THE EFFECT OF VARIATIONS IN CARBOPOL 940 CONCENTRATION ON THE STABILITY OF THE FORMULATION OF SPRAY GEL NANOPARTICLES OF BUNDUNG PLANT EXTRACT (*Actinoscirpus grossus*)

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Abstract

Bundung plant extract (*Actinoscirpus grossus*) contains flavonoid secondary metabolite compounds that can inhibit the growth of *Staphylococcus aureus* bacteria which is often the cause of skin diseases. Spray gel nanoparticles when used can speed up the drug delivery system, dry more easily, and are easy to wash. Carbopol 940 as a base because it is free of irritation. The purpose of this study was to determine the effect of carbopol 940 base on spray gel nanoparticles preparations and evaluate the stability of the spray gel nanoparticle preparations of plant extracts. This research uses laboratory experimental methods. Bundung plant extract was formulated into nanoparticle spray gel preparations with variations in the concentration of carbopol 940 as many as 4 formulations, namely 0.13%, 0.26%, 0.4%, and 0.53%. The nanoparticle size was prepared by using *high-shear stirring* technique at 500 rpm for 8 hours at room temperature. Then the evaluation includes organoleptic test, homogeneity, pH, viscosity, spraying pattern, dispersion, dry time and particle size test. The results of the evaluation and stability for 4 weeks in the organoleptic test found that formulation 4 was the most stable, the homogeneity test of all formulations was stable. The pH and viscosity test of formulation 4 was the most stable, the spray pattern and dispersion test of all formulations met the requirements, the dry time test of all formulations met the standards, and the particle size test of all formulations did not meet the requirements. Based on the research, it can be concluded that variations in the concentration of carbopol 940 affect the stability of the spray gel nanoparticle preparation. Based on the stability test, the formula that meets the requirements is formulation 4 with a concentration of carbopol 940 of 0.53%.

Keywords: Evaluation, Carbopol 940, Bundung plant extract (*Actinoscirpus grossus*), Spray gel, Nanoparticle

Introduction

Actinoscirpus grossus is one of the plants that can grow in swamp areas. This plant is often found at an altitude of <50 meters above sea level, one of which grows in the South Kalimantan area because South Kalimantan has a lot of swamp land. Empirically, bund plants are used to treat diarrhea, overcome nausea and vomiting, and are antimicrobial (Noval *et al*., 2019). Based on research conducted (Noval *et al*., 2019) the ethanolic extract of the Bundung plant (*Actinoscirpus grossus*) can inhibit the growth of *Staphylococcos aureus* bacteria with an extract concentration of 0.8%.

Drug delivery systems are very important in determining disease therapy. There are various kinds of drug delivery systems, one of which is topical drug delivery. Topical drug delivery systems are generally used for skin care and curing skin infections (Verma *et al*., 2013). Nanotechnology has a

fast drug delivery system due to modification of surface characteristics and particle size so that nanotechnology has a molecular size of < 1000 nm and can accelerate drug delivery to the target (Ayumi *et al*., 2018).

One of the developments of nanoparticles is made in spray gel. The spray technique has the advantage that the spray technique allows the preparation to be delivered to the skin more quickly and can cover a large area of skin. Spray gel when used is easier to dry, not sticky on the skin, easy to use, safe and easier to wash (Hayati *et al*., 2019).

Carbopol 940 is a gelling agent that has very short flow properties, is *biocompatible, biogradable, bioadhesive,* is not absorbed into the body and does not irritate the skin, so that carbopol 940 is the most efficient carbopol polymer compared to other carbopols in the manufacture of sprays (Aiyalu *et al.* , 2016).

Based on the background description above, the researchers wanted to formulate a spray gel nanoparticle preparation and evaluate the stability of the spraygel nanoparticle preparation from the ethanolic extract of the bundung (*Actinoscirpus grossus*) with variations in the concentration of carbopol 940 base. generated more quickly.

Material and Methods

Materials

The tools used are analytical balance, spatula, mortar and stemper, glass beaker, measuring cup, *Viscometer Stromer* dropper, stirring rod, spatula, water bath, mica paper, spray bottle, parchment paper, mica plastic, watch glass, *Magnetic Stirrer*, vessel maceration, hotplate and digital pH meter. The ingredients used are extracts of the bundung plant (*Actinoscirpus grossus*), carbopol 940, TEA, propyl paraben, methyl paraben, sorbitol, tween 80, and aquadest.

Methods

The research method used is *Quasy Experimental Design* with a *onegroup posttest-only research design*. In this study using the *One Way Anova* test, if the assumptions of normality and homogeneity are not met then use the *Kruskal-Wallis* test followed by the *Pos Hoc Mann-Whitney* test with the help of the SPSS (*Statistical Package for The Social Sciences*) application.

a. Bundung plant extract making (*Actinoscirpus grosus*)

Ethanol extraction of the bundung plant (*Actinoscirpus grossus*) used the maceration method where the simplicia of the bundung plant was soaked with ethanol in a maceration vessel, then allowed to stand for 3 days with occasional stirring, after which the liquid was removed by filtering, then evaporated using a rotary evaporator until a thick extract of the bundung plant was obtained.

b. Bundung plant extract (*Actinoscirpus grosus*) nanoparticle spray gel formulation

The preparation of spray gel nanoparticles was made with 4 formulas with variations of carbopol 940. F1 concentration of carbopol was 0.13%, F2 was 0.26%, F3 was 0.4%, and F4 was 0.53%. This formulation is a modification of the research conducted by (Khoiriyah *et al*., 2019).

Table 1. Formulation of spray gel nanoparticle

No	Material	Formula				function
		1	2	3	4	
	Basis gel					
1	Carbopol 940	0,2 gr	0,4 gr	0,6 gr	0,8 gr	Gel Base
2	TEA	0,4 gr	0,4 gr	0,4 gr	0,4 gr	Gel Base neutralizer
3	Ad Aquadest	150 ml	150 ml	150 ml	150 ml	solvent
	Nanoemulsion Formula					
1	Bundung extract	0,8 gr	0,8 gr	0,8 gr	0,8 gr	Active substance
2	Propil paraben	0,02 gr	0,02 gr	0,02 gr	0,02 gr	preservative
3	Metil paraben	0,1 gr	0,1 gr	0,1 gr	0,1 gr	preservative
4	Sorbitol	4 gr	4 gr	4 gr	4 gr	surfactan
5	Tween 80	6 gr	6 gr	6 gr	6 gr	surfactan
6	Ad Aquadest	150 ml	150 ml	150 ml	150 ml	solvent

c. Bundung plant extract (*Actinoscirpus grosus*) nanoparticle spray gel making

1. Gel Base making

   Bases was made of 4 formulas with different concentrations of carbopol 940. How it works Carbopol 940 (powder) is added with hot aquadest then ground until homogeneous and forms a gel base. Then added little by little TEA (liquid) as a neutralizing gel base.

2. Nanoemulsion making

   Bundung plant extract added sorbitol (liquid) until mixed or dissolved. Next, heat the methyl paraben (powder) and propyl paraben (powder) plus 5 ml of distilled water on the hotplate until dissolved. Then cool, put it in a mortar and add tween 80 little by little and add aquadest until it doesn't form a white color. Then add the extract mixture with sorbitol to the above mixture little by little until homogeneous. Then the preparation was stirred at a speed of 500 rpm for 8 hours using a *magnetic stirrer* at room temperature until it was homogeneous and clear (Noval & Malahayati, 2021).

3. Nanoparticle spray gel making preparate making

   For the preparation of spray gel nanoparticles, the gel base was added to the nanoemulsion preparation and then stirred again until homogeneous.

d. Stability Evaluation Test of Bundung plant extract (*Actinocirpus grossus)* nanoparticle spray gel

1. Organoleptic test

The organoleptic test was observed visually to see the physical appearance of the spray gel nanoparticle preparation, namely the smell, color, and shape of the preparation (Hayati *et al*., 2019). Then the stability test was carried out for 4 weeks at room temperature.

2. Homogeneity test

   The homogeneity of the spray gel nanoparticles was observed visually by means of smearing or flattening it on a glass slide, whether the particles were mixed or separated. Each spray gel nanoparticle formula was replicated 3 times (Sudjono *et al*., 2012). Then the stability test was carried out for 4 weeks at room temperature (Kurniawati et al, 2021).

3. pH test

   Measurement of the pH of the spray gel nanoparticles was observed using a calibrated digital pH meter and replicated 3 times (Sudjono *et al*., 2012). Then the stability test was carried out for 4 weeks at room temperature.

4. Viscosity test

   Viscosity was observed by testing 50 ml of spray gel nanoparticles with a *viscometer stromer* using spindle no 3 with 12 rpm using a *viscometer stromer* and 3 replications (Hayati *et al*., 2019). Then the stability test was carried out for 4 weeks at room temperature.

5. Spraying pattern and dispersion test

   The spray condition test was carried out on the 1st day after the preparation of the preparation. Spray gel nanoparticles were sprayed on mica plastic at a distance of 5 cm (Hayati *et al*., 2019). Determination of dispersion is based on determining the length of the diameter of the circle (Shafira *et al*., 2015).

6. Dry time test

   The preparation of the spray gel nanoparticles was applied to the inside of the respondent's forearm. Then the time needed for the spray gel nanoparticles to dry is calculated (Hayati *et al*., 2019). Dry time test was conducted on 30 respondents.

7. Particle size test

   The procedure for determining the particle size is by first diluting the spray gel nanoparticle preparation with 1 ml of distilled water into 5 grams of the spray gel nanoparticle preparation. Then 1 ml of input is taken into the cuvette, then the cuvette is inserted into the sample holder on the *particle size analyzer* tool, the tool will measure the sample within 15 minutes (Wulandari *et al*., 2019).

Result and Disscusion

Result

The results showed that 150 ml of spray gel nanoparticles preparations for all formulas with variations in carbopol 940 concentrations were 0.13%, 0.26%, 0.4% and 0.53%. After the spray gel nanoparticles were obtained, the evaluation and stability of the preparations were carried out which included organoleptic tests, homogeneity tests, pH tests, viscosity tests, spraying patterns, dispersion tests, dry time tests and particle size tests.

Figure 1. The results of the preparation of spray gel nanoparticles

a. Organoleptic test

Table 2. Result of observation of organoleptic preparation of spray gel nanoparticle

Observation Formula		Weeks			
		1	2	3	4
1	color	Yellowish Green	Yellow	Yellow	Yellow
	form	Liquid	Liquid	Liquid	Liquid
	odor	Bundung specific	Bundung specific	Bundung specific	Bundung specific
	clarity	Clear	Clear	Clear	Clear
	air bubble	Not exist	Exist	Exist	Exist
2	color	Yellowish Green	Yellow	Yellow	Yellow
	form	Liquid little bit thick	Liquid little bit thick	Liquid little bit thick	Liquid little bit thick
	odor	Bundung specific	Bundung specific	Bundung specific	Bundung specific
	clarity	Clear	Clear	Clear	Clear
	air bubble	Not exist	Exist	Exist	Exist
3	Color	Yellowish Green	Yellowish Green	Yellow	Yellow
	Form	Little bit thick	Little bit thick	Little bit thick	Little bit thick
	Odor	Bundung specific	Bundung specific	Bundung specific	Bundung specific
	Clarity	Clear	Clear	Clear	Clear
	Air bubble	Not exist	Not exist	Not exist	Not exist
4	Color	Yellowish Green	Yellowish Green	Yellowish Green	Yellow
	Form	Viscous	Viscous	Viscous	Viscous
	Odor	Bundung specific	Bundung specific	Bundung specific	Bundung specific
	Clarity	Clear	Clear	Clear	Clear
	Air bubble	Not exist	Not exist	Not exist	Not exist

b. Homogeneity test

Table 3. Result of observation of homogeneity test preparation of spray gel nanoparticle

Formula	Weeks			
	1	2	3	4
1	√	√	√	√
2	√	√	√	√
3	√	√	√	√
4	√	√	√	√

Description :

(√) : homogenous formula

(-) : non homogenous formula

c. pH test

Table 4. Result of observation of pH test preparation of spray gel nanoparticle

Formula	Weeks			
	1	2	3	4
1	7,55	6,02	6,04	6,03
2	6,66	5,87	5,73	5,54
3	6,17	5,49	5,46	5,37
4	5,71	5,23	5,20	5,00

d. Viscosity test

Table 5. Result of observation of viscosity test preparation of spray gel nanoparticle

Formula	Kecepatan (rpm)	weeks			
		1	2	3	4
1	12 rpm	370 cPs	420 cPs	480 cPs	540 cPs
2	12 rpm	470 cPs	480 cPs	490 cPs	490 cPs
3	12 rpm	520 cPs	530 cPs	550 cPs	580 cPs
4	12 rpm	680 cPs	710 cPs	890 cPs	1020 cPs

e. Spraying pattern and dispersion test

Table 6. Result of observation of Spraying pattern and dispersion test preparation of spray gel nanoparticle

Description:

Formula	Spraying pattern	Formula	Dispersion (cm)
F1	Good	F1	13
F2	Good	F2	12
F3	Good	F3	11
F4	Good	F4	10

Very bad : not spraying out

Bad : sprays out, but not in the form of particles but in the form of droplets.

Bad enough : sprays out, but the particles are too large.

Good : spraying out with uniform and small particle form.

f. Dry Time test

Table 7. Result of observation of Dry Time test preparation of spray gel nanoparticle with Bundung plant on the respondent's forearm

Respondents	Formula			
	F1 (minute)	F2 (minute)	F3 (minute)	F4 (minute)
1	1,42	1,36	2,13	2,50
2	1,33	1,20	2,23	2,48
3	1,32	1,30	2,09	2,40
4	1,30	1,30	2,09	2,45
5	1,42	1,62	2,00	2,39
6	1,31	1,22	2,17	2,64
7	1,53	1,31	2,31	2,61
8	1,47	1,26	2,22	2,41
9	1,44	1,21	2,27	2,60
10	1,32	1,33	2,28	2,70
11	1,38	1,44	2,39	2,62
12	1,51	1,41	2,16	2,51
13	1,27	1,37	2,17	2,48
14	1,58	1,26	2,27	2,52
15	1,44	1,29	2,20	2,61
16	1,43	1,53	2,31	2,47
17	1,46	1,71	2,24	2,45
18	1,51	1,45	2,20	2,52
19	1,49	1,46	2,17	2,48
20	1,37	1,27	2,31	2,53
21	1,42	1,38	2,10	2,44
22	1,19	1,53	2,11	2,47
23	1,28	1,38	2,11	2,47
24	1,37	1,52	2,25	2,55
25	1,43	1,68	2,27	2,61
26	1,51	1,61	2,23	2,46
27	1,29	1,32	2,11	2,62
28	1,33	1,52	2,12	2,39
29	1,35	1,42	2,21	2,43
30	1,40	1,43	2,07	2,45
Median	1,39	1,40	2,21	2,50

g. Particle size test

In this study, there are limitations that can reduce the perfection of the research, as for the limitations in this study, namely the particle size test where the preparation of spray gel nanoparticles of extracts of Bundung plants when tested with the PSA nanoparticle size test tool PSA (*Particle Size Analyzer*) was not readable because the spraygel nanoparticles preparation had non-uniform particle size.

Discussion

a. Organoleptic test

The organoleptic test aims to see the physical appearance (color, odor, shape, clarity, and air bubbles. The organoleptic criteria for the spray gel nanoparticle preparation are clear, not cloudy, and no air bubbles. (The results can be seen in table 2). The stability test Organoleptic research from observation of shape, clarity, and smell did not change. On the observation of color changes, it is because the amount of water content causes enzymatic processes and damage by microbes so that in long time storage can change the chemical content that has

been formed. In this study, the manufacture of spray gel nanoparticles with variations of carbopol 940 did not affect the odor and clarity, but did affect the color and degree of viscosity. The higher the concentration of carbopol 940, the thicker the shape (Noval et al, 2021).

b. Homogeneity test

Homogeneity test aims to see whether there are particles that are not evenly mixed. The homogeneity criteria for the spray gel nanoparticle preparation are no lumps, no solid particles and no spots. In the homogeneity stability test in this study (see table 3) all formulations met the homogeneity criteria, so that in the manufacture of spray gel nanoparticles with variations in the concentration of carbopol 940 it had no effect (Noval et al, 2021).

c. pH test

The pH test aims to see the degree of acidity of a preparation so that it is safe during use. The criteria for a good pH according to the pH of the skin is between 4.5-7 if the pH of the preparation is below the pH of the skin it will experience irritation and if the pH is above the pH of the skin it will experience scaly skin. In the stability of the pH test in this study (see table 4.) the pH decreased every week this could be due to environmental conditions such as light, temperature, and humidity (Haryono et al, 2021). Based on this research, the higher the concentration of carbopol 940, the lower the pH value due to the acidic nature of carbopol 940, so that the variation of carbopol 940 on spray gel nanoparticles has an effect on the pH test. Supported by *one way anova* statistical test, p value <0.05 was obtained, which means that there are significant differences between formulations (Noval et al, 2021).

d. Viscosity test

The viscosity test in the spray gel preparation aims to determine whether or not the preparation is delivered using a spray applicator. Good viscosity criteria for spray gel preparations are 500 cPs-5000 cPs (Harliantika, 2021). In the viscosity stability test of this study (see table 5.) the viscosity has increased in value every week, this is because the water in the preparation is absorbed by the gel base so that there is an increase in the volume of viscosity. Based on this research, the higher the concentration of carbopol 940, the higher the viscosity value obtained so that variations in the concentration of carbopol 940 affect the viscosity value of the spray gel nanoparticle preparation. Supported by the statistical test *Kruskal Wallis* got a p value <0.05, which means that there is a significant difference in the viscosity value of the four formulations.

e. Spraying pattern

The spraying pattern aims to see the quality of the spray applicator and viscosity is also a factor in the success of the spraying pattern (Noval & Malahayati, 2021). The standard spray

pattern for spray gel preparations is very bad, if the preparation does not spray out, it is said to be bad, if the preparation can spray out but is in the form of lumps, it is said to be quite good, if the preparation sprays out the droplets are too large and if the spray pattern is said to be good if the preparation sprays come out with small, uniform droplets. In this study (see table 6.) all formulas met the requirements for a good spraying pattern, this is because all formulas can be sprayed out well from the spray applicator with small and uniform droplet shapes. Based on this study, variations in carbopol 940 affect the spraying pattern, the higher the concentration of carbopol 940, the greater the viscosity, the greater the viscosity, the harder it will be to spray.

f. Dispersion test

Dispersion test aims to ensure that the preparation can spread easily when used. The requirements for a good spray gel dispersion test ranged from 5-7 cm. In this study, spray gel nanoparticles were made (see table 6.) the dispersion obtained exceeded the required value, it was due to the small degree of viscosity and the pressure applied when sprayed was large so that the diameter of the dispersion produced was greater. Based on this study, variations in carbopol 940 affect the dispersion. The higher the concentration, the higher the viscosity, the higher the viscosity, the narrower the dispersion produced.

g. Dry Time test

Dry time test aims to determine the time required for the preparation to dry on the skin. The criteria for a good dry time test is less than 5 minutes. If more than 5 minutes microorganisms can grow due to wet conditions. In this study (see table 7.) one of the factors that affect drying time is the size of the material so that the manufacture of nanoparticles in spray gel preparations affects the dry time test, the smaller the particle size, the faster it dries and penetrates into the skin.

1. Conclusion

Based on the results of the study, it can be concluded that variations in the concentration of carbopol 940 nanoparticle spray gel preparations affect the stability of preparations such as organoleptic, pH tests, and tests of viscosity, dispersion, and dry time tests. The formulation that met the stability evaluation for spraygel nanoparticle preparations of weed (*Actinoscirpus grossus*) plant extract with a variation of carbopol 940 base carried out for 4 weeks was formula 4 with a carbopol 940 concentration of 0.53%.

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Declaration of Interest Statement

The authors declare that they have no conflict of interest

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