Characteristic and Physical Stability of Anti-Aging Green Tea Extract (GTE) on NLC with Argan Oil as Liquid Lipid

Anita Natalia Suryawijaya[1], Tutiek Purwanti[2], Djoko Agus Purwanto[2], Widji Soeratri[2]*
[1]Master Program of Pharmaceutical Sciences, Faculty of Pharmacy, Universitas Airlangga, Surabaya, Indonesia
[2]Department of Pharmaceutical Sciences, Faculty of Pharmacy, Universitas Airlangga, Surabaya, Indonesia

*Corresponding author: widjisoeratri@yahoo.com

Abstract

Background: *Green tea extract is a hydrophilic antioxidant that is difficult to penetrate. A nanostructured lipid carrier (NLC) delivers a system consisting of solid-liquid lipids that can improve penetration. Argan oil is a vegetable oil that can be used as a liquid lipid in NLC, reducing particle size and increasing penetration by hydrating the skin.* **Objective**: *To determine the formula of NLC green tea extract (NLC-GTE) with liquid lipid argan oil, which has good characteristics and is stable.* **Methods**: *Preparation of NLC-GTE used the High Shear Homogenization with solid lipids (cetyl palmitate-glyceryl stearate) - liquid lipids (argan oil) NLC-GTE1 (50:50), NLC-GTE2 (70:30), and NLC-GTE3 (90:10). Characteristic tests included organoleptic, pH, particle size (PS), and polydispersity index (PI). The physical stability test (organoleptic, pH, PS, and PI) used the thermal cycling method (3 cycles six days).* **Result:** *NLC-GTE1 – NLC-GTE2 has an odor of argan oil. NLC-GTE3 has odorless. NLC-GTE1 – NLC-GTE3 has a pH scale from 5.782-5.784; PS ranges from 359.73–432.56 nm; PI ranges from 0.175-0.257. The statistical analysis results showed no significant difference between NLC-GTE1 – NLC-GTE3 in pH and PI, there was a significant difference in PS NLC-GTE1; NLC-GTE2 against NLC-GTE3. Physical stability test NLC-GTE2 – NLC-GTE3 phase separation occurs. The statistical analysis results showed no significant difference in pH values NLC-GTE1 – NLC-GTE3 before and after storage; there was a significant difference in NLC-GTE3 before and after storage.* **Conclusion:** *NLC-GTE1 was a formula with good characteristics and stability.*

Keywords: *argan oil, green tea extract, nanostructured lipid carrier (NLC)*

INTRODUCTION

Green tea extract is a plant material with antioxidant and antiaging properties that have been widely used in cosmetic products for many years (Yapar et al., 2013). Green tea extract contains four catechin derivatives with pharmacological activities: epicatechin, epigallocatechin, epicatechin gallate, and epigallocatechin-3-gallate (EGCG). Green tea catechin derivatives have been reported to have antioxidant, anti-inflammatory, and anticancer effects. The antioxidant properties of green tea extract catechins can neutralize reactive oxygen species (ROS), thereby preventing lipid peroxidation and photoaging (Gianeti et al., 2013). EGCG is an effective antioxidant is most commonly found in green tea (Avadhani et al., 2017). EGCG has been shown in vitro and in vivo to prevent oxidative damage and depletion of antioxidant enzymes caused by exposure to solar UV radiation. Topical treatments containing EGCG have reduced the skin's inflammatory response to sun exposure. It happened by inhibiting inflammatory leukocyte infiltration and production of prostaglandin metabolites, which were used to protect against sun-induced suppression of the skin immune system and prevent skin photoaging by reducing matrix expression metalloproteinases triggered by solar UV radiation (Scalia et al., 2014). EGCG has several limitations, namely easy oxidation (photodegradation) and hydrophilic properties so that penetration in the skin is low (log P 1.1) (Avadhani et al., 2017; Rosita et al., 2019).

NLCs were fabricated using solid lipids and liquid lipids, leading to specialized nanostructures with enhanced properties for therapeutic loading, altered drug release profile, and stability (Paruvathanahalli et al., 2016). One of the topical delivery systems that can be used to increase drug penetration into the skin and protect the active ingredients that are easily oxidized is nanostructured lipid carriers (Paruvathanahalli et al., 2016; Czajkowska-Kosnik., 2018). The presence of this liquid lipid can reduce the regularity of the crystal lattice. Thus, a larger space can be created to trap the active ingredients, thereby increasing the entrapment effectiveness of the NLC (Soerarti et al., 2019). The Selection of components that make up the NLC delivery system is one of the essential factors. The type of liquid lipid in the NLC composition affects nanoparticles physicochemical properties, particle size and drug distribution (Saedi et al., 2018). NLC remains solid by controlling the level of liquid lipid added in the NLC constituent formulation. A controllable drug release property for NLC can be achieved. The choice of constituent materials and the ratio between solid and liquid lipids are essential factors in the NLC formulation. A combination of cetyl palmitate-glyceryl stearate was also used o increase the regularity of solid lipids in this study.

Argan oil is a vegetable oil that is unique and rich in unsaturated fatty acids (80%), especially oleic acid (± 45%) and linoleic acid (± 37%) (Jordan et al., 2014). It is a natural oil widely applied in industrial applications such as cosmetics due to its antioxidant, skin hydration, antiaging, and skin protection properties. Argan oil is often used as a liquid lipid in NLC delivery systems. Based on the most prominent content of argan oil, namely oleic acid, argan oil as a liquid lipid in this NLC delivery system can produce good NLC characteristics (Tichota et al., 2014). It is evidenced by previous studies that the increasing concentration of oleic acid as a liquid lipid in the NLC formula could reduce the particle size (Kelidari et al., 2017). The small particle size causes an increase in the surface area of the particles in contact with the skin, thereby increasing the occlusivity to increase the penetration rate of the active ingredients into the skin. An active ingredient penetrating the skin increases its effectiveness (Czajkowska-Kosnik et al., 2018; Muller et al., 2002). Previous studies have also reported that the formulation of NLC-based hydrogel with argan oil as a liquid lipid has been successfully formulated and produces good NLC delivery system characteristics and can increase skin hydration. The success of an NLC system as a delivery system can be measured by the size of the particles that fall into the nanosize range, and the NLC must also be stable enough that there is no phase separation and creaming. The physicochemical stability of the emulsion-based carrier system can be controlled by designing the conditions and composition of the formulation to produce NLC that has excellent and stable characteristics (Rohmah dkk., 2019).

This study aimed to determine the best green tea extract NLC formula with various variations in the composition of solid lipid (cetyl palmitate-glyceryl stearate) - liquid lipid (argan oil). It is calculated based on the pH value that falls within the skin pH range, particle size and polydispersity index, and the stability of the NLC system. It can be used to develop antiaging formulas using antiaging formulas the active ingredient of green tea extract.

Table 1. Composition of the NLC-GTE with variations composition of the solid lipid (cetyl palmitate-glyceryl stearate) - liquid lipid (argan oil)

No.	Component	Function Materials	Formula (gram)		
			NLC-GTE1 (50 : 50)	NLC-GTE2 (70 : 30)	NLC-GTE3 (90 : 10)
1	Green Tea Extract	Active Ingredient	0.1	0.1	0.1
2	Cetyl palmitate-glyceryl stearate	Solid Lipid	2.5 : 2.5 : 5	3.5 : 3.5 : 3	4.5 : 4.5 : 1
3	Argan Oil	Liquid Lipid			
4	Tween 20	Surfactan	2	2	2
5	Lecithin	Co-Surfaktan	0.5 : 0.5		
6	Synperonic F68				
7	Buffer phospate pH 5.0	Solvent	Ad 100	Ad 100	Ad 100

*Description = total lipids **NLC-GTE1, NLC-GTE2, and NLC-GTE3** are 10%

NLC-GTE1 = Solid Lipids: Liquid Lipids (50: 50) = Cetyl palmitate: Glyceryl stearate: Argan Oil (2.5:2.5:5)

NLC-GTE2 = Solid Lipids: Liquid Lipids (70: 30) = Cetyl palmitate: Glyceryl stearate: Argan Oil (3.5:3.5:3)

NLC-GTE3 = Solid Lipid : Liquid Lipid (90 : 10) = Cetyl palmitate : Glyceryl stearate : Argan Oil (4.5:4.5:1)

MATERIALS AND METHODS

Materials

The ingredients used in this study were Green tea extract (Meditea, Department of Pharmaceutical Sciences, Faculty of Pharmacy, Airlangga University), Cetyl Palmitate (BASF), Glyceryl Stearate (Medica), Argan Oil (Olvea, France), Tween 20 (Zhang Yan, Singapore), Lecithin (Solae), Synperonic F68 (Poloxamer 188) (BASF, PT. Megasetia Agung Kimia, Indonesia), Aquademineral, $NaH_2PO_4.H_2O$, and $Na_2HPO_4.2H_2O$ (SAP, Indonesia).

Tools

The tools used in this study included SI Analytics-pH Meter Lab 855, Ultra Turrax IKA®T25 Digital High Shear Homogenizer, analytical balance (OHAUS), hotplate stirrer, Delsa Nano Submicron Particle Analyzer Beckman Coulter.

Method

The research included manufacturing NLC green tea extract (NLC-ETH) using the High Shear Homogenization method, characterization, and stability testing. Characteristic tests were pH, particle size (PS), polydispersity index (PI), and physical stability tests. A physical stability test was performed using the thermal cycling method. It measured the pH value, particle size (PS), polydispersity index (PI) before and after storage in 3 cycles for six days.

Preparation of green tea extract NLC delivery system (NLC-GTE)

NLC green tea extract was prepared using the modified High Shear Homogenization (HSH) method and refers to the previous research conducted by Manea et al., (2014). Composition of the NLC-GTE with variations composition of the solid lipid (cetyl palmitate-glyceryl stearate) - liquid lipid (argan oil) can be seen in Table 1. Two different phases were prepared, namely the oil and water phases. The oil phase consisted of cetyl palmitate, glyceryl stearate, and argan oil (10% total lipid). At the same time, the aqueous phase consisted of surfactant tween 20 as the surfactant synperonic F68, lecithin (1:1 in 1%), and phosphate buffer pH 5.0.

Furthermore, both were heated at the same temperature of 70 °C for 30 minutes and then in a different container, prepared green tea extract in phosphate buffer pH 5.0 30 ml and stirred at 100 rpm at 70 °C for 10 minutes. After that, the green tea extract solution was added to the oil phase while stirring at 300 rpm for 4 minutes and then continued at 500 rpm for 6 minutes. Before mixing the two steps, the aqueous phase was stirred for 2 minutes at high speed (15000 rpm) using Ultra Turrax IKA®T25 Digital High Shear Homogenizer. Then the two phases were mixed using Ultra Turax at 15,000 rpm for 7 minutes. Thus, a green tea extract NLC delivery system was obtained (Manea et al., 2014). The composition of the NLC-GTE with variations in composition of the solid lipid (cetyl palmitate-glyceryl stearate) - liquid lipid (argan oil) can be seen in Table 1.

Physical characteristics test of the green tea extract NLC formula

Characteristic tests were conducted on the three NLC formulas of green tea extract by visual organoleptic observation. It measured the pH value with a pH meter, particle size (PS), and polydispersity index (PI) using the DelsaTM nano submicron particle size analyzer. The organoleptic examination was carried out by visual means, including color, odor, and consistency analysis.

Measurement the degree of acidity (pH value)

The pH value was measured by calibrating the pH meter using a standard buffer solution of pH 7.0. After that, the electrodes are cleaned and then dried. The next step is to dilute the sample with CO2-free mineral water. Then check the pH value using the SI Analytics tool – pH Meter Lab 855.

Particle size (PS) and polydispersity index (PI)

Measurement of particle size (PS) and polydispersity index (PI) was carried out using a DelsaTM nano-submicron particle size analyzer. The first stage was sample dilution. A total of 50 mg of the sample was weighed on an analytical balance. Then, the aqua mineral was added to a volume of 50.0 mL. It stirred using a magnetic stirrer for 10 minutes at a speed of 500 rpm. The next step is to determine the particle size (PS) and polydispersity index (PI) by inserting the diluted sample into a glass cuvette. Then put it in the sample holder, then observe the intensity bar listed on the monitor. If it is yellow or blue, click start on the menu bar. Next, the tool measured particle size (PS) and polydispersity index (PI). After the measurements had been taken, the particle size (PS) data in nanometers (nm) and the polydispersity index appeared.

Physical stability test of green tea extract NLC formula (NLC-GTE)

This physical stability test used an accelerated stability test using the thermal cycling method. In this test, the formula was stored at 40 °C for 48 hours, and then kept at a temperature of 2-8 °C for 48 hours. This experiment was repeated for three cycles (6 days). Then observations and evaluations were carried out and compared with the formula given the treatment (Erawati et al., 2019).

Statistical analysis test

Data obtained was tested statistically on the characteristic test (pH, PS, and PI values) using one-way ANOVA to determine the significant difference between the formulas. If the result was < 0.05, it indicated a significant difference between the formulas for each test parameter. The analysis was continued with the Post Hoc Tuckey HSD test to find out which formula has a significant difference. Statistical analysis

tests were also carried out on physical stability tests (pH, PS, and PI values), which were compared before and after storage for three cycles (6 days) on each test parameter using paired sample t-test. If the results were < 0.05, this indicated a significant difference between the test results before and after storage on each test parameter.

RESULTS AND DISCUSSION

This study is distinguished based on the ratio of solid lipids (cetyl palmitate: glyceryl stearate) and liquid lipids (argan oil), such as NLC-GTE1 (50:50) with a ratio of 2.5 g: 2.5 g: 5 g (cetyl palmitate: glyceryl stearate: argan oil) in 100 grams of NLC green tea extract, NLC-GTE2 (70:30) with 3.5 g: 3.5 g: 3 g (cetyl palmitate: glyceryl stearate: argan oil) in 100 grams of NLC green tea extract, and NLC-GTE3 (90:10) with 4.5 g: 4.5 g: 1 g (cetyl palmitate: glyceryl stearate: argan oil) in 100 grams of NLC-ETH. NLC-ETH was prepared using the high shear homogenization (HSH) method. This method works by friction mechanism and breaks up particles in a mixture of lipids, surfactants, and water at a temperature of 5-10 °C above the melting point of lipids to form an emulsion.

1. Characteristics test results

Results of organoleptic examination

The results of the organoleptic examination showed that the NLC green tea extract had good physical characteristics (homogeneous). Based on the physical characteristics test, NLC-GTE1 – NLC-GTE3 is opaque white in color, NLC-GTE1 - NLC-GTE2 has a distinctive odor of argan oil, but NLC-GTE3 does not smell; this is because NLC-GTE3 has a lower concentration of argan oil, the entire formula is NLC-GTE (1-3) has a liquid consistency. The organoleptic result of NLC-GTE1, NLC-GTE2, and NLC-GTE3 can be seen in Table 2 and then result of the Characteristic test on pH value, *particle size (PS),* and *polidispersity index (PI)* NLC-GTE1, NLC-GTE2, and NLC-GTE3 can be seen in Table 3.

Table 2. Organoleptic result of NLC-GTE1, NLC-GTE2, and NLC-GTE3

Organoleptic	NLC-GTE1 (50 : 50)	NLC-GTE2 (70 : 30)	NLC-GTE3 (90 : 10)
Color			
	White opaque	White opaque	White opaque
Odor	Characteristic smell of argan oil	Characteristic smell of argan oil	odorless
Consistency	Liquid	Liquid	Liquid

Table 3. Result of Characteristic test on pH value, *particle size (PS)* and *polidispersity index (PI)* NLC-GTE1, NLC-GTE2, and NLC-GTE3

Testing	NLC-GTE1 (50 : 50)	NLC-GTE2 (70 : 30)	NLC-GTE3 (90 : 10)
pH value	5.784 ± 0.002	5.784 ± 0.001	5.782 ± 0.003
Particle Size (nm)	359.73 ± 4.214 nm	383.93 ± 8.578 nm	432.56 nm ± 13.822 nm
Polidispersity index (PI)	0.175 ± 0.059	0.213 ± 0.012	0.257 ± 0.013

pH measurement results

The results of measuring the pH value of the NLC delivery system of green tea extract with various comparisons of the combination of solid lipid cetyl palmitate-glyceryl stearate with argan oil as liquid lipid, namely NLC-GTE1 (50: 50); NLC-GTE2 (70:30) and NLC-GTE3 (90:10) using a pH-meter can be seen in Table 3. Based on the pH data in Table 3, all NLC formulas of green tea extract have a pH value of 5.7 and meet the skin pH specifications of 4.5 – 6.5 (Umar, 2021). A pH value is too acidic because less than 4.0 can cause skin irritation, inflammation, and even acne. At the same time, a pH that is too high more than 7.0, can cause dry and sensitive skin, so the preparations must be within that pH range so as not to cause adverse effects. Undesirable on the user's skin (Kamila, 2017). Based on the statistical analysis tests, the results obtained a significance value of > 0.05 (0.579), which indicates no significant difference in the pH value between the NLC formulas of green tea extract.

Measurement results of particle size (PS) and polydispersity index (PI)

The results of PS measurements of the NLC-GTE system with various comparisons of the combination of solid lipid cetyl palmitate-glyceryl stearate with argan oil as liquid lipid were NLC-GTE1 (50: 50); NLC-GTE2 (70:30), and NLC-GTE3 (90:10) using DelsaTM Nano Submicron Particle Size can be seen in Table 3. PS test results on all NLC formulas of green tea extract have PS below 500 nm. Based on the results of statistical analysis tests, a significance value of <0.05 (0.000)

indicates that there is a significant difference in PS between the NLC-GTE. The analysis continued and stated that NLC-GTE1 and NLC-GTE2 had significant differences from NLC-GTE3 to determine which formulas were significantly different. It is due to differences in the concentration of liquid lipids in the NLC formula. According to Pornputtapitak (2019), the high liquid lipid content in NLC can reduce the viscosity in the NLC, resulting in small particles size caused by low surface tension. In addition, according to Apostolou et al., 2021, with increasing liquid lipid concentration, PS will decrease. It can also be attributed to the higher amount of solid lipids than liquid lipids in an NLC constituent formula which can affect the melting process and form agglomerates during NLC production. In addition, during the solid lipid compaction process in the NLC preparation, higher concentrations of solid lipids may tend to coalesce or form aggregates, which may not break apart and appear as large particles. The measurement results of the polydispersity index (PI) of all NLC systems of green tea extract are below 0.5, which means that all formulas of the NLC system of green tea extract are homogeneous.

The above statement is also reinforced by the results of research by Ebtavanny et al (2018), that study also showed that increasing the concentration of liquid lipids in NLC could reduce PS and PI, so that the presence of argan oil as liquid lipid in NLC-GTE showed a significant role in PS and PI. Although, based on the results of the statistical analysis of PI, a significance value of > 0.05

(0.081) was obtained, which indicated no significant difference in the polydispersity index between the NLC formulas of green tea extract. When compared between the results of research conducted by Tichota et al (2014) with the results of this study, it shows that the benefits of argan oil as a liquid lipid in the NLC delivery system can produce good characteristics in PS and PI parameters.

The presence of argan oil as a liquid lipid in NLC-GTE is considered to be able for reduce PS and PI, so those small and homogeneous particles are formed in an NLC delivery system, although compared to the results of research conducted by Manea et al., (2014) the results of PS are smaller, this may be due to the liquid lipid used in this study is Grape Seed Oil and the use of other additives that are different from this study. However, the PS and PI NLC-GTE observations with argan oil as a liquid lipid still yielded values that were in accordance with the NLC standard so that they were still declared to meet the NLC requirements with small and homogeneous particle sizes.

2. Physical stability test results

In this study, the physical stability test was carried outThe physical stability test was carried out in this study using the thermal cycling method. In this test, the formula was stored at 40 °C for 48 hours, and then kept at a temperature of 2-8 °C for 48 hours. This experiment was repeated for three cycles (6 days). Aspects in of the stability test were organoleptic (presence or absence of phase separation), pH value, particle size, and polydispersity index before and after storage. Result The result of Physical Stability NLC-GTE can be seen in Table 4.

The visual inspection results on all NLC formulas of green tea extract showed that there was a phase separation in F3, but this could be overcome by stirring because during three storage cycles, there was no solid phase separation, or it could not return to its original state. NLC-GTE3 has the largest particle size (432.56 nm ± 13.822), so the phase separation tends to occur faster.

The results of measuring the pH value of all NLC formulas of green tea extract during storage for three cycles (6 days) still had a pH value in the skin pH range of 4.5-6.5 (Umar, 2021). Based on the results of statistical analysis tests on the measurement of pH values, a significance value of

> 0.05 showed that there was no significant between before and after storage in NLC-GTE1, NLC-GTE2, and NLC-GTE3 (Significance value NLC-GTE1 = 0.147; NLC-GTE2 = 0.300; NLC-GTE3 = 0.060) so that all NLC formulas of green tea extract were considered to have a stable pH value. The results of the physical stability test also showed that the increasing concentration of liquid lipid (argan oil) in a system did not affect the pH of the NLC green tea extract. Histogram A histogram of the physical stability test results observed pH values NLC-GTE1, NLC-GTE2, and NLC-GTE3 before and after storage (three cycles 6 days) can be seen in the Figure 1. The content of surfactant, co-surfactant and aqueous phase (Phosphate buffer pH 5.0) in all NLC formulas of green tea extract was also in the same amount, so that this did not affect the pH value of the NLC formula of green tea extract.

The particle size results in the three NLC formulas of green tea extract storage for three cycles (6 days) still had PS below 500 nm. It meant that the NLC green tea extract was still considered to meet the PS NLC specifications that had been set and the PI results in the three formulas still had values below 0.5 which means that the NLC of green tea extract is still considered homogeneous. Based on the statistical analysis test on PS, there was no significant difference between before and after storage in NLC-GTE1 and NLC-GTE2. Yet, there was a significant difference between before and after storage in NLC-GTE3 (Significance value NLC-GTE1 = 0.318; NLC-GTE2 = 0.066; NLC-GTE3 = 0.034). Based on the statistical analysis test on PI, there was no significant difference between before and after storage in NLC-GTE1 and NLC-GTE2. However, there was a significant difference between before and after storage in NLC-GTE3 (Significance value NLC-GTE1 = 0.150; NLC-GTE2 = 0.326; NLC-GTE3 = 0.013).

A histogram of the physical stability test results observed for particle sizes NLC-GTE1, NLC-GTE2, and NLC-GTE3 before and after storage (three cycles 6 days), can be seen in Figure 2. A histogram of the physical stability test results observing the polydispersity index NLC-GTE1, NLC-GTE2, and NLC-GTE3 before and after storage (three cycles 6 days) can be seen in the Figure 3.

Table 4. Result of Physical Stability NLC-GTE

Time	Formula	Organoleptic	pH value	*Particle Size (nm)*	*Polidispersity Index (PI)*
Before storage	NLC-GTE1		5.705 ± 0.005	363.033 ± 4.404	0.267 ± 0.026
	NLC-GTE2		5.643 ± 0.005	383.933 ± 8.578	0.268 ± 0.009
	NLC-GTE3		5.797 ± 0.006	443.233 ± 4.966	0.257 ± 0.015
After storage (3 cycles 6 days)	NLC-GTE1		5.713 ± 0.006	351.933 ± 14.189	0.301 ± 0.004
	NLC-GTE2		5.686 ± 0.012	397.8 ± 4.214	0.280 ± 0.014
	NLC-GTE3		5.754 ± 0.013	465.166 ± 5.396	0.298 ± 0.007

The combination of solid lipid (cetyl palmitate: glyceryl stearate): liquid lipid (argan oil) (90:10) in NLC-GTE3 was considered unable to form a stable green tea extract NLC delivery system for particle size and polydispersity index parameters. It is due to the concentration of argan oil as a liquid lipid at NLC-GTE3 (90: 10), at least compared to NLC-GTE1 and NLC-GTE2. The two things above are that the particle size and polydispersity index are closely related. It is confirmed by Suprobo dan Rahmi (2015), who state that the smaller the particle size, the more homogeneous the resulting system. The homogeneity of a system is closely related to the discovery of the system. The smaller the size of the dispersed particles, the configuration of the dispersed phase in the dispersing medium will also be regular. The higher liquid lipid content of NLC-GTE also occurs in the irregular matrix. The addition of liquid lipids also increases, which causes the crystallization process to be inhibited, so that drug release during storage can be minimized. The lower the recrystallization index of a material, the smaller the crystal regularity of the NLC system. The irregularity of the crystal lattice space can accommodate more prominent drugs so that the entrapment efficiency will be greater (Erawati et al.,

2019). The presence of the liquid lipid can reduce the regularity of crystal lattice so that an NLC system has a larger space to trap the active ingredients by increasing entrapment efficiency and increasing the stability of NLC (Soerarti et al., 2019).

The statistical analysis of physical stability tests on PI NLC-GTE3 showed a significant difference between PI before and after storage, so it was concluded that NLC-GTE3 was not stable to the PI parameter. However, it can be seen from the PI value before and after storage that it was still within the specified PI value specification range. It was caused by the concentration of the combination of solid lipid (cetyl palmitate-glyceryl stearate): liquid lipid (argan oil) 90:10. It meant the solid lipid content was more than the liquid lipid in the NLC-GTE3. Thus, the high solid lipids can cause a decrease in the trapping space of the active ingredient in the system, so some active ingredients may be pushed out of the NLC system and can increase the particle size and polydispersity index. The addition of liquid lipids also increased stability caused the crystallization process to be inhibited, so drug expulsion during storage can be minimized (Erawati et al., 2019). The concentration of the combination of solid lipid (cetyl palmitate-glyceryl

stearate) with liquid lipid (argan oil), which is 90: 10, is considered less able to form a good NLC system is not stable during storage against PS and PI.

Based on all the results of the physical stability test, it shows the stability of the NLC-GTE1 > NLC-GTE2 > NLC-GTE3 system, there is no phase separation, including the skin pH, particle size (PS), and polydispersity index (PI) according to the specifications of a homogeneous NLC system.
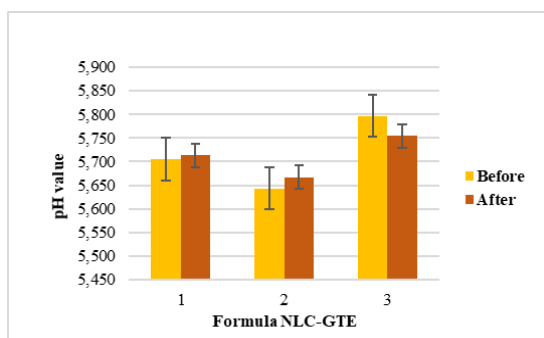

Figure 1. Histogram of the physical stability test results observed pH values NLC-GTE1, NLC-GTE2, and NLC-GTE3 before and after storage (three cycles 6 days)
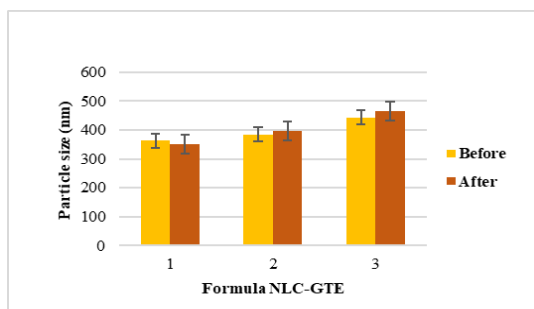

Figure 2. Histogram of the physical stability test results observed for particle sizes NLC-GTE1, NLC-GTE2, and NLC-GTE3 before and after storage (three cycles 6 days)
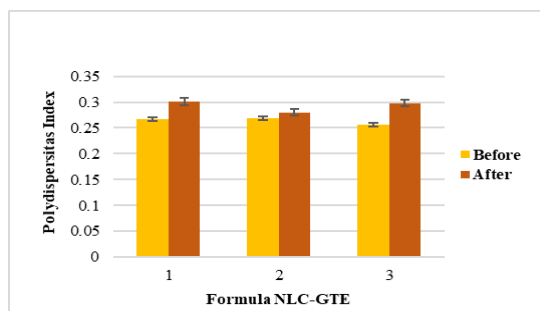

Figure 3. Histogram of the results of the physical stability test observing the polydispersity index NLC-GTE1, NLC-GTE2, and NLC-GTE3 before and after storage (three cycles 6 days)

CONCLUSION

Based on the results, the NLC system characteristics showed Green tea extract with a ratio of solid lipid cetyl palmitate-glyceryl stearate and liquid lipid argan oil 50:50; 70:30 and 90:10. It includes organoleptic, pH value, particle size (PS), and polydispersity index (PI). Besides that, increasing the amount of liquid lipid argan oil in the NLC system of green tea extract can reduce PS. Green tea extract NLC formulas have pH values within the skin pH range and have a polydispersity index value below 0.5. It indicates the homogeneity of the NLC system. Based on the results, it is concluded that NLC-GTE1 has a smaller particle size than NLC-GTE2. Based on the results of physical stability, NLC-GTE1 and NLC-GTE2 are more stable than NLC-GTE3, but NLC-GTE1 is more stable than NLC-GTE2 because there is no phase separation. NLC green tea extract with a combination of solid lipid cetyl palmitate-glyceryl stearate and liquid lipid argan oil (50:50) is a formula with good and stable characteristics.

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AUTHOR CONTRIBUTIONS

Conceptualization, A.N.S., W.S., T.P.; Methodology, A.N.S., W.S., T.P.; Validation, A.N.S.; Formal Analysis, A.N.S.; Investigation, A.N.S.; Resources, A.N.S., D.A.P.; Data Curation, A.N.S., W.S.; Writing - Original Draft, A.N.S.; Writing - Review & Editing, A.N.S., W.S., T.P.; Visualization, A.N.S.; Supervision, A.N.S., W.S., T.P.; Project Administration, A.N.S., W.S., T.P.; Funding Acquisition, A.N.S.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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