion hair serum preparation was in accordance with the acceptance criteria for a good preparation. Viscosity is the main parameter of rheology, which is related to flow resistance (Nicolini et al., 2021). Components that influence the viscosity of the preparation are Tween 80 and propylene glycol, where increasing the concentration will cause the viscosity of the preparation to also increase. Tween 80's mechanism for increasing viscosity is by reducing the movement between globules, which causes the globule diameter to decrease and the particle size to become smaller, which causes the surface area to become larger and the resistance of the nanoemulsion to also increase so that the viscosity increases (Zulfa et al., 2019). The increase in viscosity is also influenced by propylene glycol, a cosurfactant, which will help increase the bond between the surfactant, oil phase, and water phase, which causes resistance to flow to become greater (Yuliani et al., 2016). The use of cosurfactant and surfactant composition in this optimum formula is correct, as proven by the viscosity value of the preparation, which meets the requirements.

Optimum formula physical stability test results

Stability testing is one of the quality parameters. It is carried out to determine the ability of a product to survive within specified specification limits throughout the storage and use period. Several factors can influence the stability of a product, namely temperature and time. In this research, stability tests were carried out at 4ºC and 40ºC for six cycles, where one cycle consisted of 48 hours (Ma'arif et al., 2023). The stability test results are shown in Table 6.

The physical stability test using the cycling test method shows that the preparation remains stable during the storage period in the homogeneity and organoleptic tests. In the descriptive pH test, there was a decrease in pH. The significance of the data determined with a paired t-test was carried out. The requirements for carrying out a parametric paired t-test are that the data is normally distributed and homogeneous. Based on the normality test results using Shapiro Wilk, the p-value before stability was 0.637; after stability, it was 0.463. The homogeneity test shows a p-value of 0.519. The p value > 0.05 in the normality and homogeneity test indicates that the resulting data is normally and homogeneously distributed. Testing continued with the paired t-test; in this test, a tailed sig.2 value of 0.27 was obtained. The p-value > 0.05 indicates that the pH test data before and after physical stability did not show a significant change. It means that the nanoemulsion hair serum preparation is also pH stable using the cycling test method during the storage period. A stable preparation indicates that the components used are correct; apart from that, the oxidation process can also be inhibited by the presence of the antioxidant sodium metabisulfite through its interaction with the carbonyl group in the material to produce melanoidin, thereby preventing the oxidation process from occurring (Taufik et al., 2023).

Table 6. Optimum Formula characteristic test results

Parameter	Cycle-0 ($\bar{X}$ ± SD)	Cycle-6 ($\bar{X}$ ± SD)
Organoleptic	Light yellow, liquid, characteristic smell of chia seed oil, clear, and no phase separation	Light yellow, liquid, characteristic smell of chia seed oil, clear, and no phase separation
Homogeneity	Homogeneous	Homogeneous
pH	6.43 ± 0.015	6.37 ± 0.021

Note: $\bar{X}$ = average
SD = Standard Deviation

CONCLUSION

The optimum composition of surfactant (Tween 80) and cosurfactant for the preparation of chia seed oil nanoemulsion hair serum (*Salvia hispanica* L.) based on formula optimization using the Simplex Lattice Design (SLD) method is 33.52%: 46.48% with a desirability value of 0.947. The optimum formula's physical characteristics and stability for the chia seed oil nanoemulsion hair serum preparation fulfill all the physical parameter requirements for good preparation.

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REFERENCES

Aprilya, A., Rahmadevi, R., & Meirista, I. (2021). Formulasi nanoemulsi dengan bahan dasar minyak ikan (Oleum Iecoris Aselli). *Jurnal Sains Dan Kesehatan*, *3*(3), 370–375. https://doi.org/10.25026/jsk.v3i3.309

Az-Zahra, A. P., Wijayanti, F., Ramadhanti, L., & Faizal, I. A. (2022). Formulasi dan evaluasi nanoemulsi minyak ikan Sidat dengan menggunakan metode Sonikasi. *Pharmaqueous*, *4*(2).

Bagiana, I. K., Suwarmi, & Inayah. (2017). Optimasi tween 80 dan span 80 dalam sediaan krim ekstrak etanol daun Iler (Coleus atropurpureus (L) Benth) dan aktivitas antibakteri Staphylococcus aureus ATC 25923. *Majalah Farmasi Indonesia*, *10*(2), 896–905.

Collins, E., Rollando, & Monica, E. (2023). Pembuatan serum penumbuh rambut kombinasi minyak Kemiri (Aleurites moluccanus) dan ekstrak buah Apel (Pyrus malus L.). *Jurnal Farmasi Ma Chung: Sains, Teknologi, Dan Klinis Komunitas*, *1*(1), 32–41. https://doi.org/10.33479/jfmc.v1i(1).6

Dzakwan, M., & Priyanto, W. (2019). Peningkatan kelarutan fisetin dengan teknik kosolvensi. *Parapemikir : Jurnal Ilmiah Farmasi*, *8*(2), 5. https://doi.org/10.30591/pjif.v8i2.1388

Faizatun, F., Gangga, E., Anindita, S., Martati, T., & Miftahurrohmah, N. (2020). Formulation of NLC Gel from Callus Mulberry leaf extract induced by NAA and BAP. *Jurnal Ilmu Kefarmasian Indonesia*, *18*(1), 123–129. https://doi.org/10.35814/jifi.v18i1.814

Gamage, D. G. N. D., Dharmadasa, R. M., Abeysinghe, D. C., Wijesekara, R. G. S., Prathapasinghe, G. A., & Someya, T. (2022). Global perspective of plant-based cosmetic industry and possible contribution of Sri Lanka to the development of herbal cosmetics. *Evidence-Based Complementary and Alternative Medicine*, *2022*, 1–26. https://doi.org/10.1155/2022/9940548

Handayani, F. S., Nugroho, B. H., & Munawiroh, S. Z. (2018). Optimasi formulasi nanoemulsi minyak biji anggur energi rendah dengan d-optimal mixture design (DMD). *Jurnal Ilmiah Farmasi*, *14*(1), 17–34. https://doi.org/10.20885/jif.vol14.iss1.art03

Hidayat, I. R., Zuhrotun, A., & Sopyan, I. (2020). Design-expert software sebagai alat optimasi formulasi sediaan farmasi. *Majalah Farmasetika*, *6*(1). https://doi.org/10.24198/mfarmasetika.v6i1.27842

Illu, J. (2020). Pengaruh rasionalisasi terhadap relasi interpersonal. *Phronesis: Jurnal Teologi Dan Misi*, *2*(1), 74–82. https://doi.org/10.47457/phr.v2i1.33

Ma'arif, B., Rani Azzahara, Fahrul Rizki, Arief Suryadinata, Abdul Wafi, Novia Maulina, & Hajar Sugihantoro. (2023). Formulasi dan karakterisasi nanoemulsi ekstrak etanol 70% daun Semanggi (Marsilea crenata C. Presl.). *Medical Sains : Jurnal Ilmiah Kefarmasian*, *8*(2), 733–746. https://doi.org/10.37874/ms.v8i2.731

Magfirah, M., Hamdi Angka, M., & Rizka. (2022). Pemanfaatan kembang Sepatu sebagai shampountuk perawatan rambut rontok. *Jurnal DiMas*, *4*(1), 25–28. https://doi.org/10.53359/dimas.v4i1.37

Nicolini, A., Gonçalves Maciel, V., da Silva Andrade Neto, J., Roca Bragança, S., & Maldaner Jacobi, M. (2021). Rheological behavior of fresh latex polymeric mortar by squeeze-flow technique. *Construction and Building Materials*, *267*, 121175. https://doi.org/10.1016/j.conbuildmat.2020.121175

Noor, S. M. (2018). *Optimasi titik lebur pada sediaan lipstik kulit Buah Naga Merah (Hylocereus polyrhizius) menggunakan metode D-Optimal Mixture. (Skripsi)*. Universitas Brawijaya.

Pratiwi, L., Fudholi, A., Martien, R., & Pramono, S. (2018). Physical and chemical stability test of SNEDDS (Self-nanoemulsifying Drug Delivery System) and nanoemulsion ethyl acetate fraction of garcinia mangostana L. *Majalah Obat Tradisional*, *23*(2), 84. https://doi.org/10.22146/mot.28533

Rahmayanti, M., Nastiti, G. P., & Fitri, M. A. (2023). Formulasi dan uji stabilitas sediaan hair Emulsion minyak Biji Chia (Salvia hispanica) dengan kombinasi tween 80 dan span 80 sebagai emulgator. *Jurnal Mandala Pharmacon Indonesia*, *9*(1), 10–19. https://doi.org/10.35311/jmpi.v9i1.356

Rowe, R. C., Sheskey, P. J., & Quinn, M. E. (2009). *Handbook of pharmaceutical excipients* (Sixth Edit). USA: Pharmaceutical Press.

Rusdi, M. (2017). Karakteristik ukuran partikel dan indeks polidispersitas formulasi nanoemulsi pewarna alam ekstrak kayu Secang (Caesalpinia Sappan Linn). *Jurnal Pertanian Terpadu*, *5*(2), 114–127. https://doi.org/10.36084/jpt..v5i2.132

Sanaji, J. B., & Liananda3, M. S. K. dan F. R. (2019). Pengaruh konsentrasi tween 80 sebagai Surfaktan terhadap karakteristik fisik sediaan Nanoemulgel ibuprofen. *Indonesian Journal of Chemical Science and Technology*, *6*(2), 89–91.

Segura-Campos, M. R., Ciau-Solís, N., Rosado-Rubio, G., Chel-Guerrero, L., & Betancur-Ancona, D. (2014). Physiocemical Characterization of chia (Salvia hispanica) Seed Oil from Yucatan Mexico. *Agricultural Sciences*, *05*(03), 220–226. https://doi.org/10.4236/as.2014.53025

Sofwan, A. G., Hafizullah, A., Adiansyah, A., & Tampubolon, R. R. (2017). Pengaruh minyak Sawit Merah (Rpo) dan minyak Zaitun murni (EVOO) terhadap pertumbuhan rambut pada Kelinci. *Jurnal Farmanesia*, *4*(2), 105–109. https://doi.org/10.51544/jf.v4i2.2710

Taufik, I. I., Soewandhi, S. N., & Nugraha, Y. P. (2023). Optimasi formula emulgel vitamin C dengan pendekatan Simplex Lattice Design. *Jurnal Sains Farmasi & Klinis*, *10*(1), 145. https://doi.org/10.25077/jsfk.10.1.145-154.2023

Vakhariya, R. R., Oza, S. A., Bhingardeve, C. S., Patil, S. J., Mujawar, S. F., & Mohite, D. S. K. (2022). Formulation, development and evaluation of Herbal hair serum: a classical approach to enhance hair quality. *International Journal of Pharmaceutical Sciences Review and Research*, 100–103. https://doi.org/10.47583/ijpsrr.2022.v76i02.017

Xu, L., Sun, D.-W., Tian, Y., Sun, L., Fan, T., & Zhu, Z. (2022). Combined effects of radiative and evaporative cooling on fruit preservation under solar radiation: sunburn resistance and temperature stabilization. *ACS Applied Materials & Interfaces*, *14*(40), 45788–45799. https://doi.org/10.1021/acsami.2c11349

Yuliani, S. H., Hartini, M., Stephanie, Pudyastuti, B., & Istyastono, E. P. (2016). Comparison of physical stability properties of pomegranate seed oil nanoemulsion dosage forms with long-chain triglyceride

and medium-chain triglyceride as the oil phase. *Traditional Medicine Journal*, *21*(2), 93–98.
Zulfa, E., Novianto, D., & Setiawan, D. (2019). Formulasi nanoemulsi natrium diklofenak dengan variasi kombinasi tween 80 dan span 80: kajian karakteristik fisik sediaan. *Media Farmasi Indonesia*, *14*(1), 1471–1477.