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Effect of Varied Degumming Concentrations on Soap from Used Cooking Oil

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Abstract

Reused cooking oil is an edible oil formerly used for frying but no longer suitable for consumption. Used cooking oil can pose a threat to the environment if not handled properly. This research aimed to produce a bar soap from treated used cooking oil using cold process while investigating the physicochemical properties of the bar soap by varying the concentration of sulfuric acid during the degumming process. For that purpose, used cooking oil around Taman Permai was collected and treated via degumming at 90°C at 3000 rpm using three different concentrations of sulfuric acid, which is 0.2%, 0.4%, and 0.6% v/w. The treated oil was then used as a primary material in soap making by mixing it with sodium hydroxide and distilled water using cold process. It was found that the pH level and the texture of the soap made from treated used cooking oils are similar to new cooking oil. However, the result shows that all the soap achieves similar cleaning ability. It can be concluded that the oil refinery process helps improve the physical appearance of the oil and soap but no significant differences in cleaning power. As for the samples, sample C_{T3} has the softest texture and is aesthetically better than the other two treated soaps while having similar cleaning power.

1. Introduction

Used cooking oil (UCO) is a type of household waste that is often produced during the frying and cooking process [1]. It is typically derived from plant sources. Animal fat and animal products can also be made into cooking oils such as butter, lard and tallow. Used cooking oil is an edible oil that was once used for frying but is no longer suitable for such application [2]. Despite the fact that many doctors have warned about the negative consequences of WCO, it has been discovered that its use is rising, mostly as a result of the unstable price of imported cooking oil [3]. When used cooking oil is dumped into the ocean, it can also kill and harm aquatic life in the marine environment . By using the used cooking oil to create a soap, this can help reduce pollution and be used to clean ourselves rather than just washed down the drain [4,5].

Soap is a cleaning and emulsifying agent that is often created by the reaction of an alkali with fat or fatty acids, and it primarily consists of sodium or potassium salts of those acids. The main purpose of soap is to clean by removing impurities from surfaces, objects, and the skin, including dirt, oil, bacteria, and other contaminants. When body's natural oils and sweat combine, they can cause bacteria to grow on the skin. By removing this greasy layer, bar soaps allow the removal of bacteria from the skin [5]. Soaps and detergents break the lipid bilayer membrane encasing microorganisms, leave them inactive, and destroy viruses and bacteria. They also catch dirt and send it away with water [6]. Soaps are often manufactured from a combination of fats or oils and an alkali, such as NaOH or KOH through a process known as saponification. The alkali and fats or oils react

during saponification to produce soap molecules and glycerin. By combining the fatty acids produced by the breakdown of the fats or oils with the alkali, soap is created.

This research aimed to produce a bar soap from treated UCO using cold process while investigating the physicochemical properties of the bar soap by varying the concentration of sulfuric acid (H_2SO_4) during the degumming process. The degumming process used acid degumming which utilize the use of H_2SO_4. The H_2SO_4 will be ranging from 0.2% v/w to 0.6% v/w with 3 samples along with 2 other samples using new cooking oil and used cooking oil. After the degumming process, all the oil samples went through saponification process and turned into a bar soap using cold process for a better aesthetic.

2. Material and Methods

The chemical substances that are used in this experiment are used cooking oil (UCO), new cooking oil, sulfuric acid (H_2SO_4) and sodium hydroxide (NaOH). These substances will play a huge role in completing the degumming and soap-making process. The used cooking oil was collected from households at Taman Permai, Parit Raja while the sulfuric acid and sodium hydroxide were collected at UTHM Biodiesel Plant. In the degumming experimental, we will be testing with one vary parameter which is the concentration of sulfuric acid. In the product analysis, there are two test that was held which are the Fourier Transform Infrared (FTIR) and pH test. For oil analysis, the oil gone through moisture content and density while for the soap analysis, the soap will go through foam stability, foam loss and cleaning power test. The soap sample composition can be referred to in Table 1.

Table 1 *Soap sample composition*

Sample Name	Type of Oil	Degumming	H_2SO_4	
			Percentage (% w/w)	Weight (g)
CT1	Treated	Yes	0.2	1
CT2	Treated	Yes	0.4	2
CT3	Treated	Yes	0.6	3
CU1	Untreated	No	0	0
CN1	New	No	0	0

2.1 Preparation of Oil Refining

Firstly, this process was setup by cleaning the apparatus. Then, three beakers were filled with 500 g of UCO and was heated to 90°C. Next, 1 g, 2 g and 3 g of sulfuric acid were measured and placed it into different beakers. The beakers were left for heating for 2 hours. After 2 hours, the temperature of the UCO was reduced to 60°C and added 25 ml of distilled water and were left again for 15 minutes. Then, four 50 ml worth of the UCO were poured into centrifuge tubes and placed it in the centrifuge. The centrifuge was set to 3000 rpm for 15 minutes. After 15 minutes, the treated cooking oil was taken out of the centrifuge and placed in the beaker without the contaminants. The process was repeated for all samples. Since the centrifuge can only handle four 50 ml centrifuge tubes at a time, the samples cannot all go into the centrifuge at the same time.

2.2 Preparation of Soap

There are several steps taken to produce a soap from treated UCO. First, make sure that the apparatus is clean and in good condition. Next, 200 g of UCO was weighed and placed in a beaker. Then, 60 g of water was weighed and placed in another beaker. Then, 30 g of NaOH was weighed and placed in the beaker along with the water. The NaOH-water mixture was stirred consistently until the mixture became warm and turned clear. After it was warm, the mixture was poured into the UCO beaker and stirred consistently. After 5 minutes, the mixture was poured into the mold for cooling. The steps were repeated with all 3 treated oils, 1 unfiltered UCO and 1 new cooking oil. After 24 hours, the mixture had become solidified but still could not be used. The mixture was left to cure on its own for three weeks just in time for the NaOH to dissolve entirely. After 3 weeks, the solidified mixture, now a soap, can be used.

2.3 Oil Properties Determination

The samples were collected and ran a few oils analysis to compare the physicochemical of the oil. These samples were tested to find their moisture content, density, pH and will be examined using Fourier Transform Infrared Spectroscopy (FTIR).

2.3.1 Fourier Transform Infrared (FTIR)

FTIR spectroscopy reveals details on the functional groups and chemical bonds present in a material by analyzing the infrared radiation absorption. For the oil analysis, three drops of the sample were placed on the FTIR sample compartment. The machine will scan the sample before showing the wavenumber to transmittance graph. For the soap samples, the soaps were shaven and placed on the sample compartment and pressed using the auto sampler presser before scanning. The machine will provide the wavenumber to transmittance graph after a few minutes. The wavenumber ranges from 600 to 4000 cm^{-1}. The model of the FTIR used was Perkin Elmer Spectrum 100.

2.3.2 Moisture Content

The drying oven method was used to determine the oil's moisture content. The sample's weight loss at its final stage of drying is an indication for determining the moisture content. Next, an oil sample weighing roughly 10 g was placed inside a beaker. The oil sample was then heated for an hour at 103°C. After that, the beaker is weighed, and the heating procedure is repeated. This procedure was repeated until it reached constant weight. The moisture content % was calculated using equation 1.

$$\frac{(w - w_1)}{w} \times 100 \quad (1)$$

Where w is the initial weight of the oil sample in gram and w_1 is the final weight after drying in gram.

2.3.3 Density

One milliliter of the oil sample was extracted using a micropipette, put in a dry conical flask, and weighed using an analytical balance. The density of the oil sample was then calculated using equation 2.

$$p = \frac{(m - m_0)}{V} \quad (2)$$

where M is the mass of the oil sample in grams, V is the oil sample's volume in milliliters, and r is the oil sample's density in grams per milliliter.

2.4 Soap Properties Determination

For the soap analysis, there are four analysis that were done to find the physicochemical properties of the soap. The four analyses are FTIR, hardness test, pH test, foaming level and stability.

2.4.1 pH Test

The soap samples were wetted with distilled water. The pH strip is then placed on the wet side of the soap and wait for the pH strip to change colours. The colours are then compared with the colour chart that came along with the pH strip. According to ASTM (2002), the pH range of an acceptable soap is pH 9–11.

2.4.2 Foam Stability and Loss

1 g of soap and 10 ml of distilled water were placed in a test tube, which was shaken continuously for two minutes. A ruler is used to measure the initial foam height—the height of foam that has formed. After 10 minutes, the foam's final height is measured once more. Foam stability and level equation are calculated using equation 3 and 4 respectively.

$$\text{Foam Stability} = 100\% - \%\ \text{Foam Loss} \quad (3)$$

$$\%\ Foam\ Loss = \frac{h - h_1}{h} \times 100 \quad (4)$$

Where h is the initial foam height and h_1 is the final foam height after 10 minutes.

2.5 Soap Performance Determination

5 g of soap are cut into small pieces and diluted with 200 g of distilled water. A small piece of cloth was stained with some chilli sauce and left to dry. The clothes were then soaked inside a container filled with diluted soap of samples and left for cleaning. After 2 hours, the clothes are taken out and dry before compared to the stained clothes.

3. Results and Discussion

3.1 Oil Analysis

For the moisture content, C_{U1} (0.049 %) has a higher moisture content compared to C_{N1} (0.069%). However, for sample C_{T1}, C_{T2} and C_{T3}, the moisture content for these three are higher compared to C_{N1} where C_{T3} have 28 the highest value of moisture content with 0.256 % followed by C_{T2} (0.239 %) and C_{T3} (0.234 %).

Both new and used cooking oils normally have a pH of between 6 and 7, which puts them in the neutral to slightly acidic range. Within their typical pH range, both new and old oils are typically regarded as safe for consumption. All the oil samples have the same pH of 6 except for C_{U1}. C_{U1} has the pH value of 5 which is lower than all the other samples.

Used cooking oil often has slightly lower density than fresh cooking oil. C_{N1} has a higher density compared to C_{U1}. C_{N1} recorded a density of 896.8 g/m^3 while C_{U1} recorded a density of 884.8 g/m^3. For sample C_{T1}, C_{T2} and C_{T3}, these samples recorded a density of 900.5 g/m^3, 908.6 g/m^3 and 909.2 g/m^3 respectively. Table 2 shows the oil analysis result for all the oil samples.

Table 2 *Oil analysis result*

Parameter	pH	Moisture Content (%)	Density (g/m^3)	Color
C_{N1}	**6**	**0.049**	**896.8**	**Pale Yellow**
C_{U1}	**5**	**0.069**	**884.8**	**Brown**
C_{T1}	**6**	**0.234**	**900.5**	**Gold**
C_{T2}	**6**	**0.239**	**908.6**	**Gold**
C_{T3}	**6**	**0.256**	**909.2**	**Gold**

Fourier Transform Infrared was used to find the chemical properties of the soap. From Figure 4.1, the FTIR result can be seen with five samples of oil. Each sample came with four peaks, but for every peak, the range between all the oil samples is similar. The first peak shows a presence of C-CH3 which ranges from 2652 to 2972 cm^{-1}. The peak also shows a presence of CH2 bending which ranges from 2916 to 2936 cm^{-1}. The second peak had a similar compound except for the CH2, which ranges from 2843 to 2863 cm^{-1}. Table 4.2 shows the FTIR characteristic IR band position for oil analysis. The third peak shows C=O presence in stretching vibrations ranging from 1700 to 1900 cm^{-1}. Finally, C-O-C can be detected around 1175 cm^{-1} at the fourth peak. Figure 1 shows the FTIR results for oil samples analysis.

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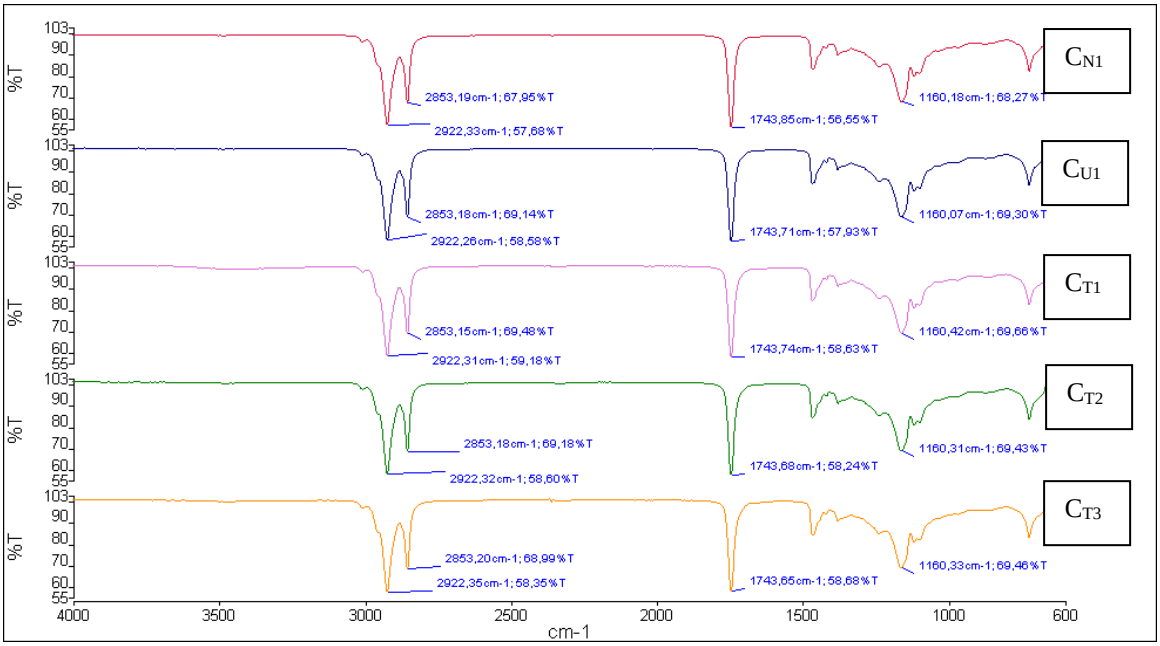

Fig. 1 *FTIR result for oil analysis*

3.2 Soap Analysis

For the soap analysis, different samples of soap are analyzed and compared in term of appearance, pH level, color, texture and the presence of lye pocket and gelling phase. The soap analysis' results are compiled and shown in Table 3.

Table 3 *Soap analysis result*

Parameter	Appearance	pH	Color	Texture	Cross Section	Lye Pocket	Gelling Phase
C_{N1}		10	Ivory	Soft		Yes	No
C_{U1}		11	Light Gold	Hard		Yes	No
C_{T1}		10	Gold	Soft		Yes	No

C_{T2}		10	Gold	Soft		Yes	No
C_{T2}		10	Gold	Soft		Yes	No

For the soap, the FTIR were run again to find the properties of the different samples of soap. Similar to the oil analysis, the soap also has 4 peaks but for all the soaps, the results were similar with every soap sample compared. The first peak, which spans 2652 to 2972 cm^{-1}, indicates the existence of C-CH3. Additionally, the peak exhibits CH2 bending, with a range of 2916 to 2936 cm^{-1}. Both second and third peak shows sign of CH2. However, these CH2 are in different form as CH2 in the second peak is in methylene stretching vibrations which ranges from 2916 to 2936 cm^{-1} and the CH2 in the third peak shows CH bending vibration which ranges from 1405 to 1465 cm^{-1}. Figure 2 shows the FTIR result for soap analysis for all 5 samples.

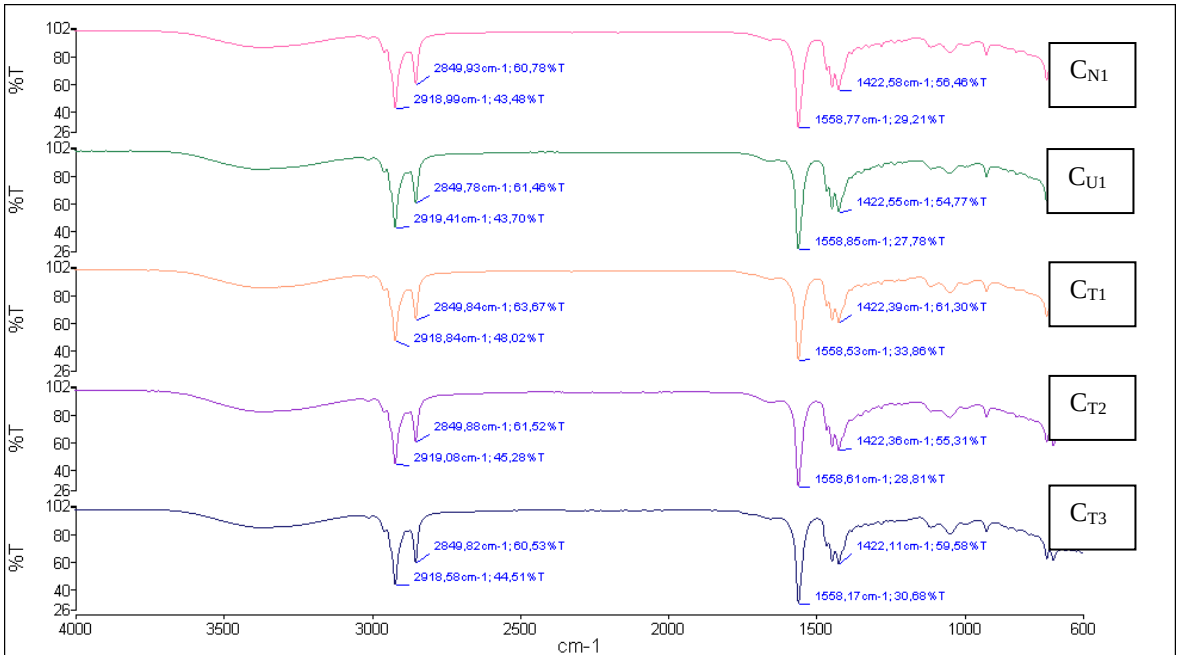

Fig. 2 *FTIR result for soap analysis*

For the foam stability, all the soaps have a higher rate of foam stability compared to the commercial soap. The commercial soap has a foam stability of 84% while other samples have it higher. Sample C_{T1} and sample C_{T3} have the highest foam stability compared to the others with 87.5%. followed by sample C_{N1}, C_{U1} and finally C_{T2}. Figure 3 shows a bar chart indicating the foam stability percentage.

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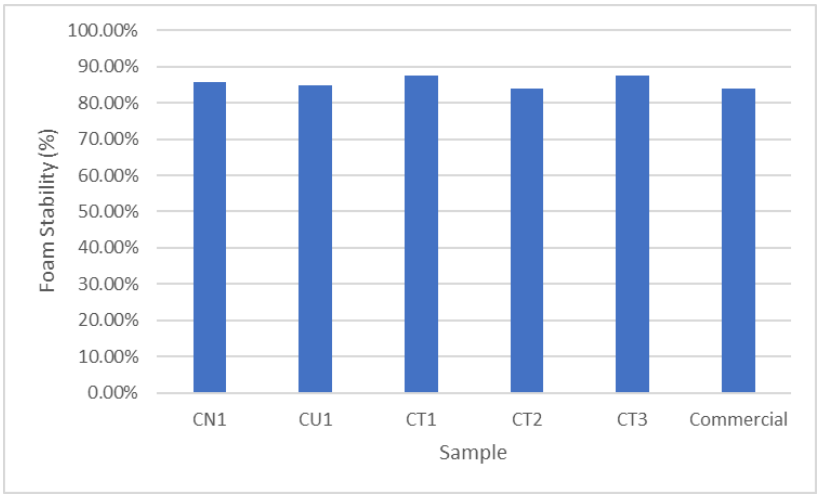


Fig. 3 *Foam stability result*

For foam loss, it is the opposite for the data in foam stability according to Eq. 3.2. The commercial soap has a foam stability of 16% while other samples have it lower except for C_{T2}. Sample C_{T2} are almost similar to the commercial soap in term of foam loss with 16.07% foam loss. Figure 4 shows the foam loss percentage for the soap samples.

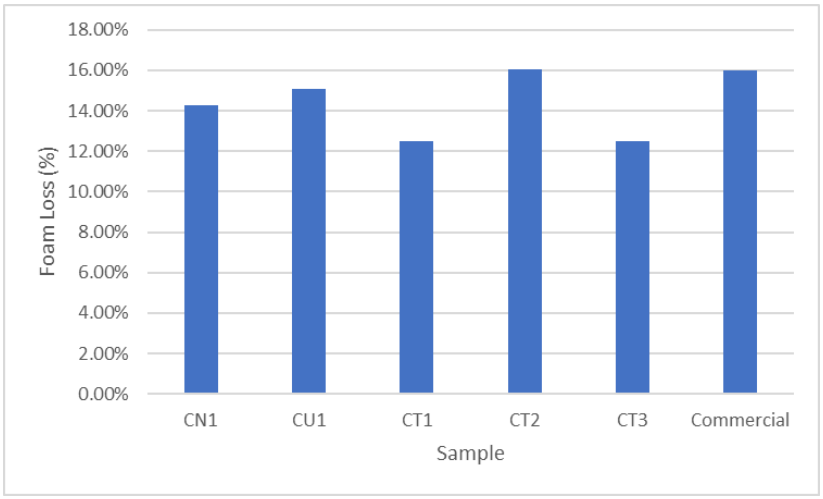
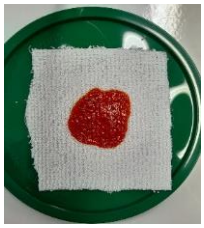
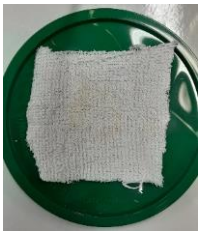
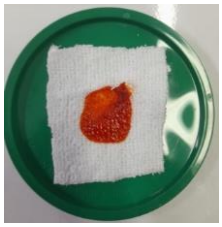
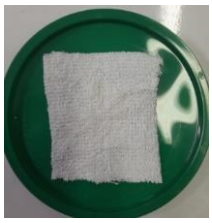
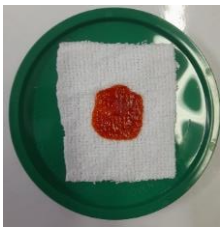
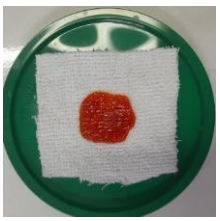


Fig. 4 *Foam loss result*

3.3 Soap Performance

For the soap performance, the experiment that are conducted is the cleansing power. The clothes were stained with chili sauce and left to dry. The clothes were then soaked inside a container filled with diluted soap of different samples and left for cleaning. After 2 hours, the clothes are taken out and dry before compared to the stained clothes. The results were somewhat similar for each sample. This can conclude that the degumming process of any concentration of H_2SO_4 has no effect on the cleaning power of the soap. Table 4 shows the soap performance analysis for all the soap samples.

Table 4 *Soap performance result*

Soap	Before	After	Description
C_{N1}			The stain was removed.
C_{U1}			The stain was removed.
C_{T1}			The stain was removed.
C_{T2}			The stain was removed.
C_{T3}			The stain was removed.
Commercial Soap			The stain was removed.

4. Conclusion

The first objective of this research is to produce bar soaps from treated cooking oil using cold process. From the methodology in chapter 3, the method used for making the soap are cold process and the soap samples were made from used cooking oil that has been through oil refinery process. This shows that the first objective is achieved, and soaps can be made from treated used cooking oil using cold process.

The second objective which is to investigate the physicochemical properties of the bar soap by varying Sulfuric Acid (H_2SO_4) concentration during acid degumming are also successful. The soap was made from treated used cooking oil that was degummed with different concentration of H_2SO_4 which is varied at 0.2%, 0.4% and 0.6% v/w. The physicochemical properties were found out using various tests such as moisture content, density,

pH value and using FTIR to find their chemical properties. The physical properties that were observed is the color and texture of the soap. The treated oils were compared amongst each other along with new cooking oil and used cooking oil as a reference.

Finally, the research is finished by completing the third objective which is to compare the efficiency of the product with a commercial soap in terms of cleaning power and foam stability. The cleaning power test was conducted, and it was found that the soap made from used cooking oil, new cooking oil, and treated cooking oil has similar cleaning power as a commercial one. In terms of foam stability, the treated cooking oil soaps have a higher foam stability % compared to commercial soaps except for C_{T1} which has slightly less foam stability compared to commercial soap.

In conclusion, the degumming process has no effect on the cleaning power of the soap. However, the sample C_{T1}, the sample of treated cooking oil with 0.6% v/w H_2SO_4 are the best compared to the other samples due to its high foam stability, soft texture and aesthetically better than the other samples while having the same cleaning power as the rest.

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