Characteristics of mosquito-repellent lotion made from pineapple peel waste

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Abstract. Pineapple peel can be used as a natural ingredient in making mosquito-repellent lotion because it contains many secondary metabolite compounds, including saponins, tannins, flavonoids, alkaloids, steroids, and essential oils. The research aims to obtain the right concentration of pineapple peel extract on the characteristics of the mosquito-repellent lotion produced. The method used was an experimental method with a Completely Randomized Design (CRD) consisting of five treatments (2%, 3%, 4%, 5%, and 6% pineapple peel extract) with three replications to obtain 15 experimental units. The selected treatment was LN2 (lotion with a 3% concentration of pineapple peel extract), providing homogeneous physical characteristics of the lotion preparation, a pH value of 7.93, a spread ability value of 5.50 cm, a viscosity value of 3829.51 cP, and mosquito protection power 80.16%. The descriptive organoleptic assessment showed that the color of the lotion was yellowish brown, slightly scented with citronella, and slightly sticky in texture, and the panelists liked the hedonic evaluation of color and texture. The panelists little appreciated the hedonic aroma.

1 Introduction

Mosquitoes belong to the phylum Arthropoda, creatures with segmented bodies, an exoskeleton, and segmented appendages [1]. Mosquitoes are one of the animals that cause diseases worldwide, including in Riau Province. Conditions that could be transmitted to humans by mosquitoes included filariasis and encephalitis by Culex mosquitoes, malaria by Anopheles mosquitoes, and dengue fever by Aedes mosquitoes. However, the most common mosquito in residential areas was Culex tarsalis, whose bites caused itching.

Various methods have been employed in controlling mosquitoes, including the use of insecticides containing active ingredients such as diethyltoluamide (DEET), dichloro vinyl dimethyl phosphate (DDP), malathion, parathion, and others. These chemical substances could have adverse effects on human health and lead to mosquitoes developing resistance. According to [2], environmentally friendly vector control methods involve mechanical and biological means, which are more eco-friendly than synthetic chemicals. One solution to this

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issue is creating eco-friendly mosquito-repellents derived from natural materials abundantly available in the environment. These repellents can be used in products such as lotions. Certain plants emit a distinctive odor and an aroma that mosquitoes dislike due to the presence of various secondary metabolite compounds [3]. Some of these plants include pineapples.

Pineapple is one of the agricultural products abundant in Kampar Regency, Riau Province. Pineapple contains alkaloid compounds in various parts of the plant. Alkaloids are a group of nitrogenous base compounds with heterocyclic chains [4]. Research conducted by [5] revealed that pineapple peel extract contains bioactive components such as saponins, tannins, and flavonoids. The study showed that applying pineapple peel extract at a concentration of 4% resulted in a 97.5% mortality rate for Culex spp—mosquito larvae.

Many studies have been conducted on making mosquito-repellent lotions from natural ingredients, such as that conducted by [6] regarding the effectiveness of lemon peel extract as a repellent against the Aedes aegypti mosquito. The research results showed that at a concentration of 5%, lemon peel extract had repellent power against the Aedes aegypti mosquito. Further studies by [7] regarding the effectiveness of lime peel extract on mosquito protection showed that the higher the concentration of essential oils derived from lime peel extract, the more effective it was on mosquito protection, up to 98% concentration. 45% for 8 hours. Santya [8], has researched the protective power of sweet kaffir lime peel extract (*Citrus hystrix*) against dengue fever mosquitoes, with research results showing that sweet kaffir lime peel can repel Ae. aegypti and Ae. albopictus. The characteristics and effectiveness of pineapple peel as an mosquito-repellent lotion are not yet known, so it needs to be studied. This research aims to obtain the right concentration of pineapple peel extract for the characteristics of the mosquito-repellent lotion produced.

2 Materials and methods

2.1 Materials and tools

The materials used for the lotion formulation include stearic acid, white petroleum jelly, mineral oil, propylene glycol, tween 80, triethanolamine, and distilled water. The equipment used includes a knife, blender, 60-mesh sieve, rotary evaporator, pH meter, 100-ml glass beaker, graduated cylinder, watch glass, dropper pipette, analytical balance, Brookfield viscometer, pycnometer, micropipette, GC-MS (Gas Chromatography-Mass Spectrometry) instrument, petri dish, plastic bottles, hot plate, magnetic stirrer, thermometer, glass stirrer, and glass slides.

2.2 Research methods

The method is experimental with a completely randomized design (RAL) consisting of five treatments and three replications, resulting in 15 experimental units.
LN1 : Pineapple skin extract 2%
LN2 : Pineapple skin extract 3%
LN3 : Pineapple skin extract 4%
LN4 : Pineapple skin extract 5%
LN5 : Pineapple skin extract 6%

Detailed formulation information can be found in Table 1. The stages of this research are pineapple skin extraction, mosquito-repellent lotion making, and analysis of the lotions made. The data obtained were analyzed statistically using analysis of variance (ANOVA) or fingerprinting using Program statistical product and service solutions (SPSS) 23. If the test

results show Fcalculate > Ftable, then a further test of Duncan's new multiple range test (DMRT) at 5% to determine the difference in influence on each treatment.

Table 1. Formulation lotion.

Material	Treatment				
	LN1	**LN2**	**LN3**	**LN4**	**LN5**
Strearic acid (g)	23	23	23	23	23
White vaseline (g)	3	3	3	3	3
Mineral oil (mL)	50	50	50	50	50
Propylene glykol (mL)	10	10	10	10	10
Tween 80 (mL)	1,5	1,5	1,5	1,5	1,5
Triethanolamine (mL)	10	10	10	10	10
Aquades (mL)	50	50	50	50	50

2.3 Conduct of research

2.3.1 Pineapple skin extraction

Pineapple peel extraction refers to [9], namely by maceration method. Pineapple peel made into flour is extracted using 80% ethanol solvent with a ratio of 1:4, then placed in a container and closed. Stirring is carried out once in 24 hours for three days at room temperature. After being allowed to stand, filtration is carried out until filtrate is obtained. The filtrate obtained is evaporated using a rotary evaporator at a temperature of 50ºC until a concentrated extract is obtained.

2.3.2 Making of mosquito-repellent lotion

Making mosquito-repellent lotion refers to [10] by combining two phases: oil and water. The oil phase consists of stearic acid, white vaseline, and mineral oil. The material is mixed in a beaker glass and heated to liquid (preparation one). The water phase comprises propylene glycol, tween 80, triethanolamine, and aquades. The material is mixed in another beaker glass and heated to approximately 70ºC (preparation two). Furthermore, preparations one and two and pineapple peel extract of each treatment are mixed in a container while stirring quickly until a stable lotion period is formed.

2.4 Research parameters

2.4.1 Chemical analysis of pineapple peel extract

Analysis of the identification of compounds contained in pineapple peel extract was carried out with the GC-MS (Gas Chromatography-Mass Spectrometry) instrument to determine the chemical components of essential oils.

2.4.2 Homogeneity test

The homogeneity test refers to [11]. The homogeneity test is carried out by applying the preparation to the object glass; then, the object glass is covered with another object glass.

After that, visually observed distributed particles. A good lotion should show a homogeneous arrangement; that is, there is no feeling of solid material on the glass object.

2.4.3 Measurement of acidity

Measuring the degree of acidity (pH) refers to [12]. pH measurement is carried out using a pH meter. The pH meter is calibrated first using aquades. A sample of lotion as much as 1 g is placed in erlenmeyer, then diluted with 20 mL of aqueous and stirred until mixed. Next, the pH Meter is dipped in diluted lotion, and the pH value listed on the pH Meter is seen.

2.4.4 Dispersion test

The dispersion test refers to [13]. A total of 500 mg of lotion is weighed and placed on a glass covered with another glass over the gel mass and left for 1 minute. The diameter of the lotion is calculated by measuring the diameter length from several sides. After that, a load of 100 g is added with each load of 50 g. Leave the lotion on for 1 minute, then record the diameter on four sides and determine the area of spread of the lotion.

2.4.5 Viscosity test

Following [14], the viscosity test involves pouring 100 mL of lotion into a 100 mL glass beaker. The viscosity is then measured using a Brookfield viscometer with a number 5 spindle at a speed of 50 rpm, expressed in centipoise.

2.4.6 Organoleptic test

Organoleptic testing of lotions aims to determine the appearance of lotions, including color, aroma, and distinctive texture (consistency). Organoleptic testing consists of a descriptive test and a hedonic test. Descriptive organoleptic tests were performed by 30, and 50 panelists performed hedonics with samples that had been coded and placed randomly.

3 Results and discussion

A lotion is a liquid emulsion consisting of an oil phase and an aqueous phase stabilized by an emulator, containing one or more active ingredients used for external skin use as protectors [15]. Lotions serve to retain skin moisture, soften and cleanse, and prevent water loss (dehydration). However, several types of lotions are developed for specific purposes, such as to prevent mosquito bites. These, namely lotions, use additional ingredients that contain active substances, such as mosquito-repellent.

Pineapple peel extract is the active ingredient used in making mosquito-repellent lotion in this study. Pineapple fruit (*Ananas comosus* L. Merr) is one plant that has secondary metabolic compounds, both in the flesh and skin. Secondary metabolic compounds are compounds produced by plants that can be antifeedant/feeding deterrent, oviposition repellent, and repellent. The results of the analysis of the chemical components of pineapple peel extract using GC-MS can be seen in Table 2.

Table 2. Results of chemical component analysis of pineapple peel extract using GC-MS.

Retention time	% Area	Compound name
3.065	0.08	2,3-Butanediol, [R-(R*,R*)]-
7.067	0.86	Glycerin
10.440	0.10	4H-Pyran-4-one, 2,3-dihydro-3,5-dihydroxy-6-methyl-
17.805	0.04	l-(+)-Ascorbic acid 2,6-dihexadecanoate
18.195	0.45	Undec-10-ynoic acid, undec-2-en-1-yl ester
19.312	11.20	9-Octadecenoic acid (Z)-, oxiranylmethyl ester
19.764	16.12	9-Octadecenoic acid (Z)-, oxiranylmethyl ester
20.045	2.53	Glycidyl palmitoleate
20.430	0.48	Oleic Acid
20.726	1.46	9-Octadecenoic acid (Z)-, oxiranylmethyl ester
21.190	4.43	Glycidol stearate
21.580	1.22	Myristoyl chloride
21.852	1.14	2-Pentadecanone, 6,10,14-trimethyl-
22.157	1.03	Hexadecanoic acid, methyl ester
23.048	37.50	l-(+)-Ascorbic acid 2,6-dihexadecanoate
24.786	5.08	Pyrido[3,4-d]pyrimidin-4(3H)-one, 2,6,8-trimethyl-
25.241	2.28	9,12-Octadecadienoic acid (Z,Z)-
26.005	0.83	Methyl stearate
26.786	10.12	Oleic Acid
27.255	1.96	Octadecanoic acid
28.605	0.08	Tetradecanoic acid
29.268	0.34	Glycidyl palmitate
30.378	0.66	Eicosanoic acid, 2,3-bis(acetyloxy)propyl ester
	100.00	

Based on the results of chemical analysis using GC-MS, it can be seen that pineapple peel extract contains flavonoids, phenols, aromatic compounds, and several acids. The content of aromatic compounds in pineapple skin can repel mosquitoes. The odors produced by these compounds can interfere with mosquitoes' ability to find humans or animals they are about to bite. Pineapple skin also contains several acidic compounds, including citric acid and malic acid, which can make human skin feel acidic, thus becoming a barrier for mosquitoes biting skin smeared with pineapple peel extract.

In addition, pineapple skin also contains the enzyme bromelain. Pineapple peel contains bromelin enzyme by 0.05-0.08% [16]. Bromelin enzymes can degrade and lyse mosquito larvae's skin walls and digestive tract, affecting damage to the reproductive tract [17]. Bromelain enzyme makes pineapple skin acidic and disrupts the mosquito's digestive system when mosquitoes try to suck blood on body parts smeared with lotion with the active ingredient of pineapple peel extract. This can make mosquitoes feel uncomfortable.

Pineapple peel is also favorable for secondary metabolite compounds such as saponins, alkaloids, tannins, phenols, flavonoids, and steroids [18]. W. Ramadhan [19] stated that tannin compounds could interfere with the digestive system of food because tannins will bind proteins in the digestive system that are needed for growth so that the process of protein absorption becomes disrupted; as a result, there will be a decrease in larval growth.

Flavonoids work as respiratory toxins. Flavonoids enter the body of larvae through the respiratory system, which can cause damage to the respiratory system, causing larvae to be unable to breathe and eventually die [20]. These secondary metabolite products are used as active ingredients in vegetable pesticides and by plants as a means of defense from attacks by disturbing organisms [21].

3.1 Characteristics of mosquito-repellent lotion preparations

Lotion preparations are visually observed to determine the characteristics of the resulting lotion preparations, including homogeneity, pH, dispersion, viscosity, and physical appearance (color, texture, and aroma) of the lotion preparation. This is done to assess the suitability of the resulting lotion preparation. The results of testing the lotion characteristics of each treatment are shown in Table 3.

3.1.1 Homogeneity

The homogeneity test is performed to see the uniformity of the active substance mixed in the lotion base. A homogeneous preparation will give good results because the active ingredients in pineapple peel extract will be evenly dispersed in the base ingredients [22]. The homogeneity test is done by applying lotion preparations to the transparency glass. The results of lotion homogeneity testing based on Table 3 showed that all treatments made had a homogeneous arrangement and did not appear to have coarse grains. However, there were differences in the concentration of active substances of pineapple peel extract in each treatment so that the active substances could spread evenly on the skin. This study's results align with [23], which showed a homogeneous preparation of mosquito-repellent lotion from citronella oil for all treatments.

3.1.2 Acidity degree (pH)

Analysis of the pH value of lotion preparations is carried out to determine the level of acidity or alkalinity of the preparations made. According to [24], the degree of acidity (pH) is an essential parameter in a cosmetic product because the pH of cosmetics affects the skin's absorption power. Cosmetics with a very high or low pH can increase the skin's absorption power, causing irritated skin. The observations (Table 3) showed that the higher the concentration of pineapple peel extract in the lotion base used, the lower the pH value of the lotion (the more acidic). This is due to the acidic pH of pineapple peel extract. Based on the results of raw material analysis, the pH of pineapple peel extract is 4.8, so using more extracts will cause the pH value to be more acidic. This study's results align with [25] regarding mosquito-repellent lotion from turmeric oil. The more turmeric oil is added, the lower the pH value produced.

Pineapple peel contains organic acids (acetic acid, citric acid, propionic acid) and amino acids (essential and non-essential) [26]. This is supported by research by [27] regarding hand sanitizers based on stevia leaves and pineapple peels, showing that the higher the pineapple peel extract used, the lower the pH produced tends to be low because pineapple peel extract is acidic. The suitability of the pH value of the lotion preparation with the pH of the skin affects the skin's acceptance of the lotion preparation. The ideal lotion preparation is not to irritate the skin. The possibility of skin irritation will be huge if the preparation is too acidic or alkaline because topical repellent requires prolonged contact with the skin.

The pH value of each lotion treatment ranges from 7.85-8.01, so from the pH value, pineapple peel extract lotions at various concentrations are relatively safe for topical use. The pH value obtained is by the pH value standard for lotions and skin moisturizers based on SNI

164399-1996, which ranges from 4.5-8, except for the LN1 treatment, which is close to neutral.

Table 3. Test results of the characteristics of each treatment lotion.

Analysis	SNI*	Treatment				
		LN1 (2%)	LN2 (3%)	LN3 (4%)	LN4 (5%)	LN5 (6%)
Homogeneity	Homogeneous	**Homogeneous**	**Homogeneous**	**Homogeneous**	**Homogeneous**	**Homogeneous**
pH	4.5-8	8.01^{c}	**7.93^{b}**	**7.89^{ab}**	**7.86^{a}**	**7.85^{a}**
Dispersion (cm)	5-7 cm**	**5.20^{a}**	**5.50^{b}**	**6.23^{c}**	**6.43^{d}**	**6.80^{e}**
Viscosity (cP)	2000-50000 cP	**3929.51^{b}**	**3829.51^{b}**	**3662.49^{ab}**	**3033.30^{ab}**	**2395.09^{a}**
Mosquito protection power (%)		**79.61**	**80.16**	**81.82**	**83.04**	**86.32**
Descriptive test						
Color		4.93^{c}	4.93^{c}	4.57^{b}	4.13^{a}	4.07^{a}
Aroma		1.47^{a}	1.83^{a}	2.30^{bc}	2.60^{c}	2.60^{c}
Texture		1.87^{a}	1.93^{a}	2.00^{a}	2.03^{a}	2.03^{a}
Hedonic test						
Color		**3.76^{b}**	**3.52^{ab}**	3.40^{a}	3.28^{a}	3.24^{a}
Aroma		**3.04**	**2.86**	**2.99**	**3.00**	**3.25**
Texture		**3.60^{b}**	**3.50^{ab}**	**3.31^{ab}**	3.26^{a}	3.20^{a}

Note: The numbers followed by different lowercase letters on the same line indicate a noticeable difference according to the DMRT test at 5%. **Color score** 1 = blackish brown, 2 = brown, 3 = fawn, 4 = yellow, 5 = pale yellow; **Aroma score** 1 = No pineapple scented, 2 = Slightly pineapple scented, 3 = Slightly pineapple flavored, 4 = pineapple-scented, 5 = very pineapple-flavored; **Texture score** 1 = Very viscous, 2 = viscous, 3 = slightly viscous, 4 = diluted, 5 = very diluted; **Hedonic score** 1 = strongly disliked, 2 = disliked, 3 = somewhat liked, 4 = like, 5 = very like
*[28]; **[29]

3.1.3 Dispersion

Dispersion is the ability to spread topical preparations on the skin. The dispersion test determines the magnitude of the lotion spread when applied to the skin. A good lotion must have enough dispersion to make it easier to apply to the skin. The results of testing the dispersion of lotion with various concentrations of pineapple peel extract (Table 3) show that the higher the concentration of pineapple peel extract, the greater the ability of lotion spreadability because the consistency of liquid pineapple peel extract causes the higher the concentration used, the greater the dispersion power of lotion. This study's results align with [25] regarding mosquito-repellent lotion from turmeric oil. The more turmeric oil is added, the lower the resulting dispersion value.

The best lotion spread is at a concentration of 6%, with a dispersion power of 6.80 cm, significantly different from other treatments because the more significant the spread value of the preparation, the easier it is to apply. According to [29], good dispersion is 5-7 cm. A dispersion of 5-7 cm indicates a semisolid consistency that is very comfortable to use [30]. The value of the dispersion of the lotion produced in this study ranged from 5.20 to 6.80 cm, which shows that the resulting dispersion has met the specified quality requirements.

3.1.4 Viscosity

The viscosity test is an essential property in the formulation of semisolid liquid preparations that provide an overview of the resistance of a liquid object to flow, both at the time of production, put into the package, and essential properties at the time of use [31]. The higher the viscosity, the higher the resistance. The results of the viscosity testing of lotions with various concentrations of turmeric oil are shown in Table 3. Based on the lotion viscosity test results, the highest viscosity value was obtained in the LN1 treatment, which was not discernible from other treatments except for the LN5 treatment. The higher the concentration of pineapple peel extract to which the viscosity is added, the lower the viscosity; this is due to the consistency of pineapple peel extract, which is more liquid than the dosage base, causing the viscosity to be lower. This study's results align with [25] regarding mosquito-repellent lotion from turmeric oil. The more turmeric oil is added, the lower the viscosity value produced.

The stability of the lotion emulsion is affected by its viscosity. Lotions with high viscosity values will be more stable but tend to be challenging to apply because they have low dispersion but have high adhesion. Conversely, the lower the viscosity of a lotion, the greater the dispersing power, but the adherence decreases. A decrease follows such a decrease in viscosity in the stability of the emulsion. This is because, at low viscosity, the dispersed phase will quickly move in the dispersing medium. Hence, interactions or collisions between dispersed phases occur and tend to combine into larger particles and clumps, which causes separation [32].

The viscosity of a good lotion, according to SNI 16-4399-1996, is 2000−50000 cP. The proper viscosity value will result in lotions being easily applied to body parts so that they are easily spread, evenly distributed, and absorbed into the skin. The viscosity value of the lotion produced by each treatment ranged from 2395.09-3929.51 cP. The viscosity value of the mosquito-repellent lotion is to the specified quality requirements.

3.1.5 Mosquito protection power

The mosquito-repellent test was carried out by placing 25 mosquitoes in a mosquito cage, then counting the number of mosquitoes that landed on hands that were not smeared with mosquito-repellent lotion and mosquitoes that landed on hands that were smeared with mosquito lotion according to the treatment. Table 3 shows that the higher the concentration of pineapple peel extract in the anti-mosquito lotion preparation, the greater the mosquito-repellent protection ability produced. The LN5 treatment with a pineapple peel extract concentration of 6% provided the best mosquito protection compared to other treatments, namely 86.32%. This is because the distinctive smell of pineapple skin is more dominant, causing fewer mosquitoes to stick to it. The results of the evaluation that has been carried out show that the higher the concentration of pineapple peel used, the fewer mosquitoes will stick to the skin. This proves that the pineapple skin lotion formulation is effective as a mosquito-repellent because pineapple skin contains essential oils that produce an aroma that mosquitoes do not like, so that it can be used as a repellent or mosquito repellent (5).

3.1.6 Organoleptic

Organoleptic testing is performed to see the color, aroma, and texture of mosquito-repellent lotion descriptively and hedonically. The observations (Table 3) showed that the average panelists descriptive assessment score on lotion color attributes ranged from 1.23–3.33 (blackish brown to fawn), lotion scent attributes ranged from 1.47–2.60 (slightly pineapple-scented to slightly pineapple-scented), and lotion texture attributes ranged from 1.87–2.03

(thick). The hedonic test aims to see a person's preference for mosquito-repellent lotion from pineapple peel extract. The observations (Table 3) showed that the average hedonic panelists' rating score on lotion color attributes ranged from 3.24–3.76 (somewhat like to like), lotion scent attribute ranged from 2.86–3.25 (somewhat like), and lotion texture attribute ranged from 3.20–3.60 (somewhat like to like). The appearance of mosquito-repellent lotion pineapple peel extract of each treatment can be seen in Figure 1.

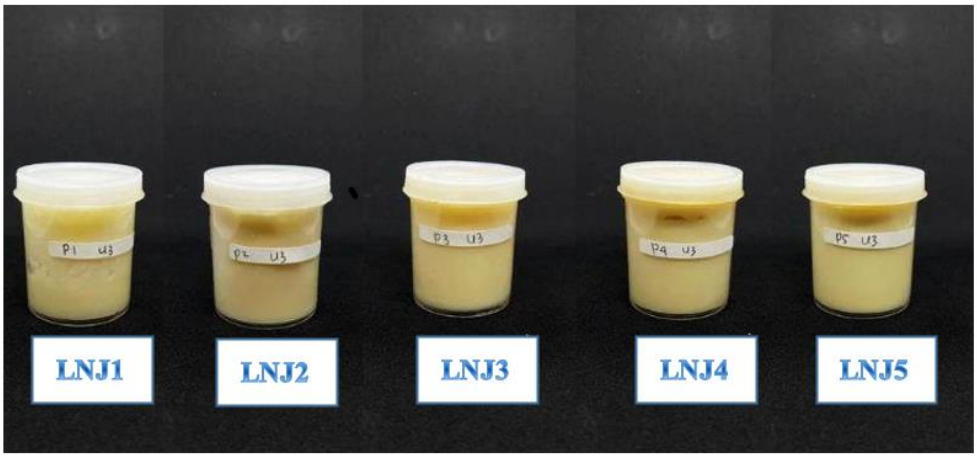

Fig. 1. The appearance of mosquito-repellent lotion pineapple peel extract of each treatment.

The results of the hedonic test conducted on the panelists obtained the results that the panelists preferred LN1 and LN2 preparations. This is because in LN1 and LN2, the concentration of pineapple peel extract is lower than other treatments. In LN1 and LN2, panelists prefer the color and texture of the skin because the color is brighter than other preparations, the dosage form is thicker, easy to apply, and quickly flattened on the skin. However, in terms of aroma, panelists prefer the LN5 treatment because in this treatment, the aroma of pineapple skin is very smelly.

4 Conclusion

Pineapple peel extract can be formulated into mosquito-repellent lotion preparations and has physical properties (homogeneity, pH, dispersion, and viscosity) that meet the requirements of the lotion. Based on research results, it is known that pineapple peel extract is effective in protecting the skin from mosquito bites. The selected treatment is LN2 (lotion with pineapple peel extract concentration of 3%), providing homogeneous physical characteristics of lotion preparations, pH value of 7.93, dispersion value of 5.50 cm, viscosity value of 3829.51 cP, and mosquito protection power 80.16%. The descriptive organoleptic assessment showed a pale yellow lotion color, slightly pineapple-scented, and thick textured, and a hedonic assessment of color and texture favored by panelists, hedonic aroma somewhat favored by panellists.

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