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# 5. The Analysis of Chemical Components of the Soap

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***Abstract:***

*Soaps are evaluated based on their physicochemical characteristics, which determine their overall quality. Knowledge of soaps' physicochemical properties allows us to evaluate their efficacy and qualities. It was determined the pH, free caustic alkali, total alkali, total fat material, and moisture content of nine commercially available soaps using established analytical procedures. The range of values was 9.64%-21.06% for the moisture content, 0.00%-6.20% for the total alkali, 0.00%-0.99% for the free caustic alkali, 68.33%-100% for the total fat material, 9.69-10.13 for the pH of a 5% solution, and 9.63-10.32 for a 10% solution.*

***Keywords:***

*Soap; Chemical Components; Soap Components, Physicochemical properties, Moisture content, pH, chemical analysis.*

## 5.1 Introduction:

Cleansing the body's natural oils or fats with sodium hydroxide or another powerful alkali, soap also contains fragrance and colorant for a pleasant bathing experience. It is without a doubt the case that soaps are crucial in the process of disinfecting and ridding the body of harmful germs and viruses. Soaps typically contain fats and oils with detergents to boost the soap's antibacterial activity. Between 65 and 85 % of bacteria on human skin can be eliminated with its use. There is a wide variety of bacteria found in a wide variety of environments, including faces, dirt, stagnant water, water, and the human body. The health consequences of bacterial infection are significant. The likelihood of contracting a skin infection is increased due to the accumulation of bacteria on the skin's surface, which is brought about by exposure to the environment. Bacteria like Pseudomonas aeruginosa and Staphylococcus aureus fall under this category. The spread of pathogens and viruses makes hand hygiene among medical professionals all the more crucial. Depending on the circumstances, it could be either pathogenic or opportunistic. Some soaps have been found to have antimicrobial agents that are more effective at killing bacteria and removing them from the body than regular soap.

There is a lot of consensus that good hand and body hygiene can help avoid infections. It is also crucial that people who work with food wash their hands often. They are the people who bring the meal to the customers [1-9].

## 5.2 History of Soap:

About 6,000 years ago, people first began making soap. Inscriptions for soap making were discovered on cylindrical objects in ancient Babylonian digs around 2800 B.C.E. Earlier than 1500 B.C.E., when records from ancient. Soap was made in ancient Egypt by combining animal and vegetable oils with alkaline salts. It is said that the Romans sacrificed animals on Mount Sapo, hence the name "soap." Rain washed the fatty remains of the sacrificed animals and the alkaline ash of the wooden pyres used in the rituals into the Tiber River, where it was used to clean garments. This method of production. For decades, colonial Americans gathered and rendered fat from animals, called tallow, then combined it with an alkali potash solution made from the resulting ash charcoal made from the hardwood ashes of their winter fires. Olive oil was also used in the production of castile soap in Europe. Soap has been readily available at most grocery stores since the middle of the nineteenth century, when the production method was first commercialized.

To this day, the majority of people who manufacture homemade soaps employ conventional techniques.

### 5.2.1 Method of Soap:

Alkali (sodium hydroxide) is used as the primary material in a cold saponification process, which was the method used to create soap.


**Figure 5.1: Flow diagram of the process of making bentonite bar soap**

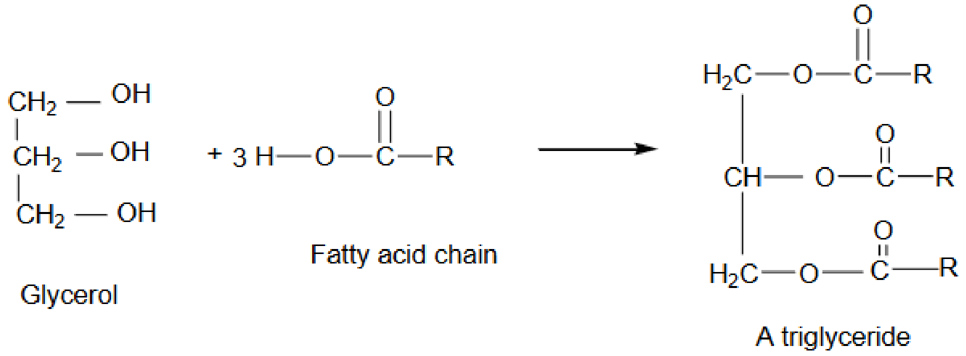
Figure 5.1 depicts the procedures followed throughout each preparation. After adding 35 g NaOH to 100 g of water and letting the mixture sit for 60 minutes to cool, the solution was analyzed (Moulay et al., 2011). Sodium hydroxide alkaline solution aliquots of 30 grams, along with 70 grams of coconut oil, were mixed thoroughly; the desired amount of bentonite (10, 12.5, 15, 17.5, or 20 grams) was then added. As long as there were still visible streaks of soap in the fluid, stirring was continued. Soap was made by pouring the mixture into a mold and letting it sit for 24 hours before proceeding to the next analytical step. [10]

### 5.2.2 The Chemistry of Soap:

To create soap, triglycerides (found in oils) are hydrolyzed in an alkaline solution, typically lye (sodium hydroxide). Trysters, triglycerides are made up of one molecule of glycerol and

3 molecules of long-chain aliphatic carboxylic acid (see Equation 5.1). Saponification refers to this step in the soap-making process. Most often, lye (sodium hydroxide) is used to hydrolyze animal fat or vegetable oil into carboxylate salts (formed when carboxylic acid chains react with the cations of the hydroxide compound) and glycerol. [11]

**Equation 5.1:**




**Equation 5.1: Reaction between glycerol and fatty acids to form a triglyceride**

### 5.2.3 Physicochemical Properties of the Soap:

Soap's physicochemical properties were examined using certain conventional methods. pH, total alkalinity, total fat, hardness, adhesion, and malondialdehyde were among the metrics tested (MDA).

When determining the pH of a solution, 2 g of soap powder was weighed and dissolved in 10 mL of distilled water. The pH levels were measured with a GRYF 259 meter in Havlickuv Brod, Czech Republic.

5 g samples were weighed precisely in dried moisture dishes using an analytical balance model ALS 250-4A, Kern, with a sensitivity of 0.1 mg, to determine the moisture content. The samples were dried in a 105°C oven for around 6 hours, or until a consistent mass was achieved.

The percentage of moisture was calculated using the following formula:

$$\% \text{ moisture} = (m\text{ (sample)} - m\text{ (dried sample)}) / (m\text{(sample)}) \times 100 \qquad (1)$$

Total alkalinity was evaluated by titrating the aqueous phase with a standard NaOH solution to neutralize the excess acid [20, 21]. For every 10 grams of soap, 100 millilitres of neutralized ethanol and 5 millilitres of 1 N H2SO4 (aq) solution were added. Soap sample was heated in the mixture until it completely dissolved, and then titration with 1 N NaOH was performed with the phenolphthalein indicator.

The total alkali was obtained with the formula:

% Total alkali = (V (Acid) − V (Base))/(m(sample)) × 3.1 (2)

We determined the total fat content by dissolving the sample in hot ethanol and then determining how much of the sample remained insoluble after being dissolved in alcohol [20]. The sample of soap, which weighed 10 g, was mixed with 150 mL of warm neutralized ethanol and heated. The filtered solution was then dried in an oven at 110 °C for one hour, after which it was weighed once more to account for any changes.

The total fat matter was obtained with the formula:

% Total fat matter = 100 − (moisture content + matter insoluble in alcohol)/1.085 (3)

## 5.2.4 Objectives:

- To study of chemical components of soap.
- To obtain the chemical components used in soap.
- Determine the chemical reaction of soap.
- Analysis of the physicochemical properties of soap.

## 5.3 Review of Literature:

Knowledge of soap dates back at least 2,300 years. According to Pliny the Elder, the Phoenicians made it circa 600 BCE out of goat's tallow and wood ashes and sometimes bartered it with the Gauls.

The Romans certainly knew how to use and make soap, but whether they picked up this skill from ancient Mediterranean peoples or the Celts, who lived in what is now known as Britannia, is unknown. Celtic soap was made from animal fats and plant ashes, and the word "soap" comes from the Celtic word "saipo."

Not until the 2nd century ce was the usefulness of soap for washing and cleaning acknowledged; the Greek physician Galen cites it as a medicinal and a means of cleansing the body. Once upon a time, soap was a curative. Soap is frequently mentioned as a cleaning agent in the works attributed to Jbir ibn Hayyn (Geber), an Arab intellectual of the eighth century. [12]

Filler concentrations of bentonite undergo the same chemical reaction as fats like coconut oil ($C_{33}H_{62}O_6$) and alkali like sodium hydroxide (NaOH), creating glycerol ($C_3H_8O_2$) and soap (Vidal et al., 2018). Soap has the chemical formula RCOONa, where R is a long-chain alkyl group of 12-18 carbon atoms.

Most natural herbal soaps have a variety of oils, including coconut oil, palm oil, olive oil, rice bran oil, and sunflower seed oil (Araseretnam and Venujah, 2019). Soap's properties, including its hardness, scent, cleansing power, foaming, and moisturizing properties, are all influenced by the ratio of saturated to unsaturated fatty acids in its composition.

The additives or fillers utilized also play a role in shaping the final soap's characteristics. Bentonite clay is a popular soap additive since it has long been utilized as part of a variety of different skin care and medicinal routines around the world.

Many natural herbal soaps combine oils from several different plants, including coconut, palm, olive, rice bran, and sunflower (Araseretnam and Venujah, 2019). Hardness, scent, cleansing power, foaming volume, and moisturizing capacity are all affected by the ratio of saturated to unsaturated fatty acids in the soap's base.

The additives or fillers utilized also play a role in shaping the final soap's characteristics. Bentonite clay is a popular soap additive since it has long been utilized as part of a variety of different skin care and medicinal routines around the world [13].

Betsy et al. (2013) are only one group of researchers that have studied the free alkali content of commercial soaps and found that all of the soaps they tested met or exceeded the limits set out by their respective countries.

Study results showed that the free alkali content of the soap decreased with increasing amounts of glycerin added by Widyasanti et al. (2018), who studied the addition of glycerin to solid soap formulae made with coconut oil as a raw material.

They reasoned that glycerin's ability to bind hydroxide ions in the soap's composition would lower the soap's free alkali content. It has been shown by Vidal et al. (2018) that excess fatty acids have a significant role in the overall sensory perception and quality of natural herbal soaps, and that this effect can be mitigated by adding excess oil or unsaponified oil to the cold saponification process. [14-15]

## 5.3.1 Research Methodology:

We relied on a wide variety of secondary materials, such as books, educational and development magazines, government papers, and print and online reference sites, to learn about the soap making process and its chemical components.

Soap's chemical characteristics will be studied as part of our research methods class. The soap's chemical composition will be compared to others.

Factors including pH, solvent composition (such as the elements/ions present in the solvent), and temperature all influence soap's efficacy. Some soaps have antimicrobial agents that kill or eliminate more bacteria than regular soap, according to studies and research.

## 5.3.2 Result and Discussion:

**A. The experimentally manufactured soaps** were analyzed by chemical parameters, including pH, dry matter, total alkali, total fat and malondialdehyde (MDA) content. Table 5.1 displays the data that was collected.

**Table 5.1: Chemical Components of obtained four samples of soap**

| Sample | pH | Dry Matter (%) | Total Alkali (%) | Total Fat (%) | MDA (pg/g) |
|---|---|---|---|---|---|
| Fresh olive oil | 9.61±0.01[c] | 92.31±1.33[c] | 0.06±0.00 | 91.53±0.93[c] | 1.94±0.00[a] |
| Fried olive oil | 9.96±0.03[b] | 97.55±0.10[b] | 0.03±0.00 | 96.24±0.19[b] | 2.33±0.01[b] |
| Fresh rapeseed-palm oil | 9.53±0.02[a] | 89.06±0.63[a] | 0.00±0.00 | 88.57±0.60[a] | 3.43±0.01[c] |
| Fried rapeseed-palm oil | 9.61±0.05[c] | 89.61±1.40[a] | 0.00±0.00 | 88.89±1.27[a] | 4.10±0.01[d] |
| Different lowercase letters ([a],[b],[c],[d]) indicate statistically significant differences (*p*<0.05) between rows. The results are presented as the mean values ± standard deviation; all analyses were done in triplicate. | | | | | |

All samples examined fell within a narrow pH range, from 9.53 to 9.96, indicating a high degree of consistency. There was a statistically significant ($p < 0.05$) contrast between the fresh oil and fried oil samples.

A range of 9.96 to 11.30 was reported in the testing of soaps manufactured from used cooking oils, which is close to the results of the other research.

Soaps with a high pH can disrupt the natural pH balance of the skin and its flora, which for human beings is between 5.4 and 5.9. Conversely, the majority of commercial soaps evaluated (pH range: 9-10) fell within that range. [16-17].

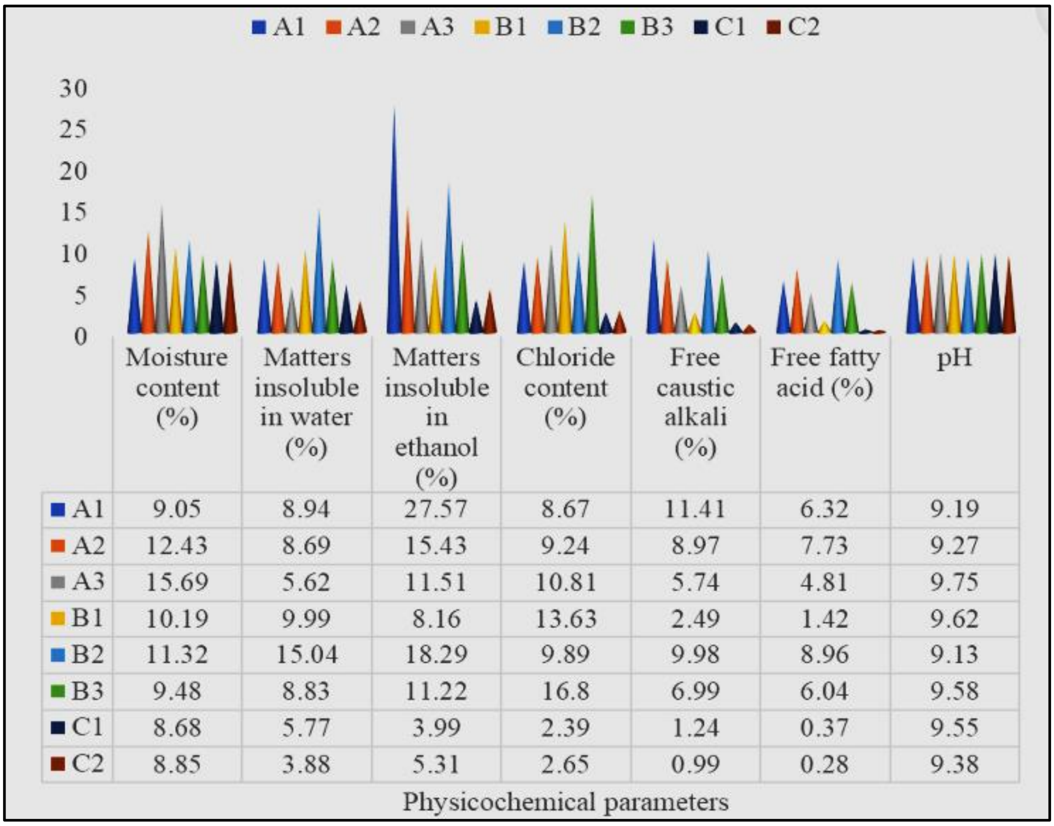
**B. Physicochemical properties of the soaps:**

Table 1 displays the percentage distribution of the three types of soaps in terms of their physicochemical attributes.

Triplicate measurements of the soaps' physicochemical qualities were taken. In most cases, the coefficient of variance for the repeat examination of the physicochemical parameters was less than 20%.

There were very slight differences in physicochemical characteristics between soaps of the same type.

**Table 5.2: Physicochemical Properties of the Soaps**




| | Moisture content (%) | Matters insoluble in water (%) | Matters insoluble in ethanol (%) | Chloride content (%) | Free caustic alkali (%) | Free fatty acid (%) | pH |
|---|---|---|---|---|---|---|---|
| A1 | 9.05 | 8.94 | 27.57 | 8.67 | 11.41 | 6.32 | 9.19 |
| A2 | 12.43 | 8.69 | 15.43 | 9.24 | 8.97 | 7.73 | 9.27 |
| A3 | 15.69 | 5.62 | 11.51 | 10.81 | 5.74 | 4.81 | 9.75 |
| B1 | 10.19 | 9.99 | 8.16 | 13.63 | 2.49 | 1.42 | 9.62 |
| B2 | 11.32 | 15.04 | 18.29 | 9.89 | 9.98 | 8.96 | 9.13 |
| B3 | 9.48 | 8.83 | 11.22 | 16.8 | 6.99 | 6.04 | 9.58 |
| C1 | 8.68 | 5.77 | 3.99 | 2.39 | 1.24 | 0.37 | 9.55 |
| C2 | 8.85 | 3.88 | 5.31 | 2.65 | 0.99 | 0.28 | 9.38 |

Table 5.2 shows that Physicochemical Properties of the Soaps. A1, A2, A3 = soaps made from cocoa pods. B1, B2, B3 = soaps made from palm bunches. C1 = Lux, C2 = JOY.

### C. Effect of Adding Bentonite on the Characteristics of the Soap Produced:

In order to be sold in Indonesia, bentonite soap must be up to the standards set forth in the Indonesian National Standard (SNI). In Table 3, we can see the soaps' free alkali content, moisture content, free fatty acid content, pH, foam stability, and hardness, among other properties.

**Table 5.3: Some characteristics of bentonite soaps**

| No. | Characteristics of soap | Content of Bentonite | | | | | SNI Standard | Unit |
|---|---|---|---|---|---|---|---|---|
| | | 10 | 12.5 | 15 | 17.5 | 20 | | |
| 1. | Free alkali Content | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | <0.10 | % |
| 2. | Moisture Content | 1.15 | 1.07 | 1.00 | 0.91 | 0.88 | <15.00 | % |
| 3. | Free fatty Acid Content | 0.28 | 0.44 | 0.68 | 0.70 | 0.72 | <15.00 | % |

| No. | Characteristics of soap | Content of Bentonite | | | | | SNI Standard | Unit |
|---|---|---|---|---|---|---|---|---|
| 4. | pH | 8.70 | 8.70 | 8.80 | 8.80 | 8.80 | 9-11 | - |
| 5. | Foam Stability | 71.00 | 72.00 | 77.00 | 81.00 | 80.00 | - | % |
| 6. | Hardness | 1.49 | 1.50 | 1.51 | 1.52 | 1.54 | - | $N/m^2$ |

According to Table 5.3, all five soaps easily pass the SNI tests for free alkali content, moisture content, and free fatty acid concentration. According to SNI standards, the soap has a pH of 8.7 to 8.8, making it a more neutral product. Soap with 17.5 g of bentonite created the most stable foam at 81%. As expected, the 10 g bentonite soap was the softest of the bunch, measuring in at only 1.49 N/m2, whereas the 20 g bentonite soap measured in at a more substantial 1.54 N/m2.

## 5.4 Conclusion:

SNI-compliant qualities were observed in soaps made with a bentonite filler of 10–20 g. The pH of the five tested soap recipes was between 8.7 and 8.8, indicating that the produced bar soaps are very mild and safe for human skin. Good stability was displayed by the foam despite a low moisture content and a lack of free fatty acids. The purpose of this research was to determine whether or not locally produced soaps in Nigeria met acceptable standards by comparing them to commercially produced soaps in terms of metal content, pH, free fatty acid content, moisture content, alkali content, matters insoluble in ethanol and water, and chloride content. While total bio accessibility is a nightmare situation, even at 50% systemic bioavailability the metal concentrations were deemed dangerous.

The physicochemical parameters and metal concentrations of the locally produced soaps were significantly greater than those of commercially produced soaps. The raw materials used in the local production of the indigenous soaps should be carefully chosen to decrease or eliminate the potential hazards users may be exposed to as a result of using the soaps, and to do the same for the potential risks of the domestic effluents on the ecosystem.

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