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Utilization of Lerak Juice (*Sapindus rarak* DC) as Natural Surfactant in the Liquid Washing Soap Production

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ABSTRACT

Before detergent was commonly used, a natural cleanser which function is to help people to clean several things in their houses was lerak berry (Sapindus rarak DC). This berry contains saponins (28%) which can be used as the ingredient for shampoo, soap, and other kind of cleaning agents. Dilutting lerak juice into soap base will produce liquid washing soap which can be an alternative to reduce the use of detergents. This study aims to find the best treatment, balance ratio of lerak juice (2:1; 3:2; 1:1; 2:3), and dilute method for the soap base (heating and non-heating) to be used for producing liquid washing soaps with the best characteristic. This study uses two-factor randomized block design method which will be analyzed using ANOVA. Organoleptic testing of the hedonic quality to the color, scent, foam quantity, cleaning-power, the after-effects impression, and the general assessment of the liquid washing soaps results a 2:1 Lerak juice balance ratio with heating method is found to be the best treatment for diluting method. The balance ratio affects the consistency and viscosity which also affects the density, pH, and water holding capacity, but does not affect the foam's stability.

1. INTRODUCTION

In addition to soap, detergents are cleaning agents usually used for washing clothes. Detergent is a product of chemical formulation mixtures that are purposed to increase cleaning power. Surfactant is one of the main components in detergents for cleaning purposes because its melting characteristic with other substances, so that it can lift stains on clothes. An example of a surfactant on the market is sodium lauryl sulfonate (SLS). This synthetic surfactant, however, can cause serious water pollution in watersheds that disrupt the water ecosystem and resulting in the death of aquatic biota. Furthermore, it causes human health problem such as irritation and protein denaturation in the skin layer (Agustina *et al*., 2005). Based on those negative impacts, it is necessary to use natural surfactants to replace the function of synthetic surfactants.

Nature has provided all human needs, from food, clothing and shelter, including cleaning materials. Before the invention of detergents, cleaning agents come out from plants. Lerak fruit (*Sapindus rarak* DC) is one of such plants having the ability to clean. Lerak is famous for its fruit's ability to clean clothes. Javanese people recommend washing batik with lerak because it is considered to be able to maintain its quality (batik's color). Lerak fruit contains 28% saponins, which will release foam when soaked in water. Therefore, it can be used as a natural surfactant. All parts of the lerak fruit contain saponins, flavonoids and tannins, and the skin contains alkaloids and polyphenols (Udarno, 2009).

The saponins in lerak fruit function as natural surfactants that lowering the surface tension of water. Lerak fruit juice can be used as a natural surfactant to replace the function of synthetic surfactants. However, because lerak is a natural material that is easily affected by environmental conditions, lerak juice must be treated so that its shelf life becomes longer. One of treatments is by dissolving the lerak juice into the soap paste then into liquid laundry soap. Wulandari (2016) has used lerak fruit as an alternative material for laundry soap based on lerak detergent. Soap making is done by mixing of lerak extract with Cocomidophyl Betaine as a foam booster and NaCl as a soap thickener. Fitriyah (2018) conducted research on the manufacture of a non-emulsion liquid soap prototype based on lerak extract as a surfactant and anti-bacterial. The soap is mixed with Tween 80 or Polysorbate and Emmal 270N or SLS (Sodium Laureth Sulfate), both of which are synthetic surfactants. From the two studies above, the laundry soap is still manufactured using synthetic surfactants as additional active ingredients which are not environmentally friendly and can have a negative impact on the skin if used continuously. Therefore, it is necessary to modify the laundry soap recipe which is environmentally friendly. This can be performed by mixing lerak extract into a soap paste made from vegetable oil and lye. This study aims to determine the effect of lerak juice ratio and soapbase dilution method, and to determine the best treatment in the manufacture of liquid laundry soap containing lerak extract. It is expected that liquid laundry soap from lerak extract can be an alternative to replace the function of detergent as a cleaning agent, especially for washing clothes, and reduce the negative impact caused by the chemical components of detergent.

2. MATERIALS AND METHODS

2.1. Materials

The material used in this research included the dry lerak bought in the large market of Malang City, coconut oil (Barco brand), potassium hydroxide (KOH), glycerin, fragrance and distilled water purchased at the Sakha Chemical Shop in Malang City.

2.2. Lerak Extraction

First, the flesh of lerak fruits was separated from their seeds and then weighed as much as 75 g. The gained materials were then cut into small pieces and mixed with 1000 ml of water. The mixture was heated to boiling (20 minutes). The extract of lerak was filtered using the fabric filter and stored in a glass container till used.

2.3. Soap Paste Preparation

The method used in making soap paste in this research is the hot process method. This method is commonly used in the manufacture of organic liquid soap stocks. In addition, this method is able to speed up the reaction process because it uses a heat process (Horowitz, 2013). Soap paste production begins with preparing tools and materials. In this study, Barco brand coconut oil which contains high lauric fatty acid (41.21%) was used. Lauric acid contributes to the cleaning ability of soap and can produce soap with a lot of foam (Fatmawati *et al*., 2016). At first, 100g of Barco brand coconut oil was weighed and then heated in a slow cooker until the temperature reached 85°C. Potassium hydroxide (KOH) was weighed according to the number of saponification of Barco brand coconut oil. The results of previous studies stated that the saponification value for Barco coconut oil was 257.9 mg KOH/g, meaning that to dissolve one g of Barco coconut oil, 257.9 mg KOH was needed (Rangkuti, 2017). In this study, 100 g of Barco coconut oil was used so that the required KOH was 25.79 g. The KOH was mixed with distilled water until homogeneous and the KOH solution was then mixed into the hot coconut oil. The mixture was stirred using a hand blender for 120 seconds until the mixture reached the trace phase. The stirring was stopped and the mixture was heated for two hours and every 30 minutes was stirred with a spatula. This process is known as saponification. Saponification is the process of hydrogen reduction or hydrolysis of bases to oils and fats. The product of this reaction is called soap containing of salts of fatty acids and free glycerol (Naomi *et al*., 2013).

The clarity test was carried out on the mixture by putting a little soap paste into a little distilled water then stirring and observing the color of the pH paper and the results of the soap paste: if the soap solution was cloudy, the soap paste was not completely saponified, but if the soap solution was clear, then the soap paste was completely saponified. Then added glycerin as much as 5% of the total weight of the soap paste. The soap paste that has been completely saponified was left for one hour until its the temperature dropped to 25 °C.

2.4. Soap Paste Dilution

Dilution of soap can be performed by heating or without heating. Dilution with heating is the most common in the manufacture of liquid soap. Previous research conducted a dilution of soap at a temperature of 60 °C (with heating). Cold dilution is generally carried out with soap made by the cold process or CPLS (Cold Process Liquid Soap), by allowing the soap paste and water to be completely diluted at room temperature (Bidillah *et al*., 2017). In this study, the method with heating and without heating was carried out to determine the effective dilution or dilution method in the manufacture of liquid laundry soap from lerak extract.

The filtered lerak juice was weighed and mixed according to the treatment ratios (weight of lerak extract: weight of soap paste) (2:1, 3:2, 1:1, 2:3) and was diluted using the appropriate treatment method, namely the dilution with heating and without heating. The dilution with heating was performed using a slow cooker at heating temperature of between 75-80 °C for 2 hours, while the dilution without heating was conducted by leaving the mixed soap paste in a container at room temperature (25°C). After the liquid soap is completely diluted, fragrance was added as much as 1% of the total weight of the soap. Liquid laundry soap was stored in a closed glass container in a cool place.

2.5. Experiment Design and Data Analysis

Completely randomized block design with two factors was used in this study. The first factor is the ratio of lerak extract to the weight of soap paste (2:1, 3:2, 1:1, 2:3) and the second factor is the soapbase dilution method (with heating and without heating). All treatment combinations were conducted with 3 replications. The obtained data is analyzed using analysis of variance (ANOVA) and continued with the Honest Significant Difference Test if a significant difference is found.

2.6. Observation

Liquid laundry soap was analyzed for physicochemical properties (specific gravity, foam stability, product moisture, pH). The De Garmo effectiveness test was also carried out to determine the best treatment in making liquid laundry soap from lerak juice.

3. RESULTS AND DISCUSSION

3.1. Liquid Laundry Soap

The specific gravity value of liquid laundry soap from lerak extract ranged from 1.0077-1.0520 g/ml. The test results showed that the lerak extract ratio of 2:3 with dilution by heating produced the soap with the highest specific gravity. Meanwhile, the treatment of ratio 2:1 with dilution without heating produced liquid laundry soap with the lowest specific gravity. Based on the statistical analysis, the effect of variation in the ratio of lerak juice on the specific gravity characteristics of liquid laundry soap showed high significantly different results. From the test results, the calculated F value (F_{calc}) is 7.1404 > F_{table} of 5.5639 at $\alpha = 0.01$. Meanwhile, the variation of the soapbase dilution methods were not significantly different on the specific gravity characteristics which can be observed from the F_{calc} (1.7202) < F_{table} (4.6001). Likewise, the interaction between the ratio of lerak extract and the dilution method did not affect the specific gravity characteristics of liquid laundry soap because the obtained value of F_{calc} (0.1474) was smaller than F_{table} (3.3439). The results of the specific gravity test for liquid laundry soap from Lerak extract are presented in Figure 1.

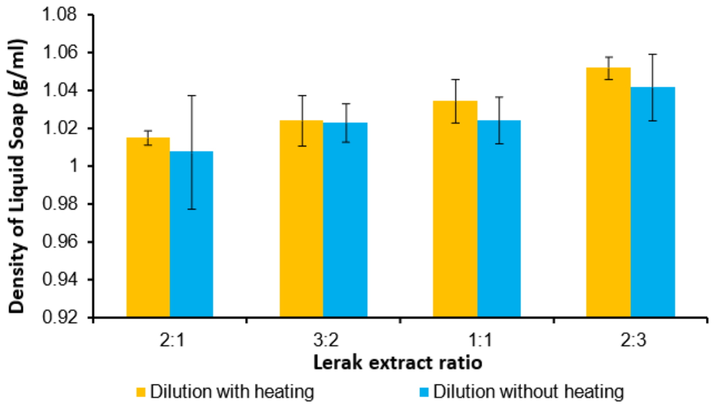

Figure 1. Effect of lerak extract ratio and dilution method on the density (g/ml) of the liquid laundry soap (dilution with heating, dilution without heating)

Figure 1 shows that the specific gravity value of liquid soap increases as the ratio of lerak extract decreases. The factor of ratio lerak juice is related to the viscosity of liquid laundry soap. The greater the ratio of the lerak extract, the more liquid the soap produced because the water content in the soap is higher. Contrary, if the ratio of the lerak extract is low, the resulting soap is thicker. The thickness of the soap is closely related to the value of the viscosity of the soap. A literature states that if the water content in liquid soap is low, then the viscosity value of the liquid soap will be higher (Widyasanti & Ramadha, 2018). If the viscosity is high, the specific gravity will be high. Similarly, if the viscosity is low, then the specific gravity value is also low (Sinko, 2006). From Figure 1, it can be observed that the specific gravity value of liquid laundry soap tends to increase along with the smaller ratio of lerak extract to the weight of soap. It can be concluded that the smaller the ratio of lerak extract, the thickness of the soap increases so that the viscosity value of liquid laundry soap also increases. If the viscosity increases with a decrease in the ratio of lerak extract, the specific gravity will increase with the decrease in the water content in the liquid laundry soap. As explained in a reference where the value of specific gravity will decrease with increasing water content in liquid soap preparations, and vice versa (Nurhadi, 2012).

3.2. pH of Liquid Laundry Soap

The pH value of liquid laundry soap from lerak extraxt ranged from 8.937 to 9.216. The resulting pH value is safe for daily use, because the skin's resistance capacity toward products is in the range of pH between 8.0 and 10.8 (Frost *et al*., 1982). The test results showed that the ratio of lerak extract 2:3 with dilution without heating produced the soap with the highest pH. Meanwhile, the lowest pH value of liquid laundry soap was found in soap with a ratio of lerak extract 2:1 and dilution method without heating. Based on the statistical analysis, the variation in the ratio of lerak juice on the pH characteristics of liquid laundry soap has a very significant effect, because the value of F_{calc} is 8.7121 > F_{table} of 5.5639 at α = 0.01. Whereas, the variation of the soapbase dilution method gave results that were not significantly different in pH characteristics because the obtained value of F_{calc} (0.1463) was smaller than F_{table} (4.6001). Likewise, the interaction between the ratio of lerak extract and the soapbase dilution method gave results that were not significantly different in the pH characteristics of liquid laundry soap because the value of F_{calc} (0.6563) was smaller than F_{table} (3.3439). Thus, it can be concluded that the variation of the soapbase dilution method did not affect the pH value of liquid laundry soap from lerak extract. The relation of the pH of the type of liquid laundry soap from lerak extract and the treatments can be seen in Figure 2.

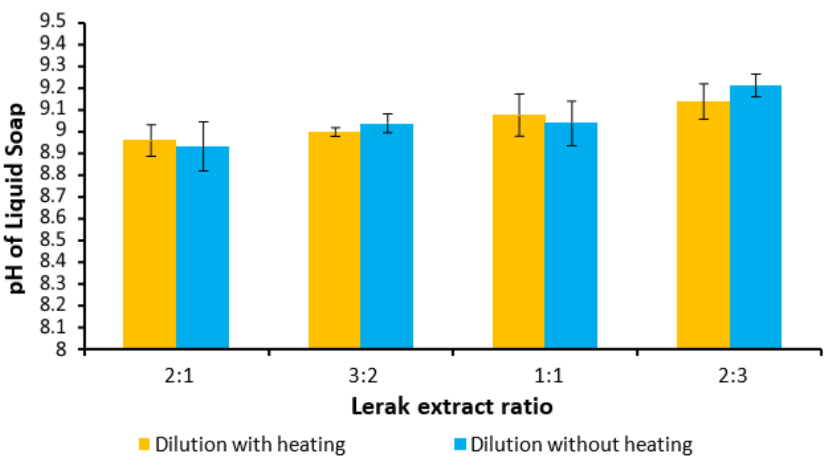

Figure 2. Effect of lerak extract ratio and dilution method on the pH of liquid laundry soap (dilution with heating, dilution without heating)

Figure 2 shows that the pH value increases as the ratio of the lerak juice decreases. This indicates that the greater the ratio of lerak extract in liquid laundry soap, the lower the pH value. The level of free alkali can affect the pH value of the soap, and the alkali (KOH) used in this experiment has been adjusted to the needs of the fatty acids used. The alkali and fatty acids in Barco coconut oil will react completely and leave only a small KOH residue and resulted liquid soap which is not too alkaline. The increase in the ratio of lerak juice also causes the pH to decrease, this is presumably because lerak juice is a mixture of water and lerak fruit. Therefore, the lerak juice has a pH similar to the pH of water which is neutral so that the addition of lerak juice causes the soap molarity to decrease and causes the pH value to decrease, close to the neutral pH of the water. A literature explains that increasing the water content in soap preparations can reduce the pH value, because the pH value of water is neutral (Widyasanti & Ramadha, 2018).

3.3. Moisture of Liquid Laundry Soap

The moisture value of liquid laundry soap products from lerak extract ranged from 83.67-89.67%. The moisture value of the product with a high percentage is thought to be because liquid laundry soap from lerak extract also contains glycerin as much as 5% of the total weight of the soap paste. Glycerin is a compound that is able to bind water and minimize evaporation in soap products (Mitsui, 1997). Moisture of liquid laundry soap products can be interpreted by the capacity of soap to maintain its mass due to evaporation that occurs due to the influence of sunlight. Moisture test is performed to see how stable the soap product against water evaporation (Putra *et al*., 2019). The results of the test showed that the treatment with lerak extract ratio of 2:3 and dilution method by heating produced the soap with the highest moisture content. Meanwhile, the lowest moisture value for liquid laundry soap was found in soap treated with ratio of lerak extract 2:1 and dilution by heating. Based on the statistical analysis, variations in the ratio of lerak extract gave a significant effect, while the soapbase dilution method and the interaction between the two factors had no effect on the moisture of liquid laundry soap. The value of F_{calc} in the treatment lerak extract ratio (3.7745) is greater than F_{table} (3.3439). Meanwhile, in the soapbase dilution method, the value of F_{calc} (0.4186) is smaller than F_{table} (4.6001). In the interaction between the two factors, the value of F_{calc} (0.9433) is smaller than F_{table} (3.3439). The results of moisture testing for liquid laundry soap products from lerak juice can be seen in Figure 3.

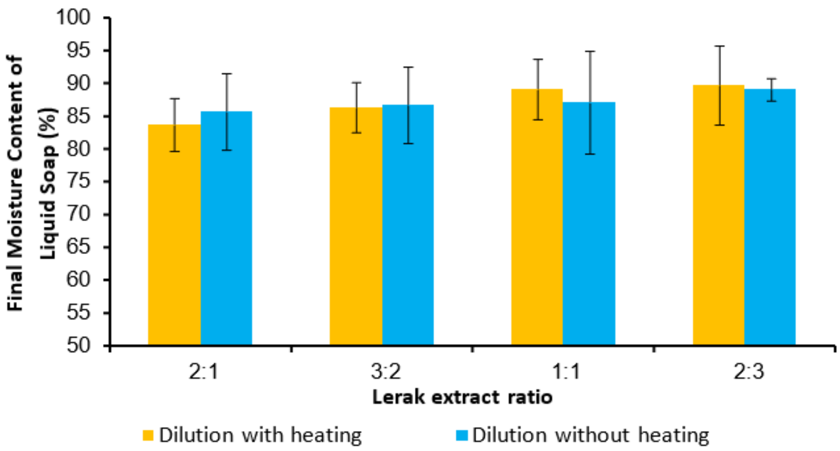

Figure 3. Effect of lerak extract ratio and dilution method on the final moisture (%) of the liquid laundry soap (dilution with heating, dilution without heating)

Liquid laundry soap produced from lerak extract ratio of 2:3 with dilution by heating is the soap with the highest viscosity among other treatments. Then the water content in the sample is less, and the viscosity increases. Soaps with high viscosity have strong bonds between their molecules, so they tend to be more able to maintain the mixture from losing weight (Sari *et al*., 2019). When compared to other treatments, liquid laundry soap from lerak extract ratio 2:1 and diluted using heating is soap with the lowest moisture, because it contains more lerak extract which is 2 times more than the total weight of soapbase. Therefore, the texture of the soap is more liquid than other soaps, in other words, the viscosity of liquid laundry soap from lerak extract ratio 2:1 with dilution by heating is lower than other soaps. In accordance with the reference which states that products with low viscosity tend to be less able to maintain the mixture from losing weight (Sari *et al*., 2019).

It can be concluded that the treatment of lerak extract ratio 2:3 with dilution by heating produced a soap product that has the best ability to maintain its weight because only a small amount of water is lost, so the stability and moisture of the soap product is also high. On the other hand, the treatment with 2:1 lerak extract ratio combined with dilution by heating was the treatment with the greatest weight loss, so the stability and humidity of the soap product was the lowest among other treatments. The small loss of water makes the weight lost of the soap also small and indicates that the level of stability and moisture of the product is high. On the other hand, the large water loss makes the weight of the soap lost also large and indicates that the level of stability and humidity of the product is low (Oktari *et al*., 2017).

3.4. Foam Stability of Liquid Laundry Soap

Foam stability can be defined as the ability of the foam to maintain its parameters constant for a certain time. These parameters can be total foam volume, liquid content and bubble size (Exerowa *et al*., 1998). Analysis of the foam stability test was carried out to determine the stability of the foam in a certain time. The results of the stability testing of the liquid soap foam resulted in an average value range between 87.35-92.15%. Based on the statistical analysis, variations in the ratio of lerak extract, soapbase dilution method and the interaction between factors did not affect the stability value of liquid laundry soap foam. The value of F_{calc} in the treatment of lerak extract ratio (0.2496) is smaller than F_{table} (3.3439). Similarly, in the case of soapbase dilution method, the value of F_{calc} (0.3464) is smaller than F_{table} (4.6001). Finally, in the interaction between the two factors, the value of F_{calc} (0,5164) is also smaller than F_{table} (3.3439). Thus, it can be concluded that the variation in the ratio of lerak extract and the soapbase dilution method did not affect the foam stability value of liquid laundry soap made from lerak extract. The results of stability testing of liquid laundry soap from lerak extract can be seen in Figure 4.

From Figure 4 it can be seen that the stability value of liquid laundry soap foam varies and there is no tendency to increase or decrease. From Figure 4, it can be concluded that the ratio of 3:2 lerak juice with heating is the soap with the best foam stability because it is able to maintain 92.15% of its foam after 5 minutes of letting it sit. While the lerak extract ratio 1:1 treatment with dilution by heating produced the soap with the lowest foam stability compared to other treatments because it was able to maintain 87.35% of its foam after 5 minutes of letting it sit.

In this study, the soap produced can fulfilled the criteria for good foam stability. As mentioned in the reference, soap with a foam stability of more than 60% after being left for 5 minutes is a soap with a stable foam (Febriyenti *et al*., 2014). The liquid laundry soap in this study was made without using synthetic surfactants or foam stabilizers because the addition of active ingredients or synthetic surfactants can trigger the formation of carcinogenic nitrosamines (Wade & Weller, 1994). The foam is produced from the saponification process between Barco coconut oil and KOH and lerak extract which is diluted into liquid laundry soap. This soap uses saponins from lerak extract as a natural surfactant. Based on the literature, solutions containing surface active ingredients such as alkaloids, flavonoids, saponins and tannins produce stable foams (Martin *et al*., 1993). Saponins have steroid or triterpenoid groups as non -polar groups and glycosyl groups as polar groups, so they have surfactant-like properties and will form micelles (which are like foam) when shaken with water (Yulianti & Husada, 2019).

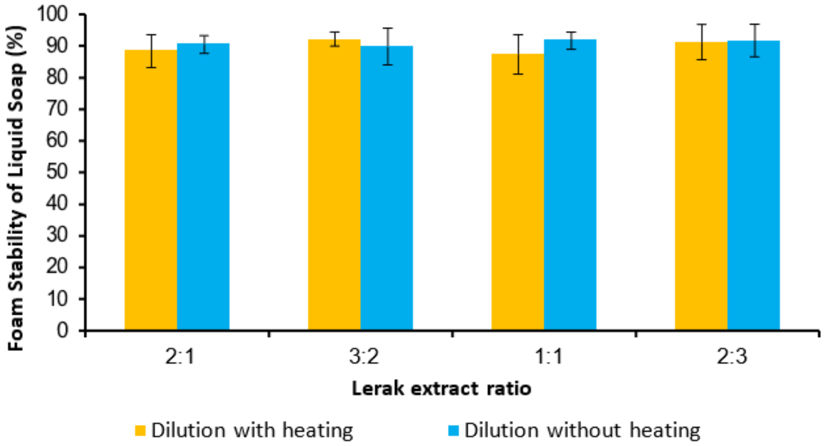

Figure 4. Effect of lerak extrac ratio and dilution method on the foam stability (%) of the liquid laundry soap (dilution with heating, dilution without heating)

3.5. De Garmo Effectiveness Test

The purpose of this test is to obtain the best treatment in the manufacturing of liquid laundry soap from lerak extract. This test was carried out by analyzing using the effectiveness test on several parameters, namely specific gravity, pH, moisture, and foam stability of the product (de Garmo *et al*., 1984). After calculation, the highest effectiveness index (IE) is 0.8971. So that the best treatment for production of liquid laundry soap was obtained, namely a ratio of lerak extract 2:3 with dilution method without heating. The liquid laundry soap from lerak extract produced from the best treatment based on characteristic parameters can be seen in Figure 5. A summary of the results of the effectiveness test is presented in Table 1.

Figure 5. Liquid laundry soap produced at lerak extract ratio of 2:3 and dilution without heating

Table 1. Effectiveness test results of characteristics of liquid laundry soap from lerak extract

Variasi Perlakuan		Parameter				Sum of NH (IE)
Dilution Method	Ratio of lerak extract	Density (g/ml)	pH	Moisture of product (%)	Foam stability (%)	
Bobot Variabel (BV)		0.7	1	0.8	0.6	3.1000
Bobot Normal (BN)		0.23	0.32	0.26	0.19	1.0000
With heating	2:1	0.0394	0.0305	0.0000	0.0423	0.1121
	3:2	0.0851	0.0724	0.1156	0.1900	0.4630
	1:1	0.1381	0.1638	0.2311	0.0000	0.5330
	2:3	0.2300	0.2362	0.2600	0.1489	0.8750
Without heating	2:1	0.0000	0.0000	0.0867	0.1249	0.2116
	3:2	0.0792	0.1181	0.1300	0.0975	0.4248
	1:1	0.0856	0.1219	0.1444	0.1728	0.5247
	2:3	0.1775	0.3200	0.2311	0.1686	0.8971

Note: The yellow label is the highest effectiveness value and the blue label is the lowest effectiveness value

4. CONCLUSION

The making of lerak liquid laundry soap is carried out in 3 stages, namely the stage of making lerak extract, the stage of making soap paste, and the stage of dilution of the soap paste with lerak juice. The treatment of lerak extract ratio variation has an effect on the characteristics of the specific gravity, acidity (pH) and moisture content of the produced soap. The variation of the soapbase dilution method has no effect on the characteristics of liquid laundry soap. Likewise, the interaction of the lerak extract balance treatment and the soapbase dilution method has no effect on the characteristics of liquid laundry soap. Based on the effectiveness test, liquid laundry soap with lerak extract ratio of 2:3 and dilution method without heating produces liquid laundry soap with the best characteristics. The value of specific gravity, pH and moisture of liquid laundry soap products are affected by the ratio of lerak juice. The research carried out still has several obstacles and weaknesses, so it is recommended that further research is carried out to examine the shelf life of liquid laundry soap from lerak juice and its impact on the environment and it is necessary to analyze the economic value of liquid laundry soap from lerak juice. In addition, it is recommended to use a larger difference in the ratio of lerak extract so that the difference in viscosity is clearly visible, as well as to add fragrance and colorants from natural ingredients to liquid laundry soap so that it is more preferred by consumers.

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