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The Influence of Strong Reduced Water and Fresh Coconut Oil in Viscosity of Liquid Hand Soap

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Abstract. Innovation of liquid hand soap continues to be done, among others, using natural local raw materials. This research used strong reduced water (SRW), an alkali produced from a water ionizer machine (with enhancer Sodium Chloride solution), which is eco-friendly and comfortable on the skin. The study also used fresh coconut oil (FCO), was produced by drying process and zero waste. The objective of this research was to determine the effect of utilization of SRW and FCO in the making process of liquid hand soap, which gave good viscosity. Fresh coconut oil (FCO) was reacted with SRW (pH 11.5) for 30 minutes at room temperature (30 ºC), then mixed with sodium lauryl sulfate, sodium sulfate, other additives such as dyes, fragrances, electrolyzed oxydized water (EOW, pH 2.5), Ethylenediaminetetraacetic acid (EDTA) and distilled water. EOW was produced from the ionizer machine too. After saponification process was completed (about 24 hours), the viscosity and density of the liquid soap was measured. The better composition of FCO-SRW yielding good viscosity of liquid soap was 30 to 50 ml based on 500 ml distilled water production. The viscosities of this product were 982.55 to 1,782.25 centipoises, density of 1.0049-1.1175 g/ml, and pH 7. The using of reaction product of fresh coconut oil (FCO) and strong reduced water (SRW) can increase the viscosity of liquid hand soap.

1. Introduction

Soap is produced by saponification process. The forms of soap can varyies, among others: solid soap, soft soap, liquid soap, and powder soap. If an alkali used is sodium hydroxide, then the result is a solid soap. If potassium hydroxide is used, the result is soft soap. Sodium hydroxide is not eco friendly, and not comfortable on the skin. Sodium hydroxide of 10 % concentration was used to produce detergents [1]. This study used alkali from a water ionization machine, instead of sodium or potassium hydroxide, and applied to the manufacture of liquid hand soap.

In this study, an alkali used was not NaOH or KOH, but it used Strong Reduced Water (SRW). Raw water (pH.7) was fed into the ionizer machine, with the help of enhancers (solution which contains Sodium chloride salt); it produced SRW (pH 11.5) and Electrolyzed Oxydized Water (EOW, pH.2.5). The SRW can remove fat and dirt on the equipment. The EOW is different from hydrochloric acid (HCl) or sulfuric acid (H_2SO_4), which is not corrosive to skin and mucous membrane. The SRW and EOW is environmentally friendly and relatively inexpensive. The EOW has been tested and used as a desinfectant in food industry and other applications [2]. It was studied the disinfection efficacy of the

combination of strongly acidic electrolyzed water and alkaline electrolyzed water on fresh-cut cilantro [3]. Electrochemically activated aqueous solutions was used in the manufacture of fur materials. The benefit of the water used was safe, the process was accelerated three fold then soaked in chemicals such as formalin and silicofluoride [4].

One of the vegetable oils can be used as raw materials for making soap is coconut oil. Several studies on the manufacture of coconut oil and its processing have been carried out. Coconut oil can be made in a wet or dry process, which dry process saves more energy. In this process, Fresh Coconut Oil (FCO) was produced from dry process using a batch modified screw mixed dryer. The dryer was operated at temperature of 80 ºC to 100 ºC [5].The Virgin Coconut Oil (VCO) extract contains phytochemicals such as phenolic compounds and also shows high antioxidants activity that might induce fibroblast cell growth and proliferation to enhance the wound closure activity. The optimum VCO concentration obtained in this study was 1.0 mg/mL to give the highest wound closure about 56.89 ± 2.35 % after 24 h [6].

The rheological properties may deviate from the nominal ones, because of process disturbances, and they can be adjusted by varying the ingredients flow rates which have a major impact without affecting excessively detergent characteristics. A point control for the viscosity curve of the non-Newtonian detergent is implemented, where the objective is to maintain the viscosity curve inside a specific range of values which represent the target [7]. It was simulated the mixing or demixing process of a quiescent binary mixture with a composition-dependent viscosity which is instantaneously brought from the two-phase (resp. one-phase) to the one-phase (resp. twophase) region of its phase diagram. The theoretical approach follows a standard diffuse-interface model of partially miscible regular binary mixtures wherein convection and diffusion are coupled via a non equilibrium capillary force, expressing the tendency of the phase-separating system to minimize its free energy. For a phase-separating system, at a fixed value of the fluidity coefficient (with the continuous phase viscosity taken as a reference), the separation depth and the characteristic length scale of single-phase microdomains increase monotonically for increasing values of viscosity ratio. However, for a mixing system the attainment of a single-phase equilibrium state by coalescence and diffusion is retarded by an increase in viscosity ratio at a fixed fluidity for the dispersed phase [8]. Viscosity is one of quality component of liquid soap. Indonesian National Standards (SNI) sets a minimum 500 centipoises dan a maximum 20,000 centipoises. The purpose of this study was to determine the effect of utilization of fresh coconut oil (FCO) and strong reduced water (SRW) on physical properties, especially the viscosity of liquid hand soap.

2. Methods

2.1. Materials

Strong reduced water (SRW or strong alkaline electrolyzed water), pH 11.5, was produced from mineral water (drinking water grade, from local, Kaliurang,Yogyakarta, Indonesia) and enhancer solution (sodium chloride solution, Enagic Co., Japan) through water ionizer machine (Leveluk SD501, Enagic Co., Japan), as shown in Figure 1. SRW contained sodium 3493.45 mg/liter. Fresh coconut oil, was produced from fresh coconut meat (from local market Yogyakarta, Indonesia). The fresh coconut meat was grated, dried at 80-100 ºC using drying machine (modified screw batch drier) until zero water content, then pressed. It was zero waste process, because the residue can be processed as coconut fluor. Sodium lauryl ether sulfate (technical), sodium sulfate (technical), cocoamide di ethanol amine (technical), citric acid (technical), Ethylene diamine tetra acetic acid (EDTA, technical), fragrance, propylene glycol (PG, technical), dyes (cosmetics grade), and distilled water. All of those materials were purchased at local market, Yogyakarta, Indonesia. It also used electrolyzed oxidized water (EOW, pH 2.5) contained of sodium (Na) 747.29 mg/liter for substituting of citric acid.

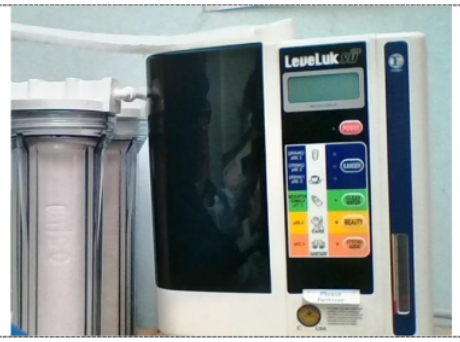

Figure 1. Water ionizer machine for producing strong reduced water and strong electrolyzed oxidized water.

2.2 Methodology

2.2.1 Reaction of Fresh coconut oil and Strong reduced water

Fresh coconut oil (FCO) 100 ml and strong reduced water (SRW) 300 ml were mixed in a basin. The reaction was carried out for 1 hour, stirring speed 1000 rpm, and reaction temperature of 50 ºC. After that, the product of FCO-SRW was placed into the separation funnel, waited for separating. The bottom layer (380 ml) was used for manufacturing of liquid hand soap, and had viscosity of 0.56 centipoises.

2.2.2 Liquid handsoap production

Experiments of liquid hand soap producing have been conducted in the laboratory of Chemical Engineering Departement, Faculty of Industrial Technology, Universitas Ahmad Dahlan, Yogyakarta, Indonesia. General or standard formula was applied as controls. Sodium lauryl sulfate 200 g, sodium sulfate 150 g, cocoamide diethanol amine 50 ml, citric acid 50 g, EDTA 10 g, fragrance 10 ml, propylene glycol 10 ml, dye (cosmetics grade) 8 drops, and distilled water 1 liter. The mixture was poured into bottles (as shown in Figure 2) and waited for 24 hours. After saponification process had been completed, the hand soap was measured its viscosity and density.

Figure 2. Liquid hand soap before saponification process completed

2.2.3 Density and viscosity

The density of the sample was determined by using a 10 ml pycnometer at room temperature.
Viscosity: Ostwald viscometer was used at room temperature of 30 °C, the viscosity was computed by equation (1).

$$\mu_s = \frac{\rho_s . t_s}{\rho_{aq} t_{aq}} . \mu_{aq} \quad (1)$$

where
μ_s is the viscosity of soap, centipoises
μ_{aq} is the viscosity of distilled water, centipoises
ρ_s is the density of soap, g/ml
ρ_{aq} is the density of distilled water, g/ml
t_s is the time required of soap in Ostwald viscometer, minutes
t_{aq} is the time required of distilled water in Ostwad viscometer, minutes.

3. Results and discussions

It was studied to substitute cocoamide diethanol amine by the reaction result of commercial coconut oil (CO) and strong reduced water (SRW). The viscosity and density of liquid hand soap resulted from CO-SRW are shown in Table 1.

Table 1. Effect of CO-SRW on viscosity and density of liquid hand soap (distilled water 500 ml, citric acid 22.56 g)

CO-SRW, ml	Viscosity, centipoises	Density, g/ml
25	94.59	1.1757
50	95.54	1.1056
S	543.25	1.0172
Y	885.09	1.0115

After the liquid soap making was completed, the average viscosity and density was measured, 95.06 centipoises and 1.1407 g/ml, respectively. National standard of Indonesia sets 500 to 20,000 centipoises for viscosity, and 1.010 to 1.100 g/ml for density. So, the results of hand soap for standard formula was not accordance with national standard. It was also measured the viscosity and density of commercial liquid hand soap S and Y (from local market at Yogyakarta, Indonesia). The S branded had viscosity 543.25 centipoises and density 1.0172 g/ml. The Y branded had viscosity 885.09 centipoises and density 1.0115 g/ml.

The fresh coconut oil and strong reduced water with the same amount was mixed, and the result of hand soap can be seen in Figure 3. It can be seen from Figure 3 that the using of fresh coconut oil increased sharply the liquid hand soap viscosity. This can be happened because FCO is more soluble in SRW compared to commercial coconut oil, so the mixture is more homogeneous, and the reaction is more completed. The viscosity of reaction product of CO-SRW mixture was 11.23 centipoises, whereas the FCO-SRW mixture was 0.56 centipoises.

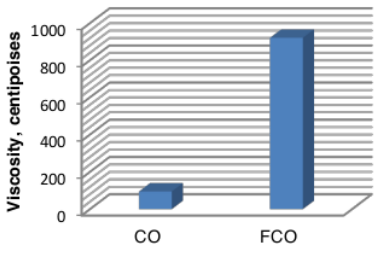

Figure 3. Comparison of CO and FCO on viscosity and density of liquid hand washing soap

The composition of FCO-SRW was made varies from 10 ml to 70 mililiters, which the physical properties and pH of liquid hand soap can be seen in the Table 2.

Table 2. Effect of FCO-SRW on viscosity, density, and pH of liquid hand soap (distilled water 500 ml, EOW = 50 ml)

FCO-SRW, ml	Viscosity, centipoises	Density, g/ml	pH
10	748.83	1,127.0	7.0
20	606.19	1,121.1	7.0
30	982.55	1,117.5	7.0
40	1,001.62	1,109.6	7.0
50	1,075.90	1,107.3	7.0
60	466.44	1,121.4	7.0
70	467.23	1,123.3	7.0

In Table 2, the composition FCO-SRW 10 ml to 50 ml gave the viscosity of liquid soap was above 500 centipoises, but at 60 ml to 70 ml the viscosity dropped under 500 centipoises. It could be caused of the excess of FCO-SRW, which decreased the mixture viscosity. The individual viscosity of FCO-SRW was 0.56 centipoises. After six months of storage, the fresh coconut oil was tested to make liquid hand soap. The composition of FCO-SRW was made varies from 10 ml to 90 mililiters, which the physical properties and pH of liquid hand soap can be seen in the Table 3. From the Table 2 it shows that the highest viscosity was achieved for fresh at 50 ml (1,075.90 centipoises), and after 6 months storage at FCO-SRW 30 ml (1782.25 centipoises). The density of liquid soap at this composition was also close to the national standard of Indonesin Government (SNI) 1.0049 g/ml. National standard for liquid soap density is 1.010 to 1.100 g/ml. So, fresh coconut oil can be stored for several months and can be used to produce the relative same quality of liquid hand soap.For the composition FCO-SRW 10 ml to 40 ml (Table 3) the viscosity of liquid soap was above 1,000 centipoises, but for 50 ml to 90 ml the viscosity decreased sharply under 500 centipoises.

Table 3. Effect of FCO-SRW (after FCO 6 months storage) on viscosity, density, and pH of liquid hand soap (distilled water 500 ml, EOW = 50 ml)

FCO-SRW, ml	Viscosity, centipoises	Density, g/ml	pH
10	1143.31	1.1178	7.0
20	1192.52	1.1071	7.0
30	1782.25	1.0049	7.0
40	1391.08	1.1095	7.0
50	439.31	1.1099	7.0
60	285.41	1.0957	7.0
70	194.26	1.1027	7.0
80	60.23	1.1063	7.0
90	50.35	1.1065	7.0

The liquid soap is Non newtonian fluid, is made from the mixtures of vegetable oil, alkali, surfactant (sodium lauryl sulfate), sodium sulfate, and others. The composition of FCO-SRW must be appropriate, 10 ml to 40 ml, in order to obtain a good viscosity (above 1,000 centipoises). The addition of 50 ml and more made the viscosity of the mixture decreased, it could be caused of excess FCO-SRW. The optimum

composition makes the mixture can be reacted completely, and the reaction of saponification is also completed. It was reported the viscosity of the mixture was up three times larger than that of pure liquids, with the maximum viscosity corresponding to either a 50 %-50 % (type 1 mixture), or a 25 %-75 % composition (type 2 mixture), to better emulate the behavior of real mixtures [9]. However, in this case, it must be found a certain composition to make a good formula of liquid hand soap.
The next investigated step was to vary the amount of electrolyzed oxydized water (EOW), to substitute the citric acid, at 25 ml FCO-SRW (Table 4). The viscosity of liquid soap was fluctuated, at 100 ml EOW the viscosity of liquid soap was maximum, but at 20 ml was minimum (164.82 centipoises). It need to be studied further about this cause. The density was vary 1.1246 to 1.1620 g/ml. The pH of liquid soap for 100 ml EOW was 6.5.

Table 4. Fresh coconut oil, the effect of electrolyzed oxydized water (EOW, pH 2.5) on viscosity, density, and pH of liquid hand soap (distilled water 500 ml, FCO-SRW = 25 ml)

EOW, ml	Viscosity, centipoises	Density, g/ml	pH
10	574.08	1.1620	7.0
20	164.82	1.1271	7.0
30	742.18	1.1533	7.0
40	761.33	1.1270	7.0
50	1157.43	1.1246	7.0
100	1404.26	1.1256	6.5

The FCO after 6 months of storage was also evaluated to produce liquid hand soap (Table 5). For the certain FCO-SRW 30 ml, the EOW was varied 10-100 ml, so it can influences the pH of liquid soap, as shown in Table 5. At the EOW 10 to 50 ml, the viscosity was above 1000 centipoises, but at 60 to 100 ml was fluctuated. The pH of liquid soap decreased for EOW 70 ml to 100 ml, the soap was acid (pH = 6.5), because the excess of EOW. The mixture of acid and alkali could be neutral, acid or base, depends on the amount of each compound. The Kay's mixing rule is a quick method for estimating these physical properties, since it takes into account just the system composition and the physical properties of the pure compounds [10].

Table 5. Effect of electrolyzed oxydized water (EOW, pH 2.5) on viscosity, density, and pH of liquid hand soap (distilled water 500 ml, FCO-SRW (after 6 months storage) = 30 ml)

EOW, ml	Viscosity, centipoises	Density, g/ml	pH
10	1668.27	1.1067	7.0
20	2335.46	1.1030	7.0
30	1321.98	1.0147	7.0
40	1656.63	1.0977	7.0
50	1682.23	1.0049	7.0
60	454.63	1.0873	7.0
70	386.06	1.0947	6.5
80	631.57	1.1023	6.5
90	1441.10	1.1107	6.5
100	78.32	1.0947	6.5

4. Conclusion

The utilization of reaction product of fresh coconut oil (FCO) and strong reduced water (SRW) can improve the viscosity of liquid hand soap. The FCO after six months storage can be applied to make the same quality of liquid hand soap. The better composition of FCO-SRW yielding good viscosity of liquid soap was 30 to 50 ml, and electrolyzed oxidized water (EOW) 30-50 ml based on 500 ml distilled water production. The viscosities of this product were 982.55 to 1,782.25 centipoises, density of 1.0049-1.1175 g/ml, and pH 7. The using of reaction product of fresh coconut oil (FCO) and strong reduced water (SRW) can increase the viscosity of liquid hand soap.

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