Utilization of natural surfactants from saponin compound of coconut leaf waste (Cocos Nucifera L.) as an environmentally friendly liquids detergent

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Abstract. The purpose of this study was to find out the results of the effectiveness of detergent detergency against stains on white cloth based on organoleptic tests and to determine the results of measurement tests for pollution levels with parameters of COD (Chemical Oxygen Demand), DO (Dissolve Oxygen) and pH levels in each treatment. This research is an experimental study with a Completely Randomized Design (CRD) or Randomized Complete Block Design method, which takes 5 treatments, namely two types of control groups including negative control (K-) by adding distilled water and positive control (K +) by adding detergent contained on the market, and there are 3 treatment groups, namely P1, P2 and P3, respectively with concentrations of 2.5%, 5% and 10% respectively. The instrument used for the extraction process is the Rotary Vacuum Evaporator and the instrument used for testing pollution levels is a set of titration tools with iodometric titration methods. The results obtained showed that the second treatment (P2) was the best treatment with an average detergency power of 3.10 or with faded parameters evenly with the edges of the stain that faded and had a minimum pollution level i.e. COD value 7.9 mg / L, DO value was 9.2 mg / L and pH level of 5.02, so that it qualifies as a low-contaminant liquid detergent that does not damage the environment.

1. Introduction
Detergent is one of the cleaning products that are widely used by Indonesian people. The need for detergent in 2010 in Indonesia, reaches an amount of 449,100 tons and will continue to increase in quantity every year, as the Indonesian population increases. But the majority of people do not have the capability in managing detergent laundry results so that it will affect the quality of domestic wastewater produced [1]. This was related to the chemical composition of synthetic detergents which could be grouped into 3 main groups, which were synthetic surfactants (20-30%), reinforcing materials or builders (70–80%) and other ingredients in the form of bleach, fragrance or foam builder (20–80%). These materials will cause negative impacts on the environment, because it is difficult to be broken down by microorganisms and cause an imbalance of aquatic ecosystems [2]. Therefore, it is necessary to have the right solution based on innovation works to create environmental sustainability by formulating natural detergents from natural ingredients [3].
Indonesia is a country that has a variety of local wisdom that grows and develops in various regions. The use of coconut leaf is inseparable from the various activities of the local wisdom. The consumption of coconut leaf in Bali is very high, on a typical day, the mass of waste produced can reach 625-800 tons and will increase 65% if it coincides with the holiday. But, so far, coconut leaf waste has been underutilized, even though according to the identification of preliminary saponins, coconut leaf waste is saponin which has surface active agent or surfactant properties. Biosurfactants are produced from various types of microorganism and plants [4,5]. Like other surfactants biosurfactants consist of both hydrophobic and hydrophilic functional groups. Biosurfactants have many advantages over commonly used commercial surfactants such as surface tension reduction, higher biodegradability, lower toxicity, preferable environmental compatibility, high selectivity and specific activity at extreme salinity, temperatures and pH [6]. The surface active agent of this saponin compound has a hydrophilic and hydrophobic group, so it can form foam in water, remove dirt and can reduce water stress. Therefore, saponins in coconut leaf waste are potentially used as alternatives to synthetic detergent [7]. In addition to these scientific studies, it is necessary to measure pollution levels with DO (Dissolve Oxygen) 4 parameters, COD (Chemical Oxygen Demand), and pH which are the parameters of the feasibility test of a wastewater [8].

According to the problems and potential described above, the authors want to explore the benefits of coconut leaf waste as a liquid detergent which is expected to produce minimal contamination, so that it will reduce the level of water pollution that occurs in the world especially in Indonesia. This innovation is also a form of support for the implementation of the 6th SDGS, namely ensuring the availability of clean water and sustainable sanitation for everyone.

2. Methods
This research was a real experimental research (true experiment). The study design used was a Completely Randomized Design (RAL) or Randomized Complete Block Design that aims to determine the effectiveness of detergent liquid detergency from coconut leaf waste and find out the results of measuring contamination produced after the washing process, with the calculation parameters of DO, COD, and pH. This study took 5 treatments, including negative and positive control group, treatment 1, 2 and 3. Negative control (K-) by adding glycerine and positive control (K+) with detergents on the market, namely Brand X. Treatment 1 (P1) given a concentration of 2.5%, treatment 2 (P2) was given a concentration of 5% and treatment 3 (P3) was given a concentration of 10%. Calculation of concentration was in appendix 2.

2.1. Coconut leaf waste extraction method
Coconut leaf waste that has been stored in a sterile state and then cut roughly, then the pieces were mashed using a blender to get 440 grams of coconut leaf waste. The blended waste then placed on a glass jar, then given ethanol 96% as much as 2 litters periodically to do the maceration process. Maceration was carried out for 2 x 24 hours, then ethanol was filtered using a filter and the filtrate was collected in a bottle. Each extract was then evaporated using a rotary vacuum evaporator.

2.2. The effectiveness of detergency of coconut leaf liquid detergent on stains on white fabric based on organoleptic test
Organoleptic test is a test based on the sensing process. Sensing is interpreted as a physio-psychological process, an awareness or introduction of sensory devices on the properties of objects because of the stimuli received by sensory devices that come from these objects. Organoleptic tests were carried out on 30 respondents by asking the respondents to give an assessment regarding the cloth that had been washed with detergent in each treatment, giving the following scores:

- Score 1 = Slightly faded but stains are still clear
- Score 2 = Slightly faded, the edges of the stain fade slightly
2.3. Analysis of tests for contamination in waste water for each treatment

2.3.1. Analysis of DO (Dissolve Oxygen) Test. Pipette 5 mL of the sample into the Erlenmeyer solution with flat cover, add 1 mL of MnSO4 and 1 mL of alkaline azide solution, cover the sample and shake it, leave it to form a half-part precipitate. Add 1 mL of concentrated H2SO4 through the bottle wall, then cover again and shake until the precipitate dissolves. Put it in the Erlenmeyer which contains a clear solution and stir until homogeneous. The solution was titrated with Sodium Thiosulfate 0.0241 N until light yellow, 2 mL of the starch indicator was added until it turns blue, then continue the titration until the blue colour disappears. Do the same thing with the form [9]. The formula for calculating BOD for washing waste as follows:

$$\text{BOD} = \frac{V_{\text{Thiosulfate}} \times N_{\text{Thiosulfate}} \times 8000 \times \text{Dilution}}{V_{\text{Sample}}}$$

2.3.2. Analysis of Test for COD (Chemical Oxygen Demand). Pipette 5 mL of the sample solution, then put in a 250 mL Erlenmeyer tube. After that, 1 gram of Hg2SO4 was added, 1 mL of K2Cr2O7 0.25 N, 3 mL of reagent containing a mixture of Ag2SO4 and H2SO4. Then close the mouth of the COD tube, shaken until homogeneous. The next step, the COD tube and its contents were inserted into the COD reactor at a temperature of 148° C. Then left for 2 hours. After 2 hours the sample was heated, the COD reactor was turned off, then the COD tube was poured into Erlenmeyer and ferroin indicator was added and titrated with Ferro Ammonium Sulfate (FAS) 0.0833 N. Furthermore, the COD content of detergent waste from each treatment will be calculated. The formula for calculating COD in the washing wastes of each treatment was as follows (note: A: mL form titrant, B: mL sample titrant, N: FAS Normality (0.0833):

$$\text{COD} = \frac{(A - B) \times N_{\text{FAS}} \times 8000}{\text{Sample Volume}}$$

2.4. Testing of pH of waste for each treatment

The pH meter was first calibrated using a standard neutral buffer solution (pH 7.01) and an acidic pH solution (pH 4.01) until the instrument shows the value of pH. Then the electrode was washed with distilled water, then dried with a tissue. Each sample was melted in a beaker with 100 mL of distilled water over a water heater. After the sample getting cold, the electrode was dipped in the solution. Left tool shows the specified pH value. The number shown by the pH meter was the pH of each treatment.

3. Results

3.1. Effectiveness of detergency power of each treatment based on organoleptic test

After going through the stages of the process of making liquid detergent from coconut leaf waste extract, the results were in the form of liquid coconut leaf waste detergent. Then washing with five treatments using a white cloth containing mud stains. So, five laundry wastewaters were obtained which was ready to be further tested by the Chemical Oxygen Demand and Dissolved Oxygen testing.

Each cloth that has been filled with mud stains and has been washed with detergent for each treatment, then it was basted for effectiveness of detergent power using an organoleptic test method. This organoleptic test was a test based on the sensing process. In the detergency power effectiveness test, each of these
treatments was specifically sensory vision to determine the differences in each treatment. 30 respondents will assess the fabric of the laundry with a score that has been determined previously in the research methodology. The results of detergent detergency effectiveness of each treatment based on organoleptic tests on 30 respondents can be seen in Table 1 below.

Table 1. Organoleptic test results on detergent power of detergents in each treatment.

| Type of Stain | Treatment | Respondent’s respond towards parameter | Total Score | Mean |
|--------------|-----------|----------------------------------------|-------------|------|
|              |           | 1  | 2  | 3  | 4  | 5  |              |              |
| Mud stain    | P1        | 9  | 13 | 5  | 3  | 0  | 62           | 2.06         |
|              | P2        | 2  | 9  | 8  | 6  | 5  | 93           | 3.10         |
|              | P3        | 5  | 11 | 13 | 1  | 0  | 70           | 2.33         |
|              | K+        | 5  | 9  | 9  | 6  | 1  | 79           | 2.63         |
|              | K-        | 14 | 7  | 5  | 4  | 0  | 59           | 1.97         |

Based on data 2, it can be concluded that P2 with a concentration of extract of coconut leaf waste of 5% was a detergent with the most optimum detergency power effectiveness value. If the detergent exceeds the P2 concentration, the effectiveness of detergency power will be reduced as well as P3 or the addition of 10% concentration of coconut leaf waste. This may be due to the concentration exceeding the threshold or saturation, causing stains or dirt not to disappear and the effectiveness of the deviation energy was not optimum.

3.2. Results of measuring the pollution levels of waste water for each treatment

Measuring the level of pollution of the waste produced by each laundry were based on 3 types of parameters, namely DO (Dissolve Oxygen) or dissolved oxygen, COD (Chemical Oxygen Demand) or oxygen requirements for chemical processes and pH values or acidity levels. The five treatments were P1, P2, P3. K+, K- each was analysed for its pollution level based on predetermined parameters. The results of measuring the pollution levels of each treatment are discussed in Table 2 as follows:

Table 2. Results of measuring the pollution levels of waste water for each treatment.

| Parameter | Treatment | DO (mg/L) | COD (mg/L) | pH |
|-----------|-----------|-----------|------------|----|
| DO        | P1        | 6.9       | 11.9       | 5.29 |
|           | P2        | 9.2       | 7.9        | 5.02 |
|           | P3        | 3.4       | 25.3       | 5.00 |
|           | K+        | 5.9       | 37.9       | 9.86 |
|           | K-        | 4.2       | 27.3       | 8.01 |

| Level of Domestic Waste Standard | ≥ 6 mg/L | < 100 mg/L | 5-7 |
|---------------------------------|----------|------------|-----|
4. Discussion
It was already known that detergent form coconut leaf waste was very effective to be used as a substitute for synthetic detergents that can cause various negative effect. This was related to the presence of secondary metabolites in the form of saponins found in the coconut leaf waste.

The saponin compound of coconut leaf which has been formulated as liquid coconut leaf waste detergent, if used in washing will experience hydrolysis events into aglycone in the form of steroids or triterpenoids and glucose (Figure 1). The hydrolysis reaction of saponin compounds in their function as dirt lifters was as follows:

![Figure 1. Hydrolysis of coconut leaf waste saponin compounds in water.](image)

The resulting aglycone in the form of steroids or triterpenoids will have a -COOH group that was hydrophobic, while the glucose produced will be hydrophilic. These two properties will affect the substrate or dirt found on the fabric during the washing process. Saponins with their surface active agent properties can affect fat-soluble substances in digestion including, formation of mixed micelles containing bile salts, diglycerides, fatty acids, and fat-soluble vitamins and capable of forming complexes with metals such as Fe, Mg, Zn and Ca [10].

Surface active agent or surfactant was a material that must be present in shampoo preparations because it serves to bind or lift dirt on a surface by lowering the interface voltage. Surfactants have properties that can reduce interface voltage, surface tension increases the stability of dispersed particles. Natural surfactants such as saponins, have a fairly high foam stability [11]. Therefore, it can be concluded that saponins can be used as a substitute for synthetic surfactants, in order to improve environmental sustainability and balance of environmental ecosystems.

5. Conclusion
The conclusions in this study are:

- Based on the effectiveness of detergency power based on organoleptic tests, the second treatment (P2) was the best treatment with the largest average value of 3.10 or faded evenly with the edges of the stain that fades. Thus, it can be concluded that P2 with a 5% concentration of coconut leaf extract was a detergent with the most optimum detergency power effectiveness value.
- The results of measurements of pollution levels of washed wastewater were found that P2 or the second treatment has a minimum pollution level. The DO value is 9.2 mg / L, the COD value was 7.9 mg / L and with a pH value of 5.02.
References

[1] Muhajir M S 2013 Penurunan Limbah Cair Bod dan Cod pada Industri Tahu Menggunakan Tanaman Cattail (Typha Angustifolia) dengan Sistem Constructed Wetland (Semarang: Universitas Negeri Semarang)

[2] Sopiah R N 2004 Pengelolaan Limbah Detergen Sebagai Upaya Minimalisasi Polutan di Badan Air dalam Rangka Pembangunan Berkelanjutan (Serpong: Balai Teknologi Lingkungan - BPP. Teknologi)

[3] Kriswiyanti E 2012 Keanekaragaman Karakter Tanaman Kelapa (Cocos Nucifera L.) yang Digunakan Sebagai Bahan Upacara Padudusan Agung Jurnal Biologi XVII (1) 15–19

[4] Kumar D, Neo K E and Rub M A 2016 Effect of alkanediyl-a, stypecationic dimeric (Gemini) surfactants on the reaction rate of ninhydrin with [Cu (II)-Gly-Tyr] + Complex J Surfactants Deterg 19 (1) 101–1092

[5] Kumar D, Neo K E and Rub M A 2016 Dipeptide Glycyl-Glycine (Gly-Gly)--Ninhydrin reaction: effect of alkanediyl-a, x-bis (dimethylcetylammonium bromide) (16-s-16, s = 4, 5, 6) Gemini surfactants on the reaction rate Tenside Surfactants Deterg 53 (2) 168–175

[6] Mulligan C N, Yong R N and Gibbs B F 2001 Surfactant-enhanced remediation of contaminated soil: a review Eng. Geol. 60 371–380

[7] Santoso S 2014 Limbah Cair Domestik: Permasalahan dan Dampaknya Terhadap Lingkungan (Purwokerto)

[8] Setyana D et al. 2014 “Bio-Nano Surf” Aplikasi Detergen Berbasis Nanoteknologi dari Ekstrak Getah Biduri (Calotropis Gigantea) Sebagai Alternatif Detergen Ramah Lingkungan (Malang)

[9] Dwinanto A 2009 Analisis faktor aksesibilitas dan efek noise jalan tol pada nilai tanah: Studi di sekitar pintu tol Jati Asih Jalan Tol Jakarta Outer Ring Road Ruas Cikunir-Hankam tahun 2005-2009 (Doctoral dissertation, Universitas Gadjah Mada)

[10] Sukmasari M and Fatimah T 2006 Analisis Kadar Saponin dalam Daun Kumis Kucing Dengan Menggunakan Metode Tlc-Scanner Temu Teknis Nasional Tenaga Fungsional Pertanian 2006 (Bogor: Balai Penelitian Tanaman Obat dan Aromatik.

[11] Suharto and Pratama M A et al. 2012 Isolasi dan Identifikasi Senyawa Saponin dari Ekstrak Metanol Batang Pisang Ambon (Musa Paradisiaca Var. Sapientum L.) (Manado)