

VALIDATION OF OIL SOURCES USING GAS CHROMATOGRAPHY FLAME IONISATION DETECTION (GC-FID) FOR CLEANSING APPLICATIONS

Submitted in partial fulfilment of the requirement for the award of

Bachelor of Technology Degree in

Chemical Engineering

by

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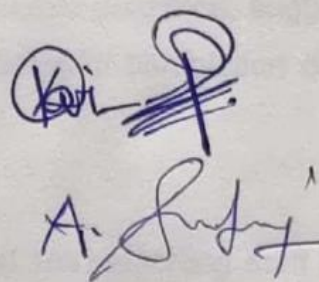
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DECLARATION

We Sakthivel A (39190028) and Kavi Amudhan V (39190011) hereby declare that the Project Report entitled **"VALIDATION OF OIL SOURCES USING GAS CHROMATOGRAPHY FLAME IONISATION DETECTION (GC-FID) FOR CLEANSING APPLICATIONS"** done by us under the guidance of **Dr.Dawn S.S M.Tech., Ph.D**, Satyabhama Institute of Science and Technology, Chennai is submitted in partial fulfilment of the requirements for the award of Bachelor of Technology degree in Chemical Engineering.

The image shows two handwritten signatures in blue ink. The top signature is more stylized and appears to be 'Kavi'. The bottom signature is more legible and appears to be 'A. Sakthivel'.

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ABSTRACT

Soaps have been used for centuries as cleaning agents, and the source of oils used to make soaps has a significant impact on the properties and applications of the resulting soap. Cleansing applications are varied including detergent soaps, toilet soaps, medicated soaps etc., Primarily detergent application was focussed. Waste cooking oil of different quality collected from local restaurants were analysed for its composition using GC-FID before being saponified. The results demonstrated that the method was reliable, accurate, and sensitive in detecting and quantifying the different fatty acids and triglycerides present in the oils. The findings suggested that the purity and composition of the oils could significantly affect their detergent properties including (moisture content, TFM, TAC, Glycerine, pH, insoluble matter, chloride content in soap and lathering power), with some oils performing better than others. The objective of the present study is to recover waste cooking oil and recycle it to develop a detergent soap that is eco-friendly generating lesser wash water during cloth rinsing giving more whitening without causing harm to the skin and cloth. Waste cooking oil soaps are thus proven to be sustainable alternatives to traditional soaps, as they utilize used cooking oils that would otherwise be discarded as waste. The work was extended to Self Help Group women who were trained to make detergent soaps from waste cooking oil. The waste to value added product translated to the SHG women for their livelihood enhancement.

Keywords: Waste cooking oil, Cleansing applications, GC-FID, Microenterprise, Eco-friendly soaps, Livelihood enhancement.

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LIST OF ABBREVIATIONS

GC-MS	Gas Chromatography-Mass Spectrometry
GC-IRMS	Gas Chromatography-Isotope Ratio Mass Spectrometry
GC-FID	Gas Chromatography-Flame Ionization Detection
TFM	Total Fatty Matter
TAC	Total Alkalinity Content
SHG	Self Help Groups
ASTM	American Society for Testing and Materials.
BIS	Bureau of Indian Standards

CHAPTER -1

INTRODUCTION

1.1 ORIGIN AND HISTORY OF SOAPS:

Soap has a long and interesting history, dating back to ancient civilizations. The earliest evidence of soap making comes from ancient Babylon, where a soap-like substance was made by mixing animal fats with wood ash[1]. The ancient Egyptians also made soap, using a mixture of vegetable oils and alkaline salts to create a cleansing agent. Soap making techniques spread throughout the ancient world, and by the time of the Roman Empire, soap was a widely used product. During the Middle Ages, soap making became an important industry in Europe, with soap makers forming guilds and developing new techniques. By the 18th century, soap production had become a large-scale industrial process, with the invention of the continuous soap making process and the introduction of synthetic detergents in the 20th century[2]. Soap making in China dates back to the Tang Dynasty (618-907 CE). The Chinese used vegetable oil, rice wine, and salt to make a type of soap for cleaning textiles. Soap making techniques continued to develop over time, with the use of natural ingredients such as sesame oil, camellia oil, and tea oil. During the Song Dynasty (960-1279 CE), soap making became a major industry, with soap factories established in many cities throughout China[3]. Soap was produced for both personal hygiene and cleaning and was exported to other countries such as Japan and Korea. In the Ming Dynasty (1368-1644 CE), soap making continued to develop, with the introduction of new ingredients such as honey, animal fat, and herbal extracts. Soap was used not only for personal hygiene and cleaning, but also for medicinal purposes. During the Qing Dynasty (1644-1912 CE), soap production continued to expand, with new techniques and ingredients being introduced. Soap was made from a variety of materials such as vegetable oil, animal fat, and mineral oil. The soap industry was concentrated in the cities of Shanghai, Tianjin, and Guangzhou. Since then, soap has evolved, gaining numerous types and different ingredients to make it acceptable in terms of appearance[2]. The modern skin cleansers contain skin-conditioning agents in addition to surfactants, making them more complicated than their name "soap" suggests.[4]. Over the past several thousand years, the practise of skin cleansing

has advanced for therapeutic, religious, and personal sanitation purposes[5]. The oldest evidence of soap production was discovered in Sumerian clay tablets from around 2000 B.C., soap was used to clean grease from cloth before dying and was created by boiling a combination of fat and wood ashes. According to the Eber's Papyrus, an Egyptian papyrus, the ancient Egyptians took regular baths and mixed animal oil and ashes as early as 1550 B.C. By 600 B.C., the Phoenicians were making soap from animal oil and tree ash. The Roman tale that referred to Mount Sapo, where animals were sacrificed, gave soap its name[5]. Animal fat and woody ashes that had formed soap along the hillside were washed away by the rain. The Roman ladies found that using this material made washing clothes easier. Pliny the Elder, a Roman scholar, wrote in his work "Naturalis historia" from 77 AD that Gauls used tallow and ash soap to give their hair a reddish tint. [6]. By, Lever Brothers in England began importing contemporary soap. During the British period, the term "Lifebuoy" was used in India. The first soap production facility was established in 1897 in India by the Uttar Pradesh city of Meerut's Northwestern Soap Company. After purchasing coconut oil factories in Cochin, Kerala, Mr. Jamshedji Tata discovered a soap manufacturing facility[7]. The first commercial soap made with coconut oil debuted in the Indian market in the early 1930s. Although consumers originally only expected soap to have cleansing benefits, over time they began to expect soap to also have health and aesthetic benefits. The main component of a cleanser, known as a surface-active substance (surfactant), is what makes it foam and clear. Because of its distinctive structure with hydrophobic and hydrophilic extremities, surfactants have the capacity to reduce surface tension. The harm to the stratum corneum (SC) that results in dryness, irritation, increased transepidermal water loss, flaking, and occasionally itching is also caused by surfactant. A new generation of technologies for producing gentle and moisturising cleansers developed as the function of SC components became better understood. Surfactants come in two varieties: natural and artificial[1]. Traditional soaps, translucent bars, super-fatted soaps, and combars were created using natural surfactants. Syndet bars, however, were made using artificial detergents. It is well known that syndet bars have a lower potential to irritate skin than soap made with natural surfactants[8]. Today's syndet bars are made with emollients like oils, glycerin, and petrolatum for moisturization and milder surfactants like sodium cocoyl isethionate and glycinate to minimise

irritation. Because they are easy to use and are more hygienic, liquid body cleansers are very well-liked. More emollient is deposited by them than by detergent or syndet bars. The health of face skin is the focus of facial cleansers, which occasionally have anti-aging properties. They vary from liquid body cleansers in that they have fewer emollients and milder, more expensive surfactants to prevent the heavy "after-use feel"[9]. "The growth of the soap business was primarily influenced by two factors that emerged around the turn of the 19th century. One of these was Cheverus's study into the makeup of fats, which provided science with the first real understanding of the chemical nature of fats and oils and subsequently of soap. The other was the discovery of a method for producing soda from common salt[10]. In Serenas Sammonicus' medicinal poem, soap is used to treat skin and facial blemishes. These applications demonstrate extensive experimentation and the fact that soap production was a well-known process at the time. Despite this, there is still no proof that the Romans produced or utilised soap as a cleanser. It is commonly claimed that Pompeii once housed a soap factory. This assertion first occurs in a letter Starke wrote from Italy in 1797, and it has since been made numerous times. However, Hofmann acquired a sample of the " soap " retrieved from the excavations from Presuhn in 1875. His chemical experiments demonstrated unequivocally that it was fuller's earth, which only contained an exceedingly small amount of organic matter, and that the "soap-works" were actually a fullonica. In general, the remnants of Roman boudoirs offer a wide range of cosmetics, but soap has not yet been discovered. The importance of soap by the seventh century led to the union of Italian soap makers into craft guilds, or "arti," and later, under Charlemagne, the soap maker assumed his place among the craftsmen of the vast domains[11].

1.2 FATTY ACID AND ITS APPLICATION:

Saturated fatty acids: These fatty acids are typically solid at room temperature and are found in high quantities in animal fats, such as butter and lard. However, they are also present in some vegetable oils, such as coconut and palm oil.

Monounsaturated fatty acids: These fatty acids are liquid at room temperature and are found in high quantities in olive oil, canola oil, and avocado oil.

Polyunsaturated fatty acids: These fatty acids are also liquid at room temperature and are found in high quantities in vegetable oils, such as sunflower, corn, and soybean oil. They are divided into two categories: omega-3 and omega-6 fatty acids. Omega-3 fatty acids are known for their anti-inflammatory properties[12]. Here are several types of saturated fatty acids, including:

Lauric acid: Found in coconut oil, palm kernel oil.

Myristic acid: Found in dairy products, coconut oil, and palm kernel oil.

Palmitic acid: Found in animal fats, palm oil, and coconut oil.

Stearic acid: Found in animal fats, cocoa butter, and shea butter.

Saturated fatty acids have several applications in cleaning due to their ability to form soap and act as surfactants. Surfactants are compounds that lower the surface tension of liquids and are often used in cleaning products to break up and remove dirt and grease. Saturated fatty acids are commonly used to make soaps and other cleaning products, such as detergents and fabric softeners[13]. Lauric acid, for example, is known for its ability to create a rich lather and is often used in soaps, shampoos, and other personal care products. Myristic acid is commonly used in detergents and cleaning products due to its ability to form stable foam. Palmitic acid is used in the production of soaps, candles, and other cosmetic products, while stearic acid is used in the production of soaps, candles, and as a thickener in creams and lotions. Some of the unsaturated fatty acids are,

Oleic acid: Found in olive oil, canola oil, and other vegetable oils.

Linoleic acid: Found in sunflower oil, corn oil, and soybean oil.

Alpha-linolenic acid: Found in flaxseed oil, chia seed oil, and walnuts[10].

Unsaturated fatty acids also have applications in cleaning activities. Similar to saturated fatty acids, they can act as surfactants and emulsifiers, allowing them to dissolve and remove dirt and grease[14]. They are commonly used in the production of soaps, detergents, and other cleaning products. Oleic acid, for example, is commonly used in soaps and other personal care products due to its ability to soften and moisturize the skin. It is also used as an emulsifier in cleaning products, helping to dissolve and remove grease from surfaces. Linoleic acid is often used in the production of laundry detergents due to its ability to penetrate and remove dirt and stains from fabrics. It is also used in the production of soaps and other personal care products. Alpha-linolenic acid is used in the production of eco-friendly cleaning products due to its biodegradability and low toxicity. It is often used as a solvent and emulsifier in cleaning products, allowing for effective removal of dirt and grease[15].

There are several types of polyunsaturated fatty acids, including:

Omega-3 fatty acids: Found in fish oils, flaxseed oil, and chia seeds.

Omega-6 fatty acids: Found in vegetable oils, such as sunflower, soybean, and corn oil.

Polyunsaturated fatty acids also have applications in cleaning activities. Similar to saturated and unsaturated fatty acids, they can act as surfactants and emulsifiers, allowing them to dissolve and remove dirt and grease. They are commonly used in the production of soaps, detergents, and other cleaning products[16].

Omega-3 fatty acids are often used in the production of eco-friendly cleaning products due to their biodegradability and low toxicity. They are also used as solvents and emulsifiers in cleaning products, allowing for effective removal of dirt and grease.

Omega-6 fatty acids are commonly used in the production of laundry detergents and other cleaning products due to their ability to penetrate and remove dirt and stains from fabrics. They are also used in the production of soaps and other personal care products[17].

1.3 SOURCES OF SOAPS:

1.3.1 Animal fats:

Tallow is a type of animal fat that is derived from beef or mutton. It is high in saturated fatty acids, making it a good source of stearic and palmitic acids for soap production. Lard is another type of animal fat that is derived from pigs. It is similar to tallow in composition, with high levels of stearic and palmitic acids. Fish oil is a source of unsaturated fatty acids, particularly omega-3 fatty acids[10]. It is commonly used in soap production to add moisturizing properties to the final product. Lanolin is a wax-like substance that is derived from sheep's wool. It is a good source of fatty acids and is commonly used in soaps and cosmetics to add emollient properties. Beeswax is a natural wax that is produced by honeybees. It is commonly used in soap production to add hardness and a mild honey-like scent to the final product[18]. Chicken fat, also known as schmaltz, is a by-product of poultry processing and is commonly used in soap production as a source of oleic and palmitic acids.[12]

1.3.2 Vegetable oils:

Vegetable oils are a common source of fatty acids used in soap production. Coconut oil is a popular choice for soap making due to its high levels of lauric acid, which contributes to a hard bar of soap with good lather[19]. Olive oil is a staple in Mediterranean cuisine and is a great source of oleic acid, which contributes to a moisturizing bar of soap. Palm oil is a versatile vegetable oil that is commonly used in soap making due to its high levels of stearic acid, which contributes to a hard bar of soap with good lather[20]. Castor oil is a unique vegetable oil that is high in ricinolein acid, which contributes to a creamy lather and moisturizing properties in soap. Shea butter is a vegetable fat that is extracted from the nuts of the shea tree. It is high in oleic and stearic acids, making it a great ingredient for soap making to add moisturizing and emollient properties. Sunflower oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of linoleic acid, which contributes to a gentle and moisturizing bar of soap. Canola oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of oleic and linoleic acids, which contribute to a gentle and moisturizing bar of soap. It is also a sustainable and renewable vegetable oil source[21].

Grapeseed oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of linoleic acid, which contributes to a gentle and moisturizing bar of soap. It also has antioxidant properties and can help improve the appearance of skin. Avocado oil is a rich and moisturizing oil that is commonly used in soap making due to its high levels of oleic acid, which contributes to a gentle and moisturizing bar of soap. It is also high in vitamin E and can help soothe dry and irritated skin[22]. Rice bran oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of oleic and linoleic acids, which contribute to a gentle and moisturizing bar of soap. It is also high in antioxidants and can help improve the appearance of skin. Hemp seed oil is a rich and moisturizing oil that is commonly used in soap making due to its high levels of omega-3 and omega-6 fatty acids, which contribute to a gentle and moisturizing bar of soap. It is also high in antioxidants and can help soothe dry and irritated skin[9].

1.3.3 Seaweed sources:

Kelp is a type of brown seaweed that is rich in vitamins and minerals, including iodine, magnesium, and calcium. It is commonly used in soap making for its moisturizing and exfoliating properties[23]. Nori is a type of red seaweed that is commonly used in sushi. It is also a popular ingredient in soap making due to its elevated levels of vitamin A and amino acids, which can help to improve skin texture and tone. Dulse is a type of red seaweed that is rich in antioxidants and can help to protect the skin from environmental stressors. It is also high in vitamins B6 and B12, which can help to improve skin health and reduce the appearance of fine lines and wrinkles[24]. Wakame is a type of brown seaweed that is commonly used in Japanese cuisine. It is also a popular ingredient in soap making due to its high levels of vitamins and minerals, including calcium, iron, and iodine, which can help to improve skin hydration and elasticity. Irish moss is a type of red seaweed that is commonly used in soap making for its natural emollient and skin-soothing properties[16]. It can help to reduce inflammation and soothe dry, irritated skin. Spirulina is a type of blue-green algae that is commonly used in soap making for its elevated levels of antioxidants and anti-inflammatory properties. It can help to protect the skin from damage caused by environmental stressors and reduce inflammation in the skin[25].

1.3.4 Soapwort:

Soapwort is a plant species that has been used for centuries as a natural source of soap. There are two main types of soapworts that are commonly used in soap production. Common Soapwort (*Saponaria officinalis*) most commonly used type of soapwort in soap production[26]. It contains natural saponins, which are soap-like substances that can be extracted from the plant by boiling it in water. The resulting liquid can be used as a natural soap for washing clothes, dishes, and even the skin. Bouncing Bet (*Saponaria officinalis* var. *pratensis*) is a variety of soapwort that is native to Europe and has natural saponins that make it useful for soap making. It is often used in herbal remedies and can be used to create a natural soap that is gentle on the skin. Both types of soapworts contain saponins, which are natural surfactants that can be used to create a lather and remove dirt and oil from the skin[26]. In addition to soap making, soapwort has also been used for medicinal purposes, including treating skin conditions like eczema and psoriasis. It is worth noting that while soapwort can be used to create a natural soap, it is not as effective as commercial soap when it comes to killing bacteria and other germs. If you're looking to create a soap that is both natural and effective at killing germs, you may want to consider adding essential oils or other natural antimicrobial agents to your soap recipe[27]. Rock Soapwort (*Saponaria ocymoides*) is variety of soapwort is native to Europe and Asia and is often used in rock gardens and as a groundcover. Its leaves and roots contain saponins, which can be used to create a natural soap. Large-flowered Soapwort (*Saponaria x lempergii*) is a hybrid species of soapwort that is a cross between *Saponaria officinalis* and *Saponaria vaccinia*[28]

1.4 TYPES OF SOAPS

1.4.1 Based on Composition:

1.4.1.1 Bar Soaps:

Bar soap is a type of soap that is solid and has a shape that is convenient for handling and storage. It is made by mixing oils or fats with an alkali (such as sodium hydroxide or potassium hydroxide) and water, which causes a chemical reaction called saponification. During this process, the oils or fats are converted into soap molecules, which are able to trap dirt, oil, and other impurities and

remove them from the skin. Bar soaps can be made using a variety of oils and fats, including animal fats, vegetable oils, and specialty oils like coconut oil, olive oil, and shea butter. Each type of oil or fat has its own unique properties that can affect the texture, scent, and cleansing ability of the soap[29].

1.4.1.2 Liquid soaps:

Liquid soap is a type of soap that is formulated as a liquid rather than a solid bar. It is made by mixing oils or fats with an alkali (such as sodium hydroxide or potassium hydroxide) and water, which causes a chemical reaction called[30] saponification. The resulting soap molecules are then diluted with additional water or other ingredients to create a liquid soap. Liquid soaps can be made using a variety of oils and fats, including animal fats, vegetable oils, and specialty oils like coconut oil, olive oil, and shea butter. Each type of oil or fat has its own unique properties that can affect the texture, scent, and cleansing ability of the soap.

1.4.1.3 Castile soaps:

Castile soap is a type of soap that originated in the Castile region of Spain, which is known for its olive oil production. It is made using a combination of olive oil, water, and lye (sodium hydroxide), and does not contain any animal fats or synthetic detergents. This makes it a popular choice for vegans and those with sensitive skin. One of the main benefits of castile soap is its mildness. It does not contain harsh detergents or other irritants, making it gentle enough for use on sensitive skin[31]. Castile soap also produces a rich, creamy lather that can be used for a variety of purposes, including hand and body washing, shampooing, and even household cleaning. Castile soap is often marketed as an all-purpose cleaner due to its versatility. It can be used for cleaning floors, countertops, and other surfaces, as well as for washing dishes and laundry. Some people even use it as a natural insecticide or pesticide. Castile soap is available in both bar and liquid form and can be scented or unscented. It is important to note that while castile soap is considered safe and gentle, it can still cause irritation or allergic reactions in some individuals. It is always recommended to patch test a small area of skin before using any new soap or skincare product[32].

1.4.1.4 Glycerine soaps:

Glycerine soap is a type of soap that contains glycerine, a natural byproduct of the saponification process. Glycerine is a humectant, which means it draws moisture from the air and helps to keep skin hydrated. This makes glycerine soap a popular choice for those with dry or sensitive skin. Glycerine soap is typically made using a combination of oils, lye, and glycerine[33]. The glycerine is often added back into the soap after saponification to ensure that it retains its moisturizing properties. Glycerine soap can be scented or unscented, and may contain added ingredients like essential oils, botanical extracts, or exfoliants. One of the main benefits of glycerine soap is its gentle, moisturizing properties. It is often used to soothe and hydrate dry, itchy skin, and can be beneficial for conditions like eczema and psoriasis. Glycerine soap can also help to balance the skin's natural oils, making it a good choice for those with oily or acne-prone skin[34]. Overall, glycerine soap is a gentle, moisturizing option for those seeking a natural alternative to traditional soaps. Its hydrating properties make it a popular choice for those with dry or sensitive skin, and it can be easily customized to suit individual preferences and needs[33].

1.4.1.5 Antibacterial soaps:

Antibacterial soap is a type of soap that is formulated with active ingredients that are designed to kill or inhibit the growth of bacteria. The most common active ingredient in antibacterial soaps is triclosan, although some brands may use other ingredients like benzalkonium chloride or chlorhexidine. One of the main benefits of antibacterial soap is its ability to help reduce the spread of harmful bacteria and viruses[35]. This is particularly important in settings like hospitals, schools, and other public places where the risk of infection is high. Antibacterial soap can also be beneficial for individuals with weakened immune systems or those who are more susceptible to infections. Overall, antibacterial soap can be a useful tool in reducing the spread of harmful bacteria and viruses, but it should be used with caution and only as directed[8]. Regular soap and water are still considered the most effective method for preventing the spread of illness and infection. It is important to note that while antibacterial soap can be effective at killing bacteria, it may also strip the skin of its natural oils and cause dryness or irritation. It is

recommended to use antibacterial soap sparingly and to follow up with a moisturizer to help protect the skin[36].

1.4.1.6 Sulphur soaps:

Sulfur soap is a type of soap that contains sulfur as its main active ingredient. Sulfur has a long history of use in skincare, dating back to ancient times, and is known for its antibacterial, antifungal, and antiparasitic properties. Sulfur soap is commonly used to treat various skin conditions, including acne, rosacea, and seborrheic dermatitis. One of the main benefits of sulfur soap is its ability to control excess oil production in the skin. Excess oil can clog pores and contribute to the development of acne and other skin conditions. Sulfur soap works by reducing oil production and helping to exfoliate dead skin cells, which can also contribute to clogged pores. Sulphur soap is also effective at treating acne. Sulfur has antibacterial properties that can help kill the bacteria that contribute to acne breakouts. Additionally, sulfur can help to reduce inflammation and redness associated with acne, making it a popular choice for those with inflammatory acne. Sulfur soap can also be beneficial for those with seborrheic dermatitis, a condition that causes scaly patches on the skin, particularly on the scalp and face. Sulfur soap can help to reduce the severity of symptoms and promote healing[30].

1.4.2 Based on Application

Bath soap is a type of soap that is specifically formulated for use in the bath or shower. It is designed to cleanse the skin of dirt, oil, and other impurities while also leaving the skin feeling soft and hydrated. Bath soap is typically made from a combination of fats or oils, such as coconut oil or palm oil, and an alkali, such as sodium hydroxide. This process is called saponification, and it results in the formation of soap molecules that are able to dissolve dirt and oil. Many bath soaps also contain other ingredients to help improve the skin's appearance and texture.

1.4.2.1 Hand soap:

Hand soap is a type of soap that is specifically formulated for use on the hands. It is designed to cleanse the skin of dirt, oil, and other impurities while also leaving the hands feeling soft and hydrated. Hand soap is typically made from a combination of fats or oils, such as coconut oil or palm oil, and an alkali, such as

sodium hydroxide. This process is called saponification, and it results in the formation of soap molecules that are able to dissolve dirt and oil. Hand soap can come in many different forms, including bar soap, liquid soap, and foaming soap. Bar soap is a solid block of soap that is typically used by wetting it with water and rubbing it onto the hands. For example, some soaps may contain moisturizing ingredients like glycerin or shea butter, which can help to hydrate the skin and prevent dryness. Other soaps may contain antibacterial ingredients like triclosan or benzalkonium chloride, which can help to kill bacteria on the skin and prevent the spread of germs. It is important to choose a hand soap that is appropriate for your skin type. Those with dry skin may want to choose a soap that contains moisturizing ingredients, while those with sensitive skin may want to choose a soap that is fragrance-free.

1.4.2.2 Shampoo bar:

Shampoo bars are a type of solid shampoo that is used to cleanse the hair. They are made from a combination of ingredients, such as oils, butters, and natural surfactants, which work together to create a lather that cleanses the hair and scalp. Shampoo bars are becoming increasingly popular because they are more eco-friendly than traditional liquid shampoos[5]. They are typically packaged in biodegradable or recyclable materials, and they do not require plastic bottles or excess packaging. One of the key benefits of shampoo bars is that they can last much longer than liquid shampoos since they are more concentrated and do not contain water. This means that a single shampoo bar can replace multiple bottles of liquid shampoo, making it a more cost-effective and sustainable option. To use a shampoo bar, you simply wet your hair and rub the bar directly onto your scalp and hair. Work the lather into your hair, then rinse thoroughly[37].

1.4.2.3 Dish soaps:

Dish soap, also known as dishwashing liquid or detergent, is a cleaning product used to wash dishes, utensils, and cookware. It is formulated to cut through grease and food residue, making it effective at removing tough stains and leaving dishes clean and shiny[19]. Dish soaps are typically made from a combination of surfactants, which are compounds that reduce the surface tension of water and help to break down oils and fats. They may also contain other ingredients, such as

enzymes, preservatives, and fragrances, depending on the brand and formulation. To use dish soap, you simply add a small amount to a sink or basin filled with warm water, then wash your dishes using a sponge or brush[13]. Rinse the dishes thoroughly with clean water, and then dry them with a towel or allow them to air dry. One of the key benefits of dish soap is its ability to effectively remove grease and food residue, even from tough-to-clean surfaces like pots and pans. It also helps to prevent the growth of bacteria and other microorganisms that can thrive on dirty dishes, helping to keep your kitchen clean and hygienic. When choosing a dish soap, it's important to look for one that is effective at cutting through grease and food residue, but also gentle enough to use on a variety of surfaces. Some dish soaps may be too harsh for delicate dishes or surfaces, so it is important to read the label and choose a product that is appropriate for your needs[16].

1.4.2.4 Speciality soaps:

Specialty soaps are types of soaps that are designed for specific purposes beyond basic cleaning. They may contain specialized ingredients that offer additional benefits such as moisturizing, exfoliating, or addressing certain skin conditions[33]. Moisturizing soap is type of soap is designed to hydrate and nourish the skin. It may contain ingredients such as shea butter, cocoa butter, or glycerin that help to lock in moisture and prevent dryness. Exfoliating soaps contain abrasive materials such as ground coffee, oatmeal, or pumice that help to remove dead skin cells and leave the skin feeling smooth and refreshed. Antifungal soaps are designed to help prevent or treat fungal infections on the skin, such as athlete's foot or ringworm[25].

1.5 VALIDATION OF SOURCES:

Validation of sources for soap production involves verifying that the ingredients meet certain standards and possess the desired properties. Some of the properties are oil and fats, essential oils, colorants, fragrance, and other additives. The properties of oils and fats that are typically validated include their fatty acid composition, iodine value, and acid value. These properties determine the lathering, cleansing, and conditioning properties of the soap. Essential oils used in soap making are validated for their therapeutic properties, fragrance, and stability. They are tested for purity, potency, and quality. Colorants used in soap making are

validated for their stability, solubility, and compatibility with the soap base. They are tested for any potential health risks, as well as for their environmental impact. Fragrances are validated for their aroma, stability, and compatibility with the soap base. They are tested for potential health risks, as well as for their environmental impact. Other additives, such as exfoliants and moisturizers, are validated for their safety, effectiveness, and compatibility with the soap base[9].

1.5.1 Validation of oils:

The validation of oil sources for soap production involves verifying that the oils possess certain properties that are desirable for soap making. There are some key properties that are typically validated for oil sources used in soap making: Fatty acid composition, Iodine value, Acid value, Peroxide value, colour, and Door, Sustainability. The fatty acid composition of the oil determines the lathering, cleansing, and conditioning properties of the soap[38]. The fatty acid profile should be balanced, with a mixture of saturated and unsaturated fatty acids. The iodine value measures the degree of unsaturation in the fatty acids of the oil. Oils with a high iodine value are more unsaturated and produce soap with more conditioning properties, while oils with a low iodine value produce soap with more cleansing properties. The acid value measures the amount of free fatty acids in the oil. High levels of free fatty acids can lead to soap that is too harsh and drying on the skin. The peroxide value measures the degree of rancidity in the oil. Oils with a high peroxide value should be avoided, as they can produce soap with an unpleasant odor. The color and odor of the oil can affect the final color and fragrance of the soap. It is important to ensure that the oil is free of any rancid or off-odors that could affect the quality of the soap. The sustainability of the oil source should also be considered. Oils that are sustainably sourced and produced have a lower environmental impact and are more socially responsible[21].

1.5.1.1 Iodine value:

The iodine value is a measure of the unsaturation of a fat or oil, which is an important property to consider when selecting sources for soap production. Iodine value is defined as the amount of iodine, in grams, that is absorbed by 100 grams of fat or oil.[39] The iodine value is an indication of the number of double bonds present in the fatty acid chains of the oil or fat. Oils and fats with high iodine values

have more unsaturated fatty acids and are more reactive, while oils and fats with low iodine values have more saturated fatty acids and are less reactive. For soap production, oils, and fats with a range of iodine values can be used, but it is important to consider the properties of the final soap product. Oils and fats with high iodine values produce softer and more moisturizing soaps, while oils and fats with low iodine values produce harder and more cleansing soaps. Soap makers can select oils and fats with specific iodine values to achieve the desired properties for their soap. For example, oils with high iodine values such as soybean oil or sunflower oil can be used to create a more moisturizing soap, while oils with low iodine values such as coconut oil or palm oil can be used to create a harder, more cleansing soap.

1.5.1.2 Acid value:

The acid value is an important property to consider when selecting sources for soap production. It is a measure of the amount of free fatty acids in a fat or oil, which is an indication of the oil or fat's quality and suitability for use in soapmaking. In the context of soap production, the acid value is particularly important because free fatty acids can negatively impact the quality of the final product. When free fatty acids react with an alkali, such as sodium hydroxide (NaOH), during the soapmaking process, they can result in the formation of excess soap and may cause the soap to be brittle, crumbly, or discolored. To determine the acid value of a fat or oil, a sample is first dissolved in a solvent, such as ethanol, and then titrated with a standard solution of potassium hydroxide (KOH). The acid value is calculated based on the amount of KOH required to neutralize the free fatty acids in the sample. Oils and fats with low acid values are preferred for soapmaking, as they contain fewer free fatty acids and are less likely to negatively impact the quality of the final product. However, some oils and fats naturally contain higher levels of free fatty acids and can still be used in soapmaking by adjusting the amount of alkali used to saponify the oil or fat.

1.5.1.3 Moisture content:

Moisture content is an important property to consider when selecting sources for soap production. Moisture content refers to the amount of water present in a raw material, such as a fat or oil. In soap production, high moisture content can

negatively impact the quality of the final product by causing problems such as rancidity, spoilage, and reduced shelf life. Ideally, oils and fats used in soap production should have a low moisture content. This helps to ensure that the raw material is stable and will not spoil or deteriorate during storage or processing. High moisture content can also affect the saponification process, leading to inconsistencies in the final product's quality and performance. It is important to note that moisture content can vary depending on the source of the fat or oil, as well as the conditions under which it was harvested and processed. For this reason, it is important to test the moisture content of each batch of raw materials to ensure that they meet the desired specifications for use in soap production.

1.5.1.4 pH Value:

pH is an important property to consider when selecting sources for soap production. pH refers to the level of acidity or alkalinity of a substance, and it is measured on a scale of 0 to 14. A pH of 7 is considered neutral, while pH levels below 7 are acidic and pH levels above 7 are alkaline. In soap production, the pH of the raw materials can affect the saponification process, which is the chemical reaction that converts fats and oils into soap. The ideal pH range for soap production is typically between 9 and 10, as this is the range in which the saponification reaction occurs most efficiently. It is important to note that the pH of oils and fats can vary depending on their source and processing methods. For example, some oils may have a naturally lower or higher pH due to the presence of organic acids or other compounds. Additionally, the pH can be affected by the conditions under which the oil or fat was harvested and processed, such as exposure to air, light, or heat.

1.5.1.5 Saponification value:

Saponification value (SV), also known as the "Koettstorfer value," is a measure of the amount of alkali needed to completely saponify a certain amount of fat or oil. In other words, it is a measure of the number of fatty acids present in the oil or fat that can react with an alkali to form soap. The saponification value is expressed in milligrams of potassium hydroxide (KOH) required to saponify one gram of fat or oil.

1.6 ANALYTICAL CHARACTERIZATION OF SOURCES:

1.6.1 GC-MS:

Gas chromatography-mass spectrometry (GC-MS) is a powerful analytical technique used to identify and quantify the chemical composition of complex mixtures. GC analysis: The oil sample is then analyzed using gas chromatography (GC) to separate the individual components of the oil based on their boiling points and other physical properties. The resulting chromatogram provides a detailed profile of the fatty acid composition of the oil. MS analysis: The separated components are then analyzed using mass spectrometry (MS) to identify the individual compounds present in the oil. This allows for the detection of any impurities or contaminants that may be present. Data analysis: The data obtained from the GC-MS analysis is then analyzed and compared to established standards for the fatty acid composition of the particular oil source. Any deviations from the expected profile can indicate the presence of impurities or adulterants. Overall, GC-MS analysis provides a reliable and accurate method for validating oil sources for soap production by confirming the purity and quality of the oil sample[9].

1.6.2 GC-IRMS:

Gas Chromatography Isotope Ratio Mass Spectrometry (GC-IRMS) is a technique used to determine the isotopic composition of a sample. It is commonly used for the validation of oil sources for soap production to ensure the authenticity and quality of the oils. GC-IRMS works by separating the compounds in the oil sample using gas chromatography, which separates the compounds based on their physical properties. The separated compounds are then introduced into the IRMS, where the isotopic composition of each compound is measured. Each element has multiple isotopes, and the ratio of these isotopes can vary depending on the source of the compound. For example, the carbon in plants has a slightly different isotopic composition than the carbon in fossil fuels. By analysing the isotopic ratios of the compounds in the oil sample, GC-IRMS can provide information about the source and authenticity of the oil. In the case of soap production, GC-IRMS can be used to validate the source of the vegetable oils used in soap making. For example, if a soap maker claims to use only organic olive oil in their soap, GC-IRMS can confirm the authenticity of the oil by analysing its isotopic composition.

This technique can also be used to detect adulteration or contamination in the oil source, which can affect the quality and properties of the final soap product.[29]

1.6.3 GC-FID:

GC-FID (Gas Chromatography-Flame Ionization Detection) is another analytical method used to validate oil sources for soap production. This technique is used to determine the types and amounts of fatty acids in the oil samples. During the GC-FID process, the oil sample is first vaporized and then injected into the GC column, which separates the individual fatty acid components based on their physical and chemical properties. The separated components are then detected by a flame ionization detector (FID), which produces a signal proportional to the amount of fatty acid present in the sample. The resulting data can be used to determine the fatty acid composition of the oil sample, which is important for determining its suitability for soap production-FID is an overly sensitive and accurate method for analysing the fatty acid composition of oil sources. It is especially useful for analysing oil samples that contain a complex mixture of fatty acids, such as vegetable oils. The results obtained from GC-FID can be used to compare different oil sources and to ensure that the oil used for soap production is of high quality and meets the desired specifications.

1.7 TYPES OF SOAP MAKING PROCESS:

1.7.1 Cold process:

Cold process soap making is a method of creating soap from scratch using oils, lye, and water. It is called a cold process because no external heat source is used to speed up the saponification process. Instead, the soap is left to cure and harden over several weeks[40]. The first step in cold process soap making is measuring and mixing the oils, lye, and water. The oils are typically melted and mixed together, and then the lye is slowly added to the water while stirring. Once both the oil mixture and lye solution are at the correct temperature, they are mixed together[41]. After the oils and lye solution are mixed, the mixture is stirred until it reaches trace. Trace is the point where the mixture has thickened to the point that when the stirring utensil is lifted out of the mixture, it leaves a visible trace behind. This is the point where any fragrance or colour additives can be added. Pouring and Melding: Once the mixture has reached trace and any additives have been

added, the soap is poured into molds[42]. The molds can be made of a variety of materials, but silicone and plastic molds are popular options. The soap is left to cool and harden in the mould for several hours. After the soap has hardened in the mould, it is removed and cut into bars. The bars are then left to cure for several weeks, typically on a drying rack or in a ventilated area. During the curing process, the soap will continue to harden, and any excess moisture will evaporate. Once the soap has fully cured, it can be packaged and used or sold. It is important to store the soap in a cool, dry place to prevent it from becoming soft or losing its scent[43].

1.7.2 Hot process:

Hot Process Soap Making is another method of making soap. Unlike cold process soap making, this method involves heating the soap mixture in order to speed up the saponification process. The hot process soap making method has been around for centuries and was often used to make soap before the cold process soap making method was invented. Just like with cold process soap making, you will need to gather all of your ingredients before you begin. This includes oils, lye, water, fragrances, and any colorants you plan to use. In hot process soap making, the lye and water are mixed together in a separate container from the oils. The mixture is then set aside to cool. While the lye mixture is cooling, you can start melting and mixing your oils. Once your oils are melted and mixed, you can add any fragrances or colorants. Once the lye mixture has cooled down to about 120-130°F, you can slowly pour it into the oils[44]. Be sure to mix the two mixtures together thoroughly. Once the mixture is combined, it is time to start cooking the soap. You will need to heat the mixture to about 170-180°F and stir it frequently. The soap will start to thicken and turn translucent. At this point, you can add any additional fragrances or colorants. You can test the soap by using a pH strip to make sure it is fully saponified. Once it is fully saponified, it should have a pH of around 9-10. Once the soap is ready, you can pour it into moulds and let it cool. After it has cooled, you can remove it from the moulds and let it cure for several weeks before using it[43].

1.7.3 Melt and pour soap making process:

Melt and pour soap making is a popular method that involves melting a pre-made soap base and adding colorants, fragrances, and other additives to create unique soap bars. This method is popular among beginners and those who do not want to handle lye, a caustic chemical used in other soap-making processes. The process involves melting a pre-made soap base, usually made of glycerine, coconut oil, palm oil, or other ingredients, in a double boiler or microwave[45]. Once melted, colorants, fragrances, and other additives can be mixed in, and the soap can be poured into moulds to cool and harden. Melt and pour soap making offers a lot of creative freedom and versatility, as different soap bases and additives can be combined to create unique colours, scents, and textures. This method is also relatively quick and easy compared to other soap-making methods, as there is no need for curing or waiting for the soap to harden[46].

1.7.4 Rebatching process:

Rebatching is a soap making method that involves taking already made soap and grating or shredding it into small pieces. These small pieces of soap are then melted down and re-blended with additional ingredients before being poured into moulds to form new bars of soap. The process of rebatching is often used to salvage a batch of soap that did not turn out quite as planned[45]. For example, if a soap maker forgot to add a fragrance or colorant, they can rebatch the soap and add those missing ingredients[47]. Rebatching can also be used to create a custom soap recipe by combining different types of soap or adding in additional ingredients like herbs, essential oils, or exfoliants. To rebatch soap, the grated soap is usually melted down in a double boiler or slow cooker until it reaches a thick, pudding-like consistency. Additional ingredients can then be added, such as essential oils, colorants, and exfoliants. The soap mixture is then stirred until all the ingredients are fully blended, and then poured into molds to cool and harden. While rebatching can be a useful method for salvaging soap batches, it does have some drawbacks[48]. The resulting bars of soap may have a slightly uneven texture or appearance, and the rebatching process can cause some loss of fragrance or other beneficial properties. Additionally, rebatched soap may not lather or perform as well as soap made using other methods.

1.7.5 Saponification process:

Saponification is the chemical process by which oils, fats, or fatty acids are converted into soap and glycerin. The process involves a reaction between the fatty acids and an alkali, typically sodium hydroxide (NaOH) or potassium hydroxide (KOH), to produce soap molecules and glycerin. This reaction is also called alkaline hydrolysis. The saponification process involves several stages. The first step in the saponification process is to weigh out the correct number of oils or fats and the correct amount of alkali needed to create the soap. The oils or fats and alkali are then mixed together in a large container, such as a stainless-steel pot, and heated to a specific temperature, usually between 120-140°F (49-60°C)[49]. The mixture is stirred continuously until the oils and alkali are fully emulsified and have formed a thick, creamy consistency. The point at which the mixture thickens and becomes creamy is called trace. This is an important stage in the saponification process, as it indicates that the oils and alkali have fully reacted and that the soap is beginning to form. Once the mixture has reached trace, it is poured into molds and left to cool and harden[50]. The molds can be made of various materials such as silicone, plastic, or metal. After the soap has been poured into molds, it is left to cure for several weeks. During this time, the soap hardens, and any excess moisture evaporates, resulting in a harder, longer-lasting bar of soap[51].

1.8 ANALYSIS OF SOAP:

Soap is a commonly used cleaning agent that has been in use for thousands of years. It is made by the reaction of a fat or oil with an alkali, typically sodium hydroxide or potassium hydroxide. The process of making soap is called saponification, and the resulting product is a mixture of soap molecules and glycerol.

Appearance: The soap can be visually inspected for its colour, texture, and shape. The appearance of the soap can give an indication of its quality and purity.

pH value: The pH of the soap can be measured using a pH meter. Soap should have a pH between 8 and 10, which is slightly alkaline. If the pH is too high or too low, it can cause skin irritation.

Cleansing power: The cleansing power of the soap can be tested by applying a small amount of the soap on a soiled surface and then rinsing it with water. The soap should be able to remove dirt and oil effectively.

Foaming capacity: The foaming capacity of the soap can be tested by agitating a small amount of soap in water. The soap should produce a rich lather that lasts for a reasonable amount of time.

Hardness: The hardness of the soap can be determined by pressing a small piece of the soap between the fingers. The soap should be hard enough to resist deformation but soft enough to lather easily.

Moisture content: The moisture content of the soap can be measured by weighing a sample of the soap before and after drying it in an oven. The soap should have a moisture content of less than 15%.

TFM: The TFM in the soap can be determined by dissolving a sample of the soap in alcohol and then titrating the solution with a standard solution of potassium hydroxide. The soap should have a TFM content of at least 70%[52]. Soap has been an essential part of human hygiene for thousands of years. The history of soap dates back to ancient times, where it was made using natural ingredients such as animal fat, ashes, and water. Over time, the process of soap-making has evolved, and various types of soaps have been developed to meet different needs. The different types of soaps include bar soap, liquid soap, glycerine soap, and more. These soaps can be classified based on their ingredients, production process, and application. The choice of soap depends on the intended use and personal preferences. Fatty acids are an essential component of soap. They are derived from natural sources such as animal fat and vegetable oils. Fatty acids play a crucial role in determining the properties of the soap, including its lather, cleansing ability, and hardness. Soap can be obtained from various sources, including animal fat, vegetable oil, and synthetic sources. The source of soap affects its quality and properties. For instance, vegetable oil-based soaps are more environmentally friendly and gentle on the skin than animal fat-based soaps[53].

CHAPTER-2

LITERATURE SURVEY

- **Sakkaravarthi's** article, "History of soap," published in Cosmoderma in 2022, provides a detailed overview of the history of soap, from its early use in ancient civilizations to the modern-day varieties available on the market [1].
- **Gibbs' article**, "The history of the manufacture of soap," published in Annals of Science in 1939, traces the development of soap-making techniques from ancient times to the modern era, highlighting the key milestones in the history of soap [2].
- The Cosmoderma website includes an article on the "History of soap," which provides a concise overview of the origins and evolution of soap, including its early use in ancient civilizations and its role in modern society [3].
- **Konkol and Rasmussen's** book chapter, "An ancient cleanser: Soap production and use in antiquity," published in ACS Symposium Series in 2015, explores the chemical properties of soap and the techniques used to manufacture it. The chapter also provides examples of the use of soap in ancient cultures, including ancient Egypt and Mesopotamia [4].
- **Burleson et al.** (2017) focused on improving the soap-making process by considering social, cultural, and resource constraints in the engineering design process. They emphasized the importance of considering these factors in order to create sustainable and culturally appropriate soap-making processes [5].
- **Maotsela et al.** (2019) investigated the utilization of waste cooking oil and tallow for the production of toilet soap. They found that waste cooking oil and tallow could be used as alternative and inexpensive raw materials for soap production, leading to potential environmental and economic benefits [6].
- **Cholifah et al.** (2021) studied the influence of cocamide DEA on the characteristics of transparent soap. They found that cocamide DEA had a significant effect on the transparency, viscosity, and surface tension of the

soap, and concluded that cocamide DEA could be used as a co-surfactant in transparent soap production [7].

- In their study, **Kostik et al.** analyzed the fatty acid composition of various edible oils and fats, including sunflower oil, soybean oil, olive oil, and others. They found that the fatty acid composition varied between different oils and fats, which could have implications for their health benefits and nutritional value [13].
- **Gervajio** focused specifically on coconut oil and its fatty acid composition. They found that coconut oil contains a high percentage of medium-chain fatty acids, which have been linked to numerous health benefits, including improved brain function and weight loss [14].
- **Chiplunkar et al.** investigated the synthesis and application of an alkyd resin based on palm fatty acid distillate in liquid detergent. They found that the resulting detergent had good emulsifying properties and could effectively remove stains from clothes. This suggests that palm fatty acid distillate could be a useful raw material for the production of detergents [15].
- **Shafie et al.** conducted a review on the application of carrageenan extract from red seaweed in cosmetic products. The review found that carrageenan extract is commonly used in the cosmetics industry as a thickening agent, emulsifier, and moisturizer. It also has several other beneficial properties, such as anti-inflammatory and antioxidant effects. The research suggests that carrageenan extract could be a valuable ingredient in cosmetic products [16]
- **Spitz** discussed the production and properties of fatty acids and their derivatives in the soap and detergent industry. The research suggests that fatty acids and their derivatives are important raw materials in the production of soaps and detergents, and their properties can be manipulated to optimize their performance in various applications [28].
- **Islamiati et al.** developed an herbal paper soap from virgin coconut oil with the addition of whey kefir. The study found that the soap had good lathering and cleansing properties and could potentially have antibacterial effects due to the presence of herbal extracts. The research suggests that this herbal paper soap could be a promising alternative to conventional soap [22].

- **Ali Ahmed et al.** reviewed the production and applications of seaweed polysaccharides. The review found that seaweed polysaccharides have a wide range of potential applications in various industries, such as food, pharmaceuticals, and cosmetics. The research suggests that seaweed polysaccharides could be a valuable source of natural materials for various applications [23].
- **Msuya** discussed the Seaweed Cluster Initiative in Zanzibar, Tanzania. The initiative aimed to promote the sustainable cultivation and utilization of seaweed as a source of income for local communities. The research suggests that seaweed farming could be a promising economic opportunity for coastal communities in developing countries [24].
- **Sabaani et al.** investigated the antibacterial activity of liquid soap with combined *Sargassum* sp. and *Eucheuma* sp. seaweed extracts. The study found that the soap with seaweed extracts had higher antibacterial activity than the soap without extracts. The research suggests that seaweed extracts could be a valuable natural ingredient in antibacterial soap formulations [25].
- **Jurek et al.** compared the effects of Soapwort extract and synthetic surfactants on skin-mimetic models. The study found that the Soapwort extract had good cleansing properties and did not cause irritation or damage to the skin. The research suggests that Soapwort extract could be a potential alternative to synthetic surfactants in cosmetic formulations [26].
- **Nowrouzi et al.** characterized and evaluated a natural surfactant extracted from the Soapwort plant for use in alkali-surfactant-polymer (ASP) slug injection into sandstone oil reservoirs. The study found that the Soapwort extract had good surfactant properties and could potentially improve oil recovery in enhanced oil recovery processes. The research suggests that natural surfactants like Soapwort extract could be a promising alternative to synthetic surfactants in oil recovery processes [27].
- **L. Spitz**, "Bar soap packaging," discusses the packaging of bar soap and the various types of packaging materials used for bar soaps, including paper wrappers, cellophane, and plastic overwraps [29].

- **Hurst, L. W. Stuttard, and R. C. S. Woodroffe**, in their study, “Disinfectants for use in bar-soaps,” explore the efficacy of various disinfectants in bar soap formulations, particularly for use in hospitals and other healthcare settings [30].
- **O. Barel, R. Lambrecht, P. Clarys, B. M. Morrison, and M. Paye’s** “A comparative study of the effects on the skin of a classical bar soap and a syndet cleansing bar in normal use conditions and in the soap chamber test,” compares the effects of a traditional bar soap and a synthetic detergent bar (syndet) on the skin. The study found that the syndet bar was less irritating to the skin and caused less dryness than the traditional bar soap [31].
- A study by **Svechnikova et al.** analyzed glycosides of *Allochruza hypochilids* in the preparation *Allokhrozid* using chromatesspectrophotometry [34].
- **Rahama and Sani** reported on the production of an antiseptic tablet aloe vera soap in the International Journal of Innovative Science Research and Technology [35].
- **Mendez et al.** described the development of an indigenous liquid soap for the prevention of infectious diseases in impoverished rural communities [36].
- **Barve and Dighe** discussed hair shampoo formulation in their book chapter [37].
- **Burleson et al.** describe an engineering design process to improve the soap-making process, considering social, cultural, and resource constraints [43].
- **Prieto Vidal et al.** investigate the effects of cold saponification on the unsaponified fatty acid composition and sensory perception of commercial natural herbal soaps [51].

CHAPTER – 3

AIM AND SCOPE

3.1 Aim

- To collect the edible and non-edible oil sources and evaluating using GC-FID
- To categorize the oil samples for detergent and toilet soaps application based on the comparison studies.
- To prepare detergent soaps from waste cooking oil(non-edible) samples collected from various food outlets in Chengalpattu.
- To prepare toilet soaps with medicinal value using coconut oil base (edible oil)
- To compare the Properties of detergent and toilet soaps synthesized and also determine the usage of washed water.
- To translate the Waste Cooking Oil detergent soaps making process SHG women of Kumizhi village, Chengalpattu for their livelihood enhancement.

3.2 Scope

- Based on the cleansing applications soaps have been manufactured categorically over the years
- Dirt removal efficiency, dermal safety, solubilizing nature etc being an important parameter for evaluating the soap, the wash water generated during the usage of a soap for a specific application will be monitored in this study.
- Further an evaluation of oil source (raw material) will be made in understanding the role of its composition in selecting the oil for a specific cleaning application will be made.
- Additionally, mechanisms will be designed to derive soaps for different cleansing applications with better cleaning efficiency, reduced rinsing water requirements, improved wash water quality to reduce the loading in the effluent treatment plant reduced pathogenic interferences etc.,

CHAPTER-4

MATERIALS AND METHODS

4.1 MATERIALS AND CHEMICALS:

The collection of various edible and non-edible oils from the local restaurants. The waste cooking oil sources like palm oil, sunflower oil, and coconut oil. The edible oil sources like cold pressed coconut oil and almond oils. The validation method used here is gas chromatography-Flame ionisation detector. Fragrance which are added to the soap is night jasmine scent. The natural filler like Kaolin clay which is eco-Friendly and safer to the skin. For medicinal soaps the extracts like neem extract, aloe vera extract and herbal extract. The base for the soap is sodium hydroxide or calcium carbonate.

4.2 COLLECTION OF OILS:

Collecting waste cooking oils for the production of soap is a wonderful way to both reduce waste and create a useful product. Find a local company or organization that collects used cooking oil. Many cities and towns have programs for this, or you may be able to find a local business that collects oil for biodiesel production. Gather used cooking oil from your own kitchen and from friends and family. Be sure to strain the oil to remove any food particles. Store the collected oil in a sealed container, preferably airtight, until you have enough to begin making soap. Here are some oil samples we collected that are tabulated.

Table 4.1 Collection of Sources and Details of the sources

ITEM	DETAILS
RESTAURANT DETAILS WITH ADDRESS	BAKERIES AND RESTARAUNTS
BRAND OF OILS USED	SVS –PALM OIL, SUNFLOWER OIL, COCONUT
PLACE OF BUYING	CHENGULPET, AMBATHUR
ITEMS COOKED	SAMOSAS, PAPADAM, POTATO CHIPS AND BANANA CHIPS

NO. OF TIMES REPEATED USED	MORE THAN 4 TIMES
AMOUNT OF OIL COLLECTED	1 LITRE
RATE EXPECTED FROM SHOPKEEPER	FREE OF COST

4.3 VALIDATION OF OIL SOURCES USING GC-FID:

Gas Chromatography-Flame Ionization Detector (GC-FID) is a common method used to validate oil sources. ASTM (ASTM) has developed a standard procedure for the GC-FID analysis of oil source validation, which is known as ASTM D6584. Here are the general steps for the ASTM D6584 procedure for oil source validation using GC-FID. The oil sample needs to be properly prepared before running it on the GC-FID. This involves weighing out a specific amount of the oil sample and dissolving it in a suitable solvent. Hexane is commonly used for this purpose. Before running the sample, the GC-FID needs to be calibrated using known standards to ensure accurate measurement of the oil components. The prepared sample is injected into the GC-FID using an auto sampler or manually with a syringe. The sample is then vaporized and separated into its individual components by the GC column. The separated components are then detected using the FID detector, which measures the amount of carbon atoms in the sample. Each component will produce a unique signal on the detector. The data obtained from the detector is analyzed using software to identify the different components and their amounts. This data is then compared to a database of known oil sources to identify the origin of the oil sample. The results of the analysis are reported along with any limitations or uncertainties in the data. The ASTM D6584 standard specifies the reporting requirements, including the use of a standard format and terminology. The results for the oil sources which are done in the GC-FID are listed below. It is important to note that the ASTM D6584 procedure is a standardized method that has been validated for oil source validation using GC-FID.

4.4 INTERPRETATION OF GRAPHS OBTAINED:

Interpreting GC-FID graphs generated from the ASTM D6584 procedure for oil source validation involves analyzing the peak areas and retention times of the different components in the sample. Here are some key points to consider when interpreting GC-FID graphs. The peak area represents the amount of each component present in the sample. The larger the peak area, the greater the amount of that component in the sample. Retention Times is next point, The retention time represents the amount of time it takes for each component to travel through the GC column and reach the detector. Each component has a unique retention time, which can be used to identify it. The ASTM D6584 procedure recommends using a standard library to compare the retention times and peak areas of the sample components to known oil sources. The standard library contains retention times and peak areas for a variety of different oil sources.: Qualitative analysis involves comparing the retention times of the sample components to those in the standard library to identify the origin of the oil source. If the retention times of the sample components match those of a known oil source in the standard library, it can be concluded that the sample originated from that source. Quantitative analysis involves comparing the peak areas of the sample components to those in the standard library to determine the relative amounts of each component in the sample. This can be used to identify any adulteration or contamination of the sample. It is important to note that interpretation of GC-FID graphs requires expertise in chromatography and familiarity with the ASTM D6584 standard.

4.5 MOISTURE CONTENT OF OIL:

- Weigh a clean, dry, and empty crucible and record its weight as "A". Add a small quantity of the oil sample to the crucible and weigh the crucible and oil sample together. Record the weight as "B".
- Place the crucible with the oil sample in an oven at a temperature of 105°C to 110°C for 1 to 2 hours until the sample is completely dry. Remove the crucible from the oven and allow it to cool in a desiccator to avoid moisture from the air entering the crucible. Weigh the crucible and dried oil sample and record the weight as "C".
- Calculation: The moisture content of the oil can be calculated using the following formula:

$$\text{Moisture content (\%)} = [(C - A) / (B - A)] \times 100$$

Where:

A = Weight of empty crucible

B = Weight of crucible and oil sample

C = Weight of crucible and dried oil sample

The result will give you the percentage of moisture present in the oil sample.

Table 4.2 Moisture Content of the sources

NAME OF THE PROPERTY	VALUE OF PROPERTY (WCO-SUNFLOWER OIL)	VALUE OF PROPERTY (WCO-PALM OIL)	VALUE OF PROPERTY (WCO-COCONUT OIL)	VALUE OF PROPERTY (COLD PRESSED COCONUT OIL)	VALUE OF PROPERTY (PURE ALMOND OIL)
MOISTURE CONTENT (wt.%)	0.88	0.65	0.98	1.01	0.69

4.6 SAPONIFICATION VALUE:

Procedure

1. About 2 g of the given oil is taken in a conical flask but weighed accurately (w g).
2. The oil is dissolved in 25 ml of 0.5 N alcoholic potassium-hydroxide solution.
3. Then the reaction mixture is refluxed using a water condenser on a water-bath for half an hour.
4. The resulting solution is cooled and titrated against a 0.5 N HCl solution adding 1 ml of phenolphthalein.
5. The number of ml of acid required is noted (a). An exactly identical blank experiment (leaving the fat or oil) is performed. Number of ml of hydrochloric acid required is noted (b)

$$\text{Calculation of Saponification Value} = \frac{(A - B) \times N \times 56.1}{W}$$

where:

A = KOH, for blank, mL

B = KOH, for sample, mL

W = weight of sample (dry basis), g

N = normality KOH solution

56.1 = equivalent weight of potassium hydroxide

Table 4.3 Saponification value of the sources

NAME OF THE PROPERTY	VALUE OF PROPERTY (WCO-SUNFLOWER OIL)	VALUE OF PROPERTY (WCO-PALM OIL)	VALUE OF PROPERTY (WCO-COCONUT OIL)	VALUE OF PROPERTY (PURE COCONUT OIL)	VALUE OF PROPERTY (PURE ALMOND OIL)
SAPONIFICATION VALUE (Mg KOH/gm)	190	202	240	242	185

4.7 SAPONIFICATION PROCESS:

Sample Preparation: The waste cooking oil is collected and filtered to remove any impurities or food particles. The kaolin clay is also weighed and ground to a fine powder.

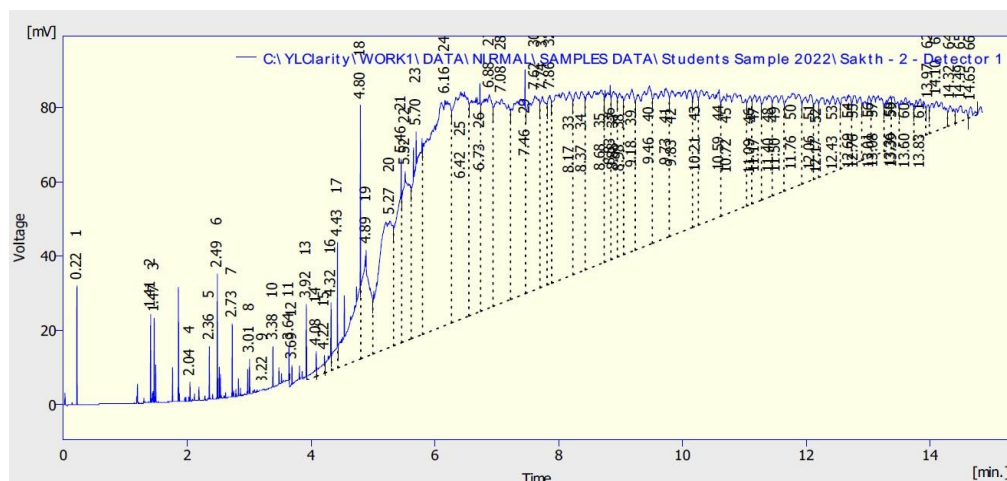
Mixing: The waste cooking oil and kaolin clay are mixed together in a container. The mixture is then heated to a specific temperature to melt the oils and ensure uniform mixing 60 D.

Addition of Sodium Hydroxide: Sodium hydroxide (NaOH) is dissolved in water and added to the mixture. The mixture is stirred continuously to ensure thorough mixing and reaction. Mix for 30 minutes
Monitoring the Reaction: The mixture is monitored to determine when the saponification reaction is complete. This is typically done using a pH indicator or by monitoring the viscosity of the mixture.
Pouring and Moulding: Once the saponification reaction is complete, the soap mixture is poured into moulds and allowed to cool and harden.

Testing and Quality Control: The soap is tested for quality control, including testing for pH, texture, and fragrance.

16	12.967	Saturated Fatty Acid	Trideconic acid
17	13.787	Unsaturated Fatty Acid	Pentadecanoic acid
18	14.907	Unsaturated Fatty Acid	Palmitoleic Acid
19	15.367	Saturated Fatty Acid	Eladic acid
20	15.680	Unsaturated Fatty Acid	Oleic acid
21	16.220	Saturated Fatty Acid	Arachidic acid
22	16.220	Unsaturated Fatty Acid	Pentadecanoic acid
23	16.633	Unsaturated Fatty Acid	Eicosenic acid
24	17.01	Saturated Fatty Acid	Stearic acid
25	19.063	Unsaturated Fatty Acid	Linoleic acid
26	21.853	Unsaturated Fatty Acid	Linolenic acid
27	28.013	Saturated Fatty Acid	Palmitic acid
28	32.043	Saturated Fatty Acid	Lignoceric acid

Note: The fatty acid tabulated above are Standard Fatty acids of the Coconut oil. For production of Soaps Specific Fatty acids are needed, For the Following Interpretations the Specific Fatty acids are tabulated along with their GC-FID Graphs.



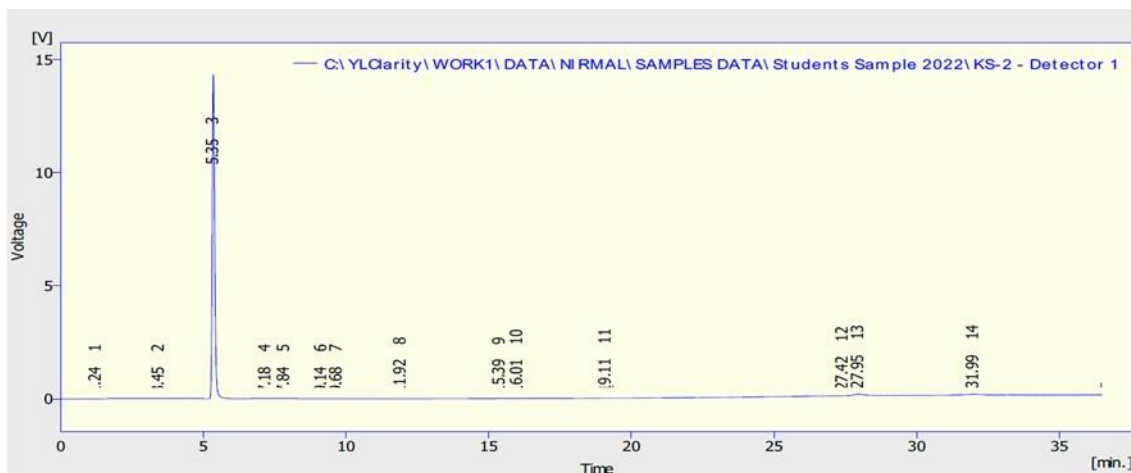


Fig 5.3: GC-FID for the waste cooking oil-sunflower oil

Table 5.3 Interpretation of waste cooking sunflower oil graph

S.NO	RETENTION TIME	TYPE OF FATTY ACID	COMPOUND NAME
1	9.4	Saturated fatty acid	Myristic acid
2	11.6	Saturated Fatty acid	Palmitic acid
3	12.9	Unsaturated Fatty acid	Palmitoleic acid
4	14.8	Saturated fatty acid	Stearic acid
5	17.0	Unsaturated fatty acid	Oleic acid
6	18.5	Unsaturated fatty acid	Linoleic acid
7	19.7	Unsaturated fatty acid	Linolenic acid
8	24.3	Unsaturated fatty acid	Eicosenic acid
9	26.6	Saturated fatty acid	Behenic acid
10	22.3	Saturated Fatty acid	Arachidic acid

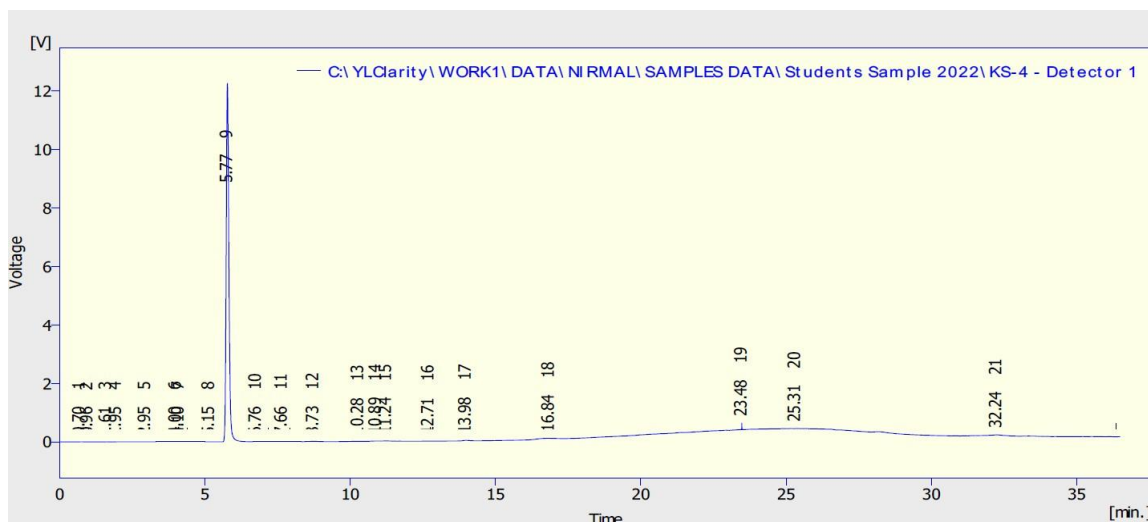


Fig 5.4: GC-FID for the Cold pressed Coconut oil

Table 5.4 Interpretation of cold pressed coconut oil graph

S.NO	RETENTION TIME	TYPE OF FATTY ACID	COMPOUND NAME
1	5.4	Saturated fatty acid	Caprylic acid
2	6.5	Saturated Fatty acid	Capric acid
3	7.6	Saturated Fatty acid	Lauric acid
4	8.8	Saturated fatty acid	Myristic acid
5	14.4	saturated fatty acid	Palmitic acid
6	18.6	saturated fatty acid	Stearic acid
7	20.5	Unsaturated fatty acid	Oleic acid
8	21.4	Unsaturated fatty acid	Linoleic acid

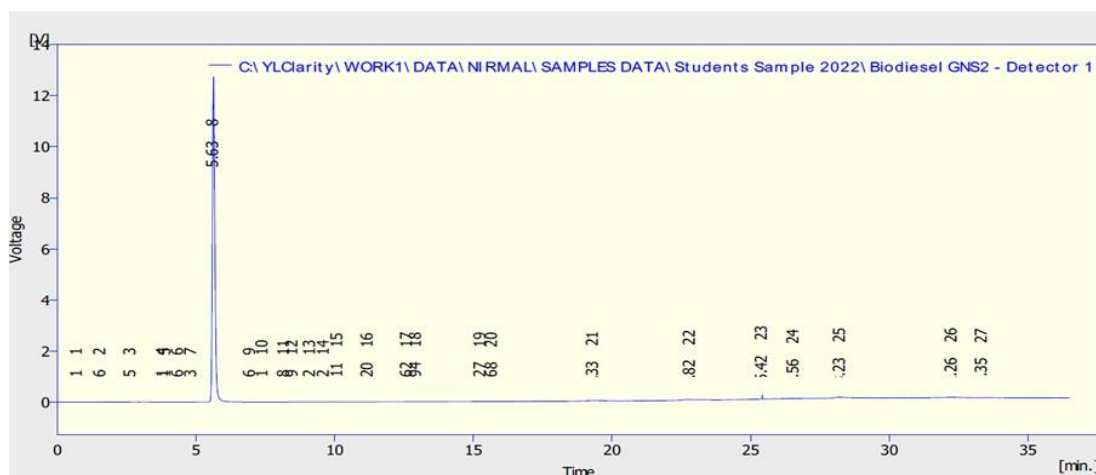


Fig 5.5: GC-FID for the Edible-Almond oil

Table 5.5 Interpretation of almond oil graph

S.NO	RETENTION TIME	TYPE OF FATTY ACID	COMPOUND NAME
1	12.5	Saturated fatty acid	Palmitic acid
2	14.7	Saturated Fatty acid	Stearic acid
3	17.3	Unsaturated Fatty acid	Oleic acid
4	18.8	Unsaturated fatty acid	Linoleic acid
5	20.3	Unsaturated fatty acid	Linolenic acid

GC-FID is a commonly used analytical technique for the identification and quantification of organic compounds in complex mixtures such as waste cooking oils. The graph obtained from this analysis typically shows the retention time on the x-axis and the detector response (peak area) on the y-axis. By analyzing the peaks on the graph, we can identify the individual components present in the waste cooking oil sample. The area under each peak is proportional to the amount of the corresponding compound in the sample. The retention time can also be used to help identify the compound, as each compound has a characteristic retention time. Additionally, the shape of the peaks can provide information on the quality and purity of the sample. For example, a well-defined peak with a narrow base indicates a pure compound, while a broad peak with a sloping baseline may indicate the presence of impurities. Overall, the GC-FID graph can provide valuable information on the composition and quality of waste cooking oils, which can help inform decisions on appropriate disposal or recycling methods.

5.2 SOAPS DERIVED FROM DIFFERENT OIL SOURCES:

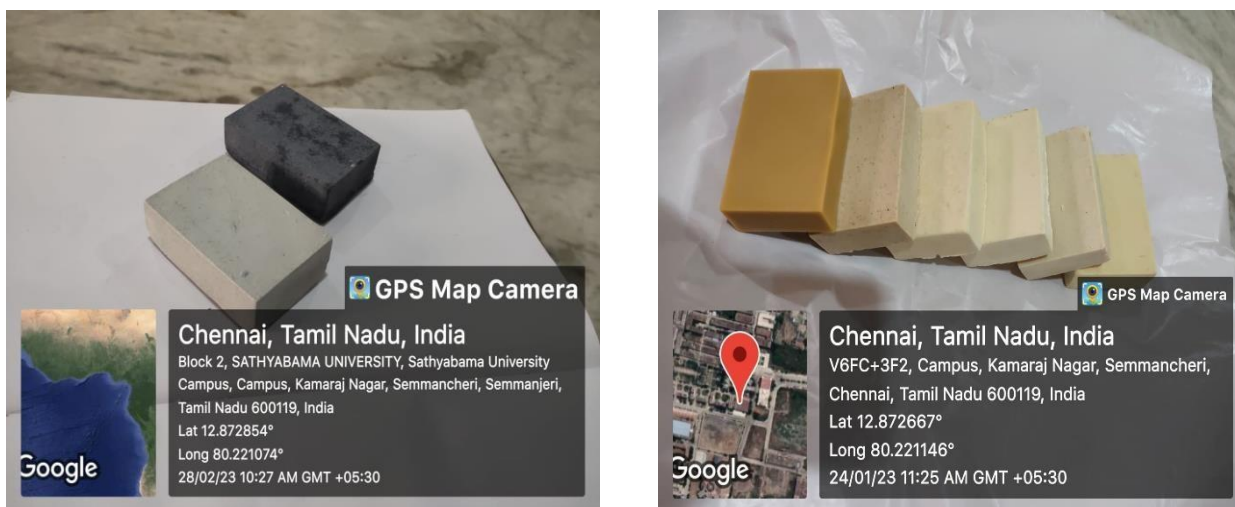


Fig.5.6: Soaps prepared from waste cooking oils.

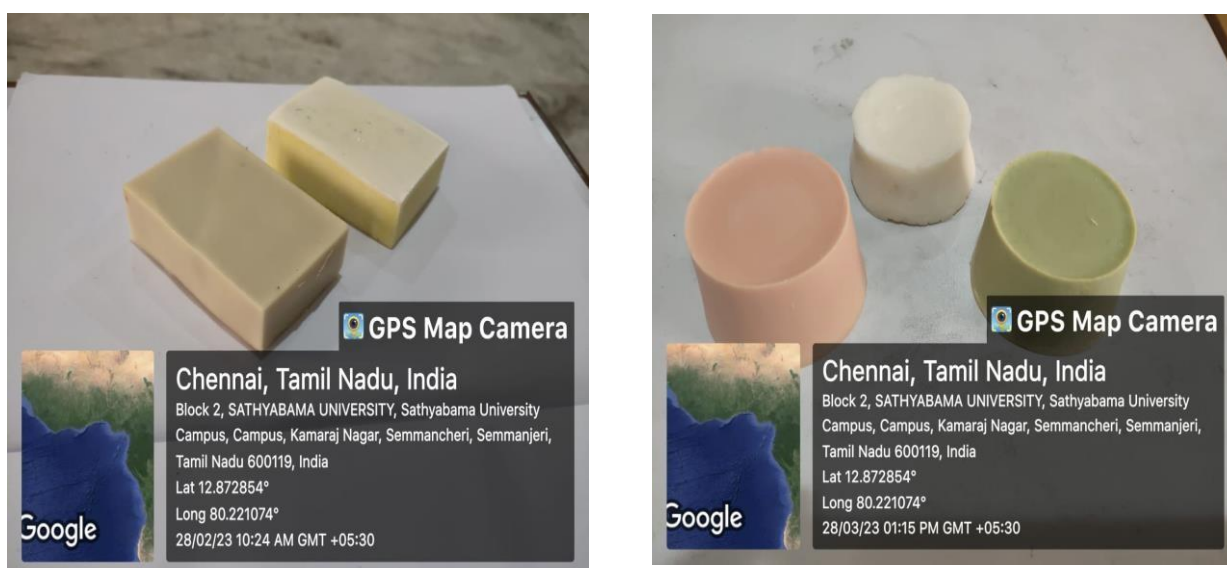


Fig.5.7: Soaps prepared from the edible oils by adding herbal extracts.

5.2.1 Properties of Soaps

5.2.1.1 Total Fatty matter:

TFM is an important parameter to determine the quality of soap. TFM represents the amount of fatty acid or oil present in the soap. It is the percentage of the mass of the soap which is composed of fatty acids and other oils. The TFM value of soap is used to determine its cleansing properties and can indicate the amount of lather produced by the soap. A higher TFM value indicates a higher number of fatty acids present in the soap, which results in a better cleansing property and more lather. Hence, the TFM value is an important parameter to determine the quality of soap's (ASTM) procedure D 5558-94 is used for the determination of TFM (TFM) in soaps. The procedure involves the following steps:

Sample Preparation: A representative sample of the soap is collected and crushed to a uniform size.

Drying: A 2-gram sample of the crushed soap is weighed accurately and dried in a stifling air oven at 105°C for 1 hour. The sample is then cooled in a desiccator.

Weighing: The dry soap sample is weighed accurately to the nearest 0.0001 gram.

Titration: The weighed sample is dissolved in a mixture of 50 ml of ethanol and 50 ml of water. 1 ml of phenolphthalein indicator is added to the solution. The solution is then titrated with 0.5 N alcoholic KOH solution until a faint pink color appears.

Calculation: The TFM content of the soap is calculated using the following formula:

$$\text{TFM} = [(B - A) \times 28.2 \times 100] / W$$

Where,

A = volume of 0.5 N alcoholic KOH solution used for blank

B = volume of 0.5 N alcoholic KOH solution used for sample

W = weight of the sample in grams

The TFM content of the soap is expressed as a percentage of the weight of the soap. The minimum TFM content required for a soap to be considered as a toilet soap is 76% as per the Bureau of Indian Standards (BIS).

5.2.1.2 Total Alkalinity Content:

TAC in soap refers to the total amount of alkali (mainly sodium hydroxide or potassium hydroxide) present in the soap sample. The determination of TAC is an important quality control test in soap manufacturing because the amount of alkali used in the soap-making process can affect the properties of the soap, such as hardness, lather, and cleansing ability. The TAC in soap refers to the amount of alkali present in the soap, which is usually in the form of sodium or potassium hydroxide. It is important to determine the alkaline content in soap as it affects the pH level and overall quality of the soap. ASTM has provided a standard procedure for the determination of TAC in soap, which is ASTM D555-88 (2018) Standard Test Method for Total Alkali in Soaps and Detergents. The procedure involves the titration of a soap solution with hydrochloric acid (HCl) to determine the amount of free alkali present in the soap. The steps involved in the procedure are as follows:

Weigh accurately about 10 g of the soap sample and dissolve it in 50 mL of hot distilled water. Add phenolphthalein as an indicator to the soap solution.

Titrate the soap solution with 0.1 N hydrochloric acid (HCl) until a pink color appears, indicating the endpoint of the titration. The titration should be performed slowly to ensure accurate results.

Record the volume of HCl used for the titration.

Calculate the TAC in the soap using the following formula:

$$\text{TAC (\%)} = [(V1 - V2) \times N \times 40.01 \times 100] / W$$

Where,

V1 = volume of HCl used for the titration of the soap solution (mL)

V2 = volume of HCl used for the blank (mL)

N = normality of the HCl solution

40.01 = molecular weight of potassium hydroxide (KOH)

W = weight of the soap sample taken (g)

The result obtained from this test method indicates the TAC in terms of percentage by weight of the sample. The typical range of TAC in soap is between 0.1% and 1.0%, depending on the type and quality of the soap.

5.2.1.3 Glycerine:

Glycerine is a valuable by-product of the soap making process, and its presence in the soap can indicate that the soap has been properly formulated and processed. Checking the glycerine content ensures that the soap is of excellent quality and has not been over-processed, which can result in a lower glycerine content. Glycerine is a natural humectant, which means it attracts and retains moisture in the skin. Soaps with a higher glycerine content are often preferred by consumers for their moisturizing properties, which can help prevent dryness and irritation. Glycerine is a valuable commodity, and soaps with a higher glycerine content can command a higher price. Checking the glycerine content can help manufacturers ensure that they are getting the maximum economic value from their soap making process. The ASTM procedure for determining the glycerine content in soap is ASTM D4590. This method involves the extraction of glycerine from the soap sample using a solvent and then measuring the amount of glycerine present in the extract using gas chromatography.

Preparation of sample: The soap sample is first melted and then allowed to cool to room temperature. A small quantity of the cooled soap is then weighed and transferred to a glass extraction thimble.

Extraction: The extraction thimble containing the soap sample is then placed in a Soxhlet extractor. The extractor is filled with a solvent (such as chloroform) that is immiscible with water. The Soxhlet extractor is then connected to a condenser and the solvent is heated to reflux.

Collection of extract: The solvent will dissolve the glycerine present in the soap sample and the extract will drip down into a collection flask. The extraction process is continued for several hours until all of the glycerine has been extracted from the soap.

Analysis of extract: The extract containing glycerine is then analyzed using gas chromatography. A known quantity of the extract is injected into the

chromatograph and the glycerine is separated from other components of the extract using a suitable column.

Calculation of glycerine content: The amount of glycerine present in the extract is determined by comparing its peak area to that of a known standard. The glycerine content of the soap is then calculated as a percentage of the total weight of the soap sample. The glycerine content in soap is an important parameter as it is a by-product of the saponification process and has important properties such as moisturizing and emollient properties.

5.2.1.4 pH of the soap:

The (ASTM) provides a standard procedure for determining the pH of soap produced from waste cooking oil, which is known as ASTM D1287-91(2015) "Standard Test Method for pH of Alkaline Detergents. "The procedure involves preparing a 10% (w/v) solution of the soap in distilled water and measuring the pH of the solution using a pH meter calibrated with buffer solutions of known pH values. The soap solution is first diluted with distilled water to obtain a pH in the range of 8 to 10, which is then adjusted to a pH of 8.5 ± 0.1 with 0.1 N hydrochloric acid or 0.1 N sodium hydroxide solution. The pH meter electrode is then immersed in the solution and allowed to stabilize, and the pH value is recorded. The measurement is repeated three times, and the average value is reported as the pH of the soap solution. The pH of soap is an important parameter as it affects the skin's natural pH balance, and soaps with a pH value of 7 or slightly acidic are considered better for the skin. Soap with a high pH value can cause irritation and dryness of the skin. Additionally, the pH value can affect the performance of the soap in cleaning, and soaps with a pH value that is too high or too low may not clean as effectively.

5.2.1.5 Moisture Content:

The moisture content in soap from waste cooking oil can be determined using the ASTM D 460-92 standard test method. The procedure involves weighing a sample of soap and heating it in an oven at a temperature of 105 ± 2 °C until it reaches a constant weight. The weight loss during the heating process indicates the amount of moisture in the sample.

Weigh a clean and dry aluminium dish to the nearest 0.0001 g and record the weight as W1.

Weigh approximately 2 g of the sample of soap to the nearest 0.0001 g into the dish. Record the weight as W2.

Place the dish with the sample into an oven and heat it at a temperature of 105 ± 2 °C for 2 hours.

Remove the dish from the oven and allow it to cool to room temperature in a desiccator.

Weigh the dish and the dried sample to the nearest 0.0001 g and record the weight as W3.

Calculate the moisture content of the sample using the following formula:

$$\text{Moisture content} = ((W2 - W3) / (W2 - W1)) \times 100$$

where:

W1 = weight of the dish

W2 = weight of the dish and the sample

W3 = weight of the dish and the dried sample

The moisture content in soap should typically be less than 10% by weight. High moisture content can lead to the growth of bacteria and mold, spoilage of the soap, and reduced shelf life.

5.2.1.6 Insoluble Matter in Alcohol:

ASTM D801-16 is the standard test method for insoluble matter in alcohol for soaps. Here is a summary of the procedure:

- Weigh about 5g of the soap sample into a 250 mL beaker.
- Add 50 mL of 95% ethanol to the beaker.
- Heat the beaker on a hot plate or water bath until the soap is completely dissolved.
- Remove the beaker from the heat source and let it cool to room temperature.
- Add 50 mL of 95% ethanol to the beaker and mix well.
- Pour the mixture through a weighed sintered glass or porcelain filtering crucible.
- Rinse the beaker with 25 mL of 95% ethanol and pour the rinse through the filter.
- Wash the residue on the filter with three 25 mL portions of 95% ethanol.
- Dry the filter and its contents in an oven at 105°C for at least 1 hour.
- Cool the filter and its contents to room temperature in a desiccator and weigh it.
- Calculate the percentage of insoluble matter in the soap sample by dividing the weight of the residue by the weight of the soap sample and multiplying by 100.

Note: The test method specifies the use of 95% ethanol, but other alcohols or solvent systems may be used if they are shown to give equivalent results.

TABLE 5.6 Properties of Soap Produced from Waste Cooking Palm Oil

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (PALM OIL)
TFM	22%
TAC	11.84%
Glycerine	9.5%
pH	7.9
Moisture Content	1.09%
Insoluble Matter in Alcohol	9%

TABLE 5.7 Properties of Soap Produced from Waste Cooking Coconut Oil

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (COCONUT OIL)
TFM	35%
TAC	8.5%
Glycerine	15.4%
pH	7.64
Moisture Content	0.98%
Insoluble Matter in Alcohol	7.34%

TABLE 5.8 Properties of Soap Produced from Waste Cooking Sunflower Oil

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (SUNFLOWER OIL)
TFM	30%
TAC	7.9%
Glycerine	14.4%
pH	6.5
Moisture Content	0.88%
Insoluble Matter in Alcohol	8.5%

TABLE 5.9 Properties of Soap Produced From cold pressed coconut Oil.

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (COCONUT OIL)
TFM	68%
TAC	10.84%
Glycerine	10.45%
pH	7.38
Moisture Content	1.09%
Insoluble Matter in Alcohol	8.04%

TABLE 5.10 Properties of Soap Produced From edible almond Oil.

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (ALMOND OIL)
TFM	65%
TAC	9.8%
Glycerine	13.4%
pH	7.64
Moisture Content	0.98%
Insoluble Matter in Alcohol	7.2%

5.3 CLEANSING EFFICIENCY:

To compare the cleansing activity between rin soap and the soap prepared from waste cooking oil with natural filler, several factors need to be considered, including the composition of the soap, the type of natural filler used, and the testing method for cleansing activity. In terms of composition, rin soap is a commercial detergent bar that contains synthetic surfactants, whereas the soap prepared from waste cooking oil with natural filler is a handmade soap that uses natural oils and lye as the primary ingredients. The addition of natural filler can enhance the cleansing activity of the soap by providing additional abrasive or absorbent properties, depending on the type of filler used. In terms of water consumption, the soap prepared from waste cooking oil with natural filler is likely to have a lower environmental impact as it is a handmade product that can be produced using less energy and water compared to the industrial manufacturing process used for rin soap. Additionally, waste cooking oil is a readily available and inexpensive raw material, which can help to reduce the environmental impact of soap production by diverting waste from landfills and reducing the need for virgin oils. In conclusion, while the composition and testing methods may differ, the soap prepared from waste cooking oil with natural filler has the potential to offer comparable or even superior cleansing activity to commercial detergents such as

rin soap, while also providing a more sustainable and eco-friendly option with lower water consumption.

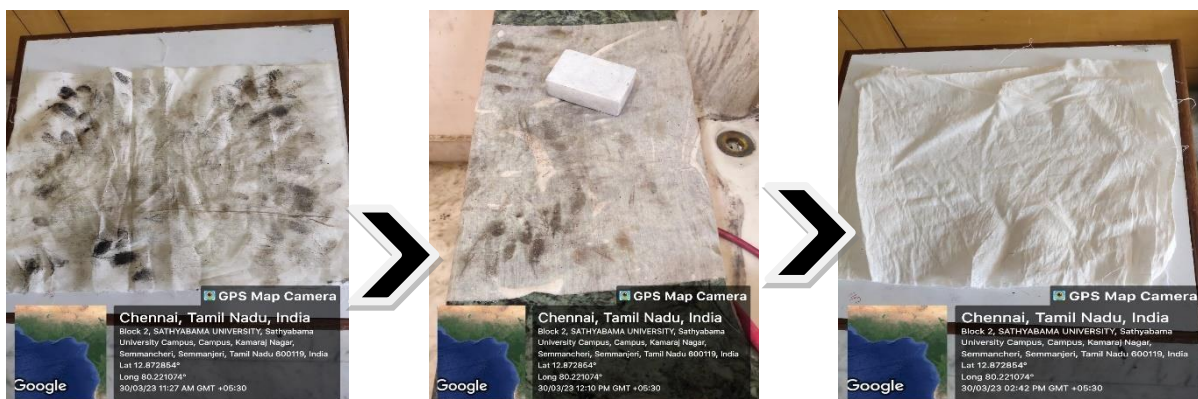


Fig 5.8: Cleaning of dirtied clothes using soap prepared by using natural filler.

5.4 COMPARITIVE STUDIES:

5.4.1: Water consumption

Water is commonly used to clean dirt and stains from clothes. When you wash your clothes with water, the water molecules help to loosen and remove dirt, sweat, and other contaminants from the fabric.

The usage of water can also vary between natural filler waste cooking oil soap and commercial soap when washing. Here are some points of comparison:

Lather: Natural filler waste cooking oil soap may produce less lather than commercial soap, which can mean that less water is needed to rinse off the soap during washing.

Residue: Commercial soap may leave behind more residue on clothes, requiring more water to remove it completely. In contrast, natural filler waste cooking oil soap may rinse off more easily, using less water during the washing process.

Water temperature: Commercial soap may require higher water temperatures to effectively dissolve and remove dirt and stains from clothes, using more energy to heat the water. Natural filler waste cooking oil soap, on the other hand, may work effectively with cooler water, using less energy overall.

Sudsing: Commercial soap may produce more suds than natural filler waste cooking oil soap, which can lead to the need for more water to rinse off the suds and any remaining soap residue.

Environmental impact: As mentioned before, natural filler waste cooking oil soap is biodegradable and will not harm the environment. Commercial soap, depending on its formulation, may contain chemicals that can harm the environment if they enter waterways.

TABLE 5.11 Water Consumption Comparison Between waste cooking oil Soap and Commercial Soap.

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPARED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED
Water Consumption for washing the clothes	1.6 litres	2 litres	1.2 litres	2.4 litres

Soap made from waste palm oil required the least amount of water (1.2 litres) for washing clothes compared to soap made from waste cooking coconut oil (1.6 litres), soap made from waste cooking sunflower oil (2 litres), and commercial soap (2.4 litres). This suggests that soap made from waste palm oil may be more efficient in terms of water usage during laundry compared to other types of soap. However, it is important to consider other factors such as the quality and effectiveness of the soap in cleaning clothes, as well as its environmental impact and sustainability.

5.4.2 pH of washed water:

To check the pH range of washed water of waste cooking oil soap and commercial soaps using ASTM method, we followed the following procedure:

- Collect a sample of the washed water from the laundry cycle that has been completed using the soap in question.
- . Using a pH meter or pH indicator strips, measure the pH of the washed water sample.
- . Follow the ASTM method for pH testing, which may involve preparing a calibration curve using standard buffer solutions of known pH, and then measuring the pH of the sample against the curve. Record the pH value obtained from the sample.
- Repeat the procedure for each type of soap being tested (waste cooking oil soap and commercial soap). Compare the pH values obtained for each type of soap and analyse the results.

TABLE 5.12 pH Comparison of Washed water

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPARED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED
pH range of washed water	7.3(at 4 th wash)	7.54(at 5 th wash)	7.44(at 4 th wash)	7.9(at 6 th wash)

Soap made from waste cooking coconut oil resulted in washed water with a pH range of 7.3 (at the 4th wash), while soap made from waste cooking sunflower oil resulted in washed water with a slightly higher pH range of 7.54 (at the 5th wash). Soap made from waste palm oil resulted in washed water with a pH range of 7.44 (at the 4th wash), and commercial soap resulted in washed water with the highest pH range of 7.9 (at the 6th wash). The pH range of the washed water can be an important factor to consider as it may affect the fabric's softness, color retention, and overall quality. Typically, a pH range of 7 is considered neutral, while values below 7 are acidic and values above 7 are basic. The results suggest that all types of soap tested resulted in washed water with a neutral to slightly basic pH range. However, it is important to note that other factors such as water hardness and fabric type may also influence the pH of washed water. Overall, the table suggests that soap made from waste cooking coconut oil resulted in washed water with a slightly lower pH range compared to the other types of soap tested, while commercial soap resulted in washed water with the highest pH range.

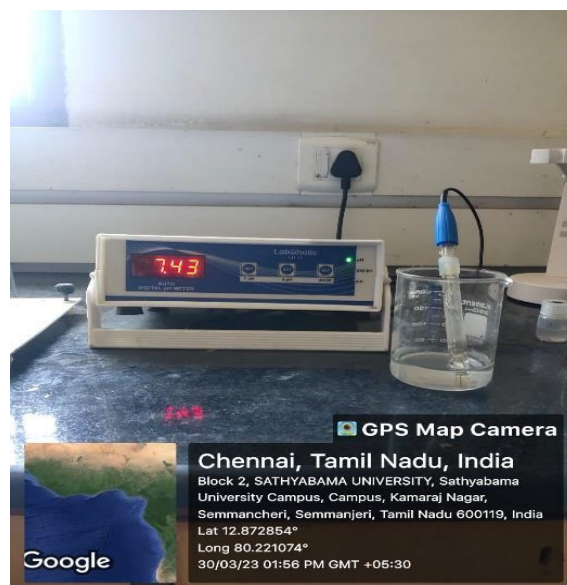
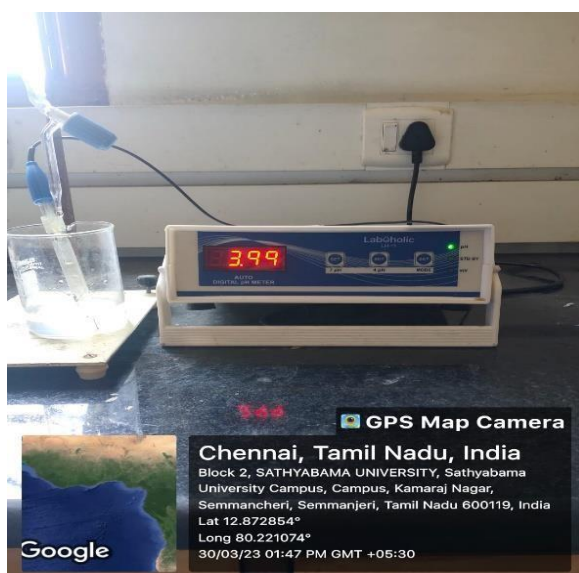


Fig 5.10: Checking pH range of washed water.

5.4.3 Alkalinity range of washed water:

To check the alkalinity range of washed water of waste cooking oil soap and commercial soaps using an ASTM method, we followed the following procedure:

- Collect a sample of the washed water from the laundry cycle that has been completed using the soap in question.
- Prepare a known volume of the washed water sample (typically 50 mL or 100 mL) in a clean glass beaker. Add a few drops of phenolphthalein indicator solution to the washed water sample.
- . Titrate the washed water sample with standardized hydrochloric acid (HCl) solution until the color of the solution changes from pink to colourless. Record the volume of HCl solution used for titration.
- Calculate the alkalinity of the washed water sample using the following formula:

$$\text{Alkalinity (mg/L as CaCO}_3\text{)} = [(\text{Volume of HCl used} \times \text{Normality of HCl} \times 50,000) / \text{Sample volume in mL}]$$

- Repeat the procedure for each type of soap being tested (waste cooking oil soap and commercial soap).
- Compare the alkalinity values obtained for each type of soap and analyze the results.

TABLE 5.13 Alkalinity Comparison of washed water

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPARED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED
Alkalinity range of used water	180mg/l (at 4 th wash)	189mg/l (at 5 th wash)	190mg/l (at 4 th wash)	280mg/l (at 6 th wash)



Fig 5.11: Checking alkalinity range of washed water.

Soap made from waste cooking coconut oil resulted in used water with an alkalinity range of 180 mg/L (at the 4th wash), while soap made from waste cooking sunflower oil resulted in used water with an alkalinity range of 189 mg/L (at the 5th wash). Soap made from waste palm oil resulted in used water with an alkalinity range of 190 mg/L (at the 4th wash), and the commercial soap resulted in used water with the highest alkalinity range of 280 mg/L (at the 6th wash). Alkalinity is a measure of the water's ability to neutralize acids, and it can affect the performance of detergents in removing dirt and stains from clothes. A higher alkalinity range may indicate that more soap is required to achieve the same level of cleaning compared to water with a lower alkalinity range. The results suggest that soap made from waste cooking coconut oil resulted in used water with the lowest alkalinity range, while commercial soap resulted in used water with the highest alkalinity range. However, it is important to note that other factors such as water hardness and detergent dosage can also influence the alkalinity of the used water. Overall, the table suggests that the type of oil used to make soap can affect the alkalinity range of the used water during laundry, with waste cooking coconut oil soap resulting in the lowest alkalinity range.

5.4.4 Turbidity range of washed water:

The ASTM method for measuring turbidity in washed water involves using a nephelometer, which is a device that measures the amount of light scattered by suspended particles in the water.

To check the turbidity range of washed water of waste cooking oil soap and commercial soaps using the ASTM method, the following steps can be taken:

- Collect a sample of the washed water from the washing machine after the clothes have been washed with the soap.
- Pour the sample into a clean, clear glass container.
- Insert the nephelometer probe into the sample and turn on the device.
- Record the turbidity reading displayed on the device.
- Repeat steps 1-4 for each soap sample being tested.

The results obtained will show the turbidity range of the washed water for each soap sample tested.

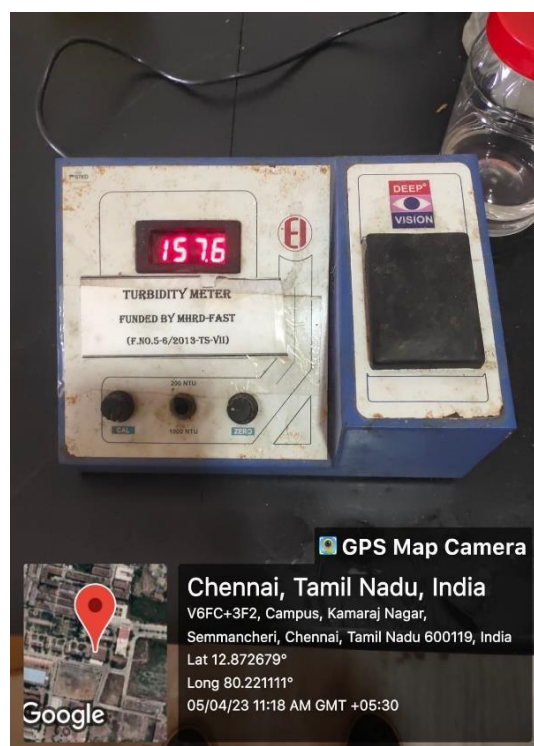
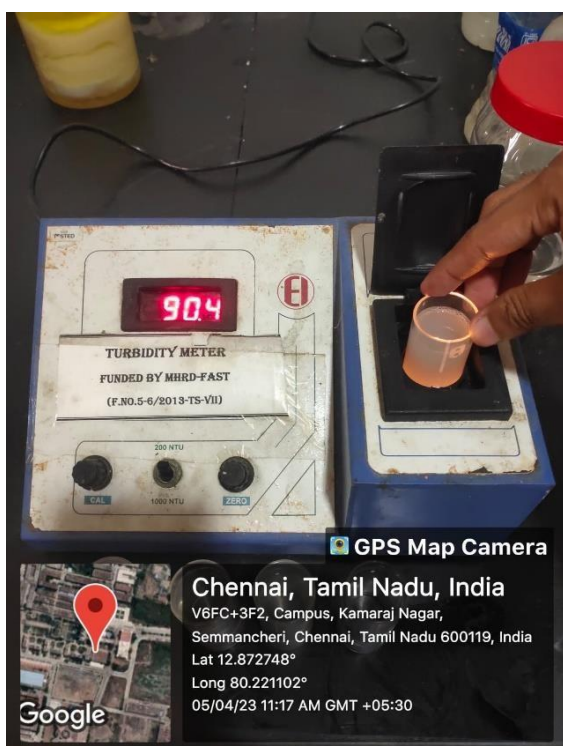


Fig 5.11: Checking turbidity range of washed water.

TABLE 5.14 Turbidity range Comparison of washed water

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPARED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED
Turbidity of used water	-01.7 NTU (at 4 th wash)	-02.1 (at 5 th wash)	-02.23 (at 4 th wash)	-03.8 NTU (at 6 th wash)

From above discussions, it can be inferred that the turbidity of the washed water for all soap samples is exceptionally low, as indicated by the negative values. This suggests that the water is clear and contains very few suspended particles. Among the soap samples, the waste cooking coconut oil soap had the lowest turbidity reading at the 4th wash, followed by the waste cooking sunflower oil soap and waste palm oil soap, while the commercial soap had the highest turbidity reading at the 6th wash. The comparison of different types of soaps prepared from waste cooking oils and a commercial soap based on their performance in terms of water consumption, pH, alkalinity, and turbidity of the washed water revealed several interesting findings. Firstly, the waste cooking coconut oil soap and waste palm oil soap consumed less water compared to the commercial soap, which could be attributed to the composition of the soap and the ability of the soap to generate suds. Secondly, all soap samples showed a similar pH range in the washed water, indicating that they were all effective in removing soil and dirt from the clothes without altering the pH of the water significantly. Thirdly, the waste cooking sunflower oil soap showed higher alkalinity in the washed water compared to the other soap samples, which could be attributed to the presence of residual fatty acids in the soap. Finally, all soap samples showed very low turbidity readings in the washed water, suggesting that they were all effective in removing suspended particles from the water and leaving it clear. Overall, the comparison suggests that soaps prepared from waste cooking oils can be a sustainable and effective alternative to commercial soaps in terms of their performance in washing clothes and reducing water consumption.

5.5 LIVELIHOOD ENHANCEMENT OF SHG WOMEN:

The term "livelihood enhancement" refers to activities or programs that aim to improve the economic well-being and social status of individuals or communities. These activities may include promoting entrepreneurship, skill development, providing access to credit, creating employment opportunities, and improving market linkages. The objective is to enable individuals or communities to have sustainable livelihoods that can help them improve their standards of living, reduce poverty, and achieve economic independence. Livelihood enhancement programs are often targeted at disadvantaged and marginalized groups, such as women, youth, and rural communities. In this case, the program is focused on enhancing

the livelihoods of Self-Help Group (SHG) women through the production of waste cooking oil soaps. Waste cooking oil is a by-product of cooking and is often discarded as waste. By using this waste cooking oil to produce soap, the SHG women can generate income and contribute to the local economy. This program not only provides a source of income for the SHG women but also helps to reduce environmental pollution by promoting the recycling of waste cooking oil. About 15 Self-Help Group (SHG) women from kumizhi village were identified and were trained to make detergent soap from waste cooking oil. They were given guidance to market the soap and enhance their livelihood.



Fig.5.12: Soap produced by SHG women in kumizhi village, Chengalpattu.

5.6 COST ESTIMATION:

5.6.1 Raw Material:

Table 5.15 Cost Estimation of Production of soap from waste cooking oil.

Name of the oil	Details	Price of Source
Waste Cooking Palm Oil	Local Restaurant, Chengalpattu	Rs 7/-
Waste Cooking Coconut Oil	Kumar Bakery, Chengalpattu	Rs 5/-
Waste Cooking Sunflower Oil	AS Sweets and Bakery, Chennai	Rs 4/-
Kaolin Clay	Ashoka Marketing Agencies	Rs 4/-
Fragrance for Soap	S.S Perfumes, Chennai	Rs 1/-
Cold pressed Coconut oil	S.A oils, Chengalpattu	Rs 4/-
Edible Almond oil	S.A oils, Chengalpattu	Rs 2/-
Utilities	Water, Equipments, Chemicals	-
Miscellaneous Cost	Packing & Transporting	-

CHAPTER 6

SUMMARY AND CONCLUSION

In conclusion, the validation of oil sources for soap production using GC-FID is an effective method for determining the fatty acid composition of different oils. By analyzing the retention times and types of fatty acids present in each oil sample, it is possible to identify and compare their quality and suitability for soap production. This information can be used to optimize soap formulations and ensure consistent quality in the final product. Additionally, the use of GC-FID for oil validation is a reliable and cost-effective technique that can be easily implemented in soap manufacturing facilities. Overall, this method can contribute to the development of more sustainable and efficient soap production processes. Based on the GC-FID analysis of the soap samples, it can be concluded that the saponification process was successful in converting the different types of fatty acids present in the oil sources into their corresponding soap products. The retention times and peak areas of the fatty acid methyl esters obtained from the soap samples matched with those of the pure standards, indicating the presence of the expected fatty acid compositions in the soap samples. The results also suggest that the type and proportion of the fatty acids present in the oil sources used for soap production can significantly affect the properties of the resulting soap products. Hence, careful selection of oil sources with desired fatty acid compositions and optimization of the saponification process parameters can be crucial in achieving soap products with desired characteristics such as good lather, cleansing ability, and skin compatibility. Based on the literature reviewed, it can be concluded that the production of soaps from waste cooking oil and medicinal extracts can be a viable option for sustainable and eco-friendly soap production. The use of waste cooking oil not only helps in reducing environmental pollution but also reduces the cost of raw materials, making the soap production process more cost-effective. Additionally, the incorporation of medicinal extracts in soap formulation can provide added health benefits to the users, such as moisturizing, antibacterial, and antifungal properties. The literature suggests that the saponification process, which is the conversion of fats and oils into soap, can be optimized by controlling process parameters such as temperature, concentration of reactants, and mixing rate. The GC-FID analysis has proven to be an effective method for determining

the quality of the soap produced, as well as the composition of fatty acids present in the soap. Overall, the production of soaps from waste cooking oil and medicinal extracts has the potential to contribute to sustainable development and create a circular economy by reducing waste and utilizing natural resources efficiently. Based on the results of the study comparing the cleansing efficiency of soaps made from waste cooking oil and commercial soaps, it can be concluded that soaps made from waste cooking oil can be a viable alternative to commercial soaps. The study showed that the soaps made from waste cooking oil had comparable or even better cleansing efficiency than the commercial soaps tested. Furthermore, the use of medicinal extracts in the soap-making process resulted in additional benefits such as antimicrobial and antioxidant properties. This suggests that the use of waste cooking oil and medicinal extracts can lead to the production of eco-friendly and potentially healthier soaps. Overall, the study highlights the potential of waste cooking oil and medicinal extracts as alternative and sustainable sources for soap production. The project has demonstrated the potential of utilizing local resources and knowledge, as well as the importance of collaboration between government agencies, NGOs, and the private sector, in creating sustainable livelihood opportunities for marginalized communities. Overall, the success of this project highlights the importance of promoting entrepreneurship and skill development among women, especially those from disadvantaged backgrounds, as a means of achieving economic empowerment and poverty reduction. The waste cooking oil soap production project can serve as a model for similar initiatives in other areas, and the lessons learned from this project can help guide the development of future livelihood enhancement programs.

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CHAPTER -1

INTRODUCTION

1.1 ORIGIN AND HISTORY OF SOAPS:

Soap has a long and interesting history, dating back to ancient civilizations. The earliest evidence of soap making comes from ancient Babylon, where a soap-like substance was made by mixing animal fats with wood ash[1]. The ancient Egyptians also made soap, using a mixture of vegetable oils and alkaline salts to create a cleansing agent. Soap making techniques spread throughout the ancient world, and by the time of the Roman Empire, soap was a widely used product. During the Middle Ages, soap making became an important industry in Europe, with soap makers forming guilds and developing new techniques. By the 18th century, soap production had become a large-scale industrial process, with the invention of the continuous soap making process and the introduction of synthetic detergents in the 20th century[2]. Soap making in China dates back to the Tang Dynasty (618-907 CE). The Chinese used vegetable oil, rice wine, and salt to make a type of soap for cleaning textiles. Soap making techniques continued to develop over time, with the use of natural ingredients such as sesame oil, camellia oil, and tea oil. During the Song Dynasty (960-1279 CE), soap making became a major industry, with soap factories established in many cities throughout China[3]. Soap was produced for both personal hygiene and cleaning and was exported to other countries such as Japan and Korea. In the Ming Dynasty (1368-1644 CE), soap making continued to develop, with the introduction of new ingredients such as honey, animal fat, and herbal extracts. Soap was used not only for personal hygiene and cleaning, but also for medicinal purposes. During the Qing Dynasty (1644-1912 CE), soap production continued to expand, with new techniques and ingredients being introduced. Soap was made from a variety of materials such as vegetable oil, animal fat, and mineral oil. The soap industry was concentrated in the cities of Shanghai, Tianjin, and Guangzhou. Since then, soap has evolved, gaining numerous types and different ingredients to make it acceptable in terms of appearance[2]. The modern skin cleansers contain skin-conditioning agents in addition to surfactants, making them more complicated than their name "soap" suggests.[4]. Over the past several thousand years, the practise of skin cleansing has advanced for therapeutic, religious, and personal sanitation purposes[5]. The oldest

evidence of soap production was discovered in Sumerian clay tablets from around 2000 B.C., soap was used to clean grease from cloth before dyeing and was created by boiling a combination of fat and wood ashes. According to the Eber's Papyrus, an Egyptian papyrus, the ancient Egyptians took regular baths and mixed animal oil and ashes as early as 1550 B.C. By 600 B.C., the Phoenicians were making soap from animal oil and tree ash. The Roman tale that made reference to Mount Sapo, where animals were sacrificed, gave soap its name[5]. Animal fat and woody ashes that had formed soap along the hillside were washed away by the rain. The Roman ladies found that using this material made washing clothes easier. Pliny the Elder, a Roman scholar, wrote in his work "Naturalis historia" from 77 AD that Gauls used tallow and ash soap to give their hair a reddish tint. [6]. By, Lever Brothers in England began importing contemporary soap. during the British period, the term "Lifebuoy" was used in India .The first soap production facility was established in 1897 in India by the Uttar Pradesh city of Meerut's North Western Soap Company.After purchasing coconut oil factories in Cochin, Kerala, Mr. Jamshedji Tata discovered a soap manufacturing facility[7]. The first commercial soap made with coconut oil debuted in the Indian market in the early 1930s.Although consumers originally only expected soap to have cleansing benefits, over time they began to expect soap to also have health and aesthetic benefits. The main component of a cleanser, known as a surface-active substance (surfactant), is what makes it foam and clear. Because of its distinctive structure with hydrophobic and hydrophilic extremities, surfactants have the capacity to reduce surface tension. The harm to the stratum corneum (SC) that results in dryness, irritation, increased transepidermal water loss, flaking, and occasionally itching is also caused by surfactant. A new generation of technologies for producing gentle and moisturising cleansers developed as the function of SC components became better understood. Surfactants come in two varieties: natural and artificial[1]. Traditional soaps, translucent bars, super-fatted soaps, and combars were created using natural surfactants. Syndet bars, however, were made using artificial detergents. It is well known that syndet bars have a considerably lower potential to irritate skin than soap made with natural surfactants[8]. Today's syndet bars are made with emollients like oils, glycerin, and petrolatum for moisturization and milder surfactants like sodium cocoyl isethionate and glycinate to minimise irritation. Because they are easy to use and are more hygienic, liquid body cleansers are very well-liked. More emollient is deposited by them than by detergent or syndet bars. The health of face

skin is the focus of facial cleansers, which occasionally have anti-aging properties. They vary from liquid body cleansers in that they have fewer emollients and milder, more expensive surfactants to prevent the heavy "after-use feel"[9]. "The growth of the soap business was primarily influenced by two factors that emerged around the turn of the 19th century. One of these was Cheverus's study into the makeup of fats, which provided science with the first real understanding of the chemical nature of fats and oils and subsequently of soap. The other was the discovery of a method for producing soda from common salt[10]. In Serenas Sammonicus' medicinal poem, soap is used to treat skin and facial blemishes . These applications demonstrate extensive experimentation and the fact that soap production was a reasonably well-known process at the time. Despite this, there is still no proof that the Romans produced or utilised soap as a cleanser. It is commonly claimed that Pompeii once housed a soap factory. This assertion first occurs in a letter Starke wrote from Italy in 1797, and it has since been made numerous times. However, Hofmann acquired a sample of the " soap " retrieved from the excavations from Presuhn in 1875. His chemical experiments demonstrated unequivocally that it was fuller's earth, which only contained a very small amount of organic matter, and that the "soap-works" were actually a fullonica. In general, the remnants of Roman boudoirs offer a wide range of cosmetics, but soap has not yet been discovered. The importance of soap by the seventh century led to the union of Italian soap makers into craft guilds, or "arti," and later, under Charlemagne, the soap maker assumed his place among the craftsmen of the vast domains[11].

1.2 FATTY ACID AND ITS APPLICATION:

Saturated fatty acids: These fatty acids are typically solid at room temperature and are found in high quantities in animal fats, such as butter and lard. However, they are also present in some vegetable oils, such as coconut and palm oil. Monounsaturated fatty

acids: These fatty acids are liquid at room temperature and are found in high quantities in olive oil, canola oil, and avocado oil. Polyunsaturated fatty acids: These fatty acids are also liquid at room temperature and are found in high quantities in vegetable oils, such as sunflower, corn, and soybean oil. They are divided into two categories: omega-3 and omega-6 fatty acids. Omega-3 fatty acids are known for their anti-inflammatory properties[12]. Here are several types of saturated fatty acids, including:

Lauric acid: Found in coconut oil, palm kernel oil.

Myristic acid: Found in dairy products, coconut oil, and palm kernel oil.

Palmitic acid: Found in animal fats, palm oil, and coconut oil.

Stearic acid: Found in animal fats, cocoa butter, and shea butter.

Saturated fatty acids have several applications in cleaning due to their ability to form soap and act as surfactants. Surfactants are compounds that lower the surface tension of liquids and are often used in cleaning products to break up and remove dirt and grease. Saturated fatty acids are commonly used to make soaps and other cleaning products, such as detergents and fabric softeners[13]. Lauric acid, for example, is known for its ability to create a rich lather and is often used in soaps, shampoos, and other personal care products. Myristic acid is commonly used in detergents and cleaning products due to its ability to form stable foam. Palmitic acid is used in the production of soaps, candles, and other cosmetic products, while stearic acid is used in the production of soaps, candles, and as a thickener in creams and lotions. Some of the unsaturated fatty acids are,

Oleic acid: Found in olive oil, canola oil, and other vegetable oils.

Linoleic acid: Found in sunflower oil, corn oil, and soybean oil.

Alpha-linolenic acid: Found in flaxseed oil, chia seed oil, and walnuts[10].

Unsaturated fatty acids also have applications in cleaning activities. Similar to saturated fatty acids, they can act as surfactants and emulsifiers, allowing them to dissolve and remove dirt and grease[14]. They are commonly used in the production of soaps, detergents, and other cleaning products. Oleic acid, for example, is commonly used in soaps and other personal care products due to its ability to soften

and moisturize the skin. It is also used as an emulsifier in cleaning products, helping to dissolve and remove grease from surfaces. Linoleic acid is often used in the production of laundry detergents due to its ability to penetrate and remove dirt and stains from fabrics. It is also used in the production of soaps and other personal care products. Alpha-linolenic acid is used in the production of eco-friendly cleaning products due to its biodegradability and low toxicity. It is often used as a solvent and emulsifier in cleaning products, allowing for effective removal of dirt and grease[15].

There are several types of polyunsaturated fatty acids, including:

Omega-3 fatty acids: Found in fish oils, flaxseed oil, and chia seeds.

Omega-6 fatty acids: Found in vegetable oils, such as sunflower, soybean, and corn oil.

Polyunsaturated fatty acids also have applications in cleaning activities. Similar to saturated and unsaturated fatty acids, they can act as surfactants and emulsifiers, allowing them to dissolve and remove dirt and grease. They are commonly used in the production of soaps, detergents, and other cleaning products[16].

Omega-3 fatty acids are often used in the production of eco-friendly cleaning products due to their biodegradability and low toxicity. They are also used as solvents and emulsifiers in cleaning products, allowing for effective removal of dirt and grease.

Omega-6 fatty acids are commonly used in the production of laundry detergents and other cleaning products due to their ability to penetrate and remove dirt and stains from fabrics. They are also used in the production of soaps and other personal care products[17].

1.3 SOURCES OF SOAPS:

1.3.1 Animal fats:

Tallow is a type of animal fat that is derived from beef or mutton. It is high in saturated fatty acids, making it a good source of stearic and palmitic acids for soap production. Lard is another type of animal fat that is derived from pigs. It is similar to tallow in

composition, with high levels of stearic and palmitic acids. Fish oil is a source of unsaturated fatty acids, particularly omega-3 fatty acids[10]. It is commonly used in soap production to add moisturizing properties to the final product. Lanolin is a wax-like substance that is derived from sheep's wool. It is a good source of fatty acids and is commonly used in soaps and cosmetics to add emollient properties. Beeswax is a natural wax that is produced by honeybees. It is commonly used in soap production to add hardness and a mild honey-like sent to the final product[18]Chicken fat, also known as schmaltz, is a by-product of poultry processing and is commonly used in soap production as a source of oleic and palmitic acids.[12]

1.3.2 Vegetable oils:

Vegetable oils are a common source of fatty acids used in soap production. Coconut oil is a popular choice for soap making due to its high levels of lauric acid, which contributes to a hard bar of soap with good lather[19]. Olive oil is a staple in Mediterranean cuisine and is a great source of oleic acid, which contributes to a moisturizing bar of soap. Palm oil is a versatile vegetable oil that is commonly used in soap making due to its high levels of stearic acid, which contributes to a hard bar of soap with good lather[20]. Castor oil is a unique vegetable oil that is high in ricinoleic acid, which contributes to a creamy lather and moisturizing properties in soap. Shea butter is a vegetable fat that is extracted from the nuts of the shea tree. It is high in oleic and stearic acids, making it a great ingredient for soap making to add moisturizing and emollient properties. Sunflower oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of linoleic acid, which contributes to a gentle and moisturizing bar of soap. Canola oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of oleic and linoleic acids, which contribute to a gentle and moisturizing bar of soap. It is also a sustainable and renewable vegetable oil source[21]. Grapeseed oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of linoleic acid, which contributes to a gentle and moisturizing bar of soap. It also has antioxidant properties and can help improve the appearance of skin. Avocado oil is a rich and moisturizing oil that is commonly used in soap making due to its high levels of oleic acid, which contributes to a gentle and moisturizing bar of soap. It is also high in vitamin E and can help soothe dry and irritated skin[22]. Rice bran oil is a light and moisturizing oil that is commonly used in soap making due to its high levels of oleic and linoleic acids, which contribute to a

gentle and moisturizing bar of soap. It is also high in antioxidants and can help improve the appearance of skin. Hemp seed oil is a rich and moisturizing oil that is commonly used in soap making due to its high levels of omega-3 and omega-6 fatty acids, which contribute to a gentle and moisturizing bar of soap. It is also high in antioxidants and can help soothe dry and irritated skin[9].

1.3.3 Seaweed sources:

Kelp is a type of brown seaweed that is rich in vitamins and minerals, including iodine, magnesium, and calcium. It is commonly used in soap making for its moisturizing and exfoliating properties[23]. Nori is a type of red seaweed that is commonly used in sushi. It is also a popular ingredient in soap making due to its elevated levels of vitamin A and amino acids, which can help to improve skin texture and tone. Dulse is a type of red seaweed that is rich in antioxidants and can help to protect the skin from environmental stressors. It is also high in vitamins B6 and B12, which can help to improve skin health and reduce the appearance of fine lines and wrinkles[24]. Wakame is a type of brown seaweed that is commonly used in Japanese cuisine. It is also a popular ingredient in soap making due to its high levels of vitamins and minerals, including calcium, iron, and iodine, which can help to improve skin hydration and elasticity. Irish moss is a type of red seaweed that is commonly used in soap making for its natural emollient and skin-soothing properties[16]. It can help to reduce inflammation and soothe dry, irritated skin. Spirulina is a type of blue-green algae that is commonly used in soap making for its elevated levels of antioxidants and anti-inflammatory properties. It can help to protect the skin from damage caused by environmental stressors and reduce inflammation in the skin[25].

1.3.4 Soapwort:

Soapwort is a plant species that has been used for centuries as a natural source of soap. There are two main types of soapworts that are commonly used in soap production. Common Soapwort (*Saponaria officinalis*) most commonly used type of soapwort in soap production[26]. It contains natural saponins, which are soap-like substances that can be extracted from the plant by boiling it in water. The resulting liquid can be used as a natural soap for washing clothes, dishes, and even the skin. Bouncing Bet (*Saponaria officinalis* var. *pratensis*) is a variety of soapwort that is native to Europe and has natural saponins that make it useful for soap making. It is

often used in herbal remedies and can be used to create a natural soap that is gentle on the skin. Both types of soapworts contain saponins, which are natural surfactants that can be used to create a lather and remove dirt and oil from the skin[26]. In addition to soap making, soapwort has also been used for medicinal purposes, including treating skin conditions like eczema and psoriasis. It's worth noting that while soapwort can be used to create a natural soap, it is not as effective as commercial soap when it comes to killing bacteria and other germs. If you're looking to create a soap that is both natural and effective at killing germs, you may want to consider adding essential oils or other natural antimicrobial agents to your soap recipe[27]. Rock Soapwort (*Saponaria ocymoides*) is a variety of soapwort is native to Europe and Asia and is often used in rock gardens and as a groundcover. Its leaves and roots contain saponins, which can be used to create a natural soap. Large-flowered Soapwort (*Saponaria x lempergii*) is a hybrid species of soapwort that is a cross between *Saponaria officinalis* and *Saponaria vaccinia*[28]

1.4 TYPES OF SOAPS

1.4.1 Based on Composition:

1.4.1.1 Bar Soaps:

Bar soap is a type of soap that is solid and has a shape that is convenient for handling and storage. It is made by mixing oils or fats with an alkali (such as sodium hydroxide or potassium hydroxide) and water, which causes a chemical reaction called saponification. During this process, the oils or fats are converted into soap molecules, which are able to trap dirt, oil, and other impurities and remove them from the skin. Bar soaps can be made using a variety of oils and fats, including animal fats, vegetable oils, and specialty oils like coconut oil, olive oil, and shea butter. Each type of oil or fat has its own unique properties that can affect the texture, scent, and cleansing ability of the soap[29].

1.4.1.2 Liquid soaps:

Liquid soap is a type of soap that is formulated as a liquid rather than a solid bar. It is made by mixing oils or fats with an alkali (such as sodium hydroxide or potassium hydroxide) and water, which causes a chemical reaction called[30] saponification. The resulting soap molecules are then diluted with additional water or other ingredients to

create a liquid soap. Liquid soaps can be made using a variety of oils and fats, including animal fats, vegetable oils, and specialty oils like coconut oil, olive oil, and shea butter. Each type of oil or fat has its own unique properties that can affect the texture, scent, and cleansing ability of the soap.

1.4.1.3 Castile soaps:

Castile soap is a type of soap that originated in the Castile region of Spain, which is known for its olive oil production. It is made using a combination of olive oil, water, and lye (sodium hydroxide), and does not contain any animal fats or synthetic detergents. This makes it a popular choice for vegans and those with sensitive skin. One of the main benefits of castile soap is its mildness. It does not contain harsh detergents or other irritants, making it gentle enough for use on sensitive skin[31]. Castile soap also produces a rich, creamy lather that can be used for a variety of purposes, including hand and body washing, shampooing, and even household cleaning. Castile soap is often marketed as an all-purpose cleaner due to its versatility. It can be used for cleaning floors, countertops, and other surfaces, as well as for washing dishes and laundry. Some people even use it as a natural insecticide or pesticide. Castile soap is available in both bar and liquid form, and can be scented or unscented. It is important to note that while castile soap is generally considered safe and gentle, it can still cause irritation or allergic reactions in some individuals. It is always recommended to patch test a small area of skin before using any new soap or skincare product[32].

1.4.1.4 Glycerine soaps:

Glycerine soap is a type of soap that contains glycerine, a natural byproduct of the saponification process. Glycerine is a humectant, which means it draws moisture from the air and helps to keep skin hydrated. This makes glycerine soap a popular choice for those with dry or sensitive skin. Glycerine soap is typically made using a combination of oils, lye, and glycerine[33]. The glycerine is often added back into the soap after saponification to ensure that it retains its moisturizing properties. Glycerine soap can be scented or unscented, and may contain added ingredients like essential oils, botanical extracts, or exfoliants. One of the main benefits of glycerine soap is its gentle, moisturizing properties. It is often used to soothe and hydrate dry, itchy skin, and can be beneficial for conditions like eczema and psoriasis. Glycerine soap can

also help to balance the skin's natural oils, making it a good choice for those with oily or acne-prone skin[34]. Overall, glycerine soap is a gentle, moisturizing option for those seeking a natural alternative to traditional soaps. Its hydrating properties make it a popular choice for those with dry or sensitive skin, and it can be easily customized to suit individual preferences and needs[33].

1.4.1.5 Antibacterial soaps:

Antibacterial soap is a type of soap that is formulated with active ingredients that are designed to kill or inhibit the growth of bacteria. The most common active ingredient in antibacterial soaps is triclosan, although some brands may use other ingredients like benzalkonium chloride or chlorhexidine. One of the main benefits of antibacterial soap is its ability to help reduce the spread of harmful bacteria and viruses[35]. This is particularly important in settings like hospitals, schools, and other public places where the risk of infection is high. Antibacterial soap can also be beneficial for individuals with weakened immune systems or those who are more susceptible to infections. Overall, antibacterial soap can be a useful tool in reducing the spread of harmful bacteria and viruses, but it should be used with caution and only as directed[8]. Regular soap and water are still considered the most effective method for preventing the spread of illness and infection. It is important to note that while antibacterial soap can be effective at killing bacteria, it may also strip the skin of its natural oils and cause dryness or irritation. It is recommended to use antibacterial soap sparingly and to follow up with a moisturizer to help protect the skin[36].

1.4.1.6 Sulphur soaps:

Sulfur soap is a type of soap that contains sulfur as its main active ingredient. Sulfur has a long history of use in skincare, dating back to ancient times, and is known for its antibacterial, antifungal, and antiparasitic properties. Sulfur soap is commonly used to treat various skin conditions, including acne, rosacea, and seborrheic dermatitis. One of the main benefits of sulfur soap is its ability to control excess oil production in the skin. Excess oil can clog pores and contribute to the development of acne and other skin conditions. Sulfur soap works by reducing oil production and helping to exfoliate dead skin cells, which can also contribute to clogged pores. Sulphur soap is also effective at treating acne. Sulfur has antibacterial properties that can help kill the bacteria that contribute to acne breakouts. Additionally, sulfur can help to reduce

inflammation and redness associated with acne, making it a popular choice for those with inflammatory acne. Sulfur soap can also be beneficial for those with seborrheic dermatitis, a condition that causes scaly patches on the skin, particularly on the scalp and face. Sulfur soap can help to reduce the severity of symptoms and promote healing[30].

1.4.2 Based on Application

Bath soap is a type of soap that is specifically formulated for use in the bath or shower. It is designed to cleanse the skin of dirt, oil, and other impurities while also leaving the skin feeling soft and hydrated. Bath soap is typically made from a combination of fats or oils, such as coconut oil or palm oil, and an alkali, such as sodium hydroxide. This process is called saponification, and it results in the formation of soap molecules that are able to dissolve dirt and oil. Many bath soaps also contain other ingredients to help improve the skin's appearance and texture.

1.4.2.1 Hand soap:

Hand soap is a type of soap that is specifically formulated for use on the hands. It is designed to cleanse the skin of dirt, oil, and other impurities while also leaving the hands feeling soft and hydrated. Hand soap is typically made from a combination of fats or oils, such as coconut oil or palm oil, and an alkali, such as sodium hydroxide. This process is called saponification, and it results in the formation of soap molecules that are able to dissolve dirt and oil. Hand soap can come in many different forms, including bar soap, liquid soap, and foaming soap. Bar soap is a solid block of soap that is typically used by wetting it with water and rubbing it onto the hands. For example, some soaps may contain moisturizing ingredients like glycerin or shea butter, which can help to hydrate the skin and prevent dryness. Other soaps may contain antibacterial ingredients like triclosan or benzalkonium chloride, which can help to kill bacteria on the skin and prevent the spread of germs. It is important to choose a hand soap that is appropriate for your skin type. Those with dry skin may want to choose a soap that contains moisturizing ingredients, while those with sensitive skin may want to choose a soap that is fragrance-free.

1.4.2.2 Shampoo bar:

Shampoo bars are a type of solid shampoo that is used to cleanse the hair. They are made from a combination of ingredients, such as oils, butters, and natural surfactants, that work together to create a lather that cleanses the hair and scalp. Shampoo bars are becoming increasingly popular because they are more eco-friendly than traditional liquid shampoos[5]. They are typically packaged in biodegradable or recyclable materials, and they don't require plastic bottles or excess packaging. One of the key benefits of shampoo bars is that they can last much longer than liquid shampoos since they are more concentrated and do not contain water. This means that a single shampoo bar can replace multiple bottles of liquid shampoo, making it a more cost-effective and sustainable option. To use a shampoo bar, you simply wet your hair and rub the bar directly onto your scalp and hair. Work the lather into your hair, then rinse thoroughly[37].

1.4.2.3 Dish soaps:

Dish soap, also known as dishwashing liquid or detergent, is a cleaning product used to wash dishes, utensils, and cookware. It is formulated to cut through grease and food residue, making it effective at removing tough stains and leaving dishes clean and shiny[19]. Dish soaps are typically made from a combination of surfactants, which are compounds that reduce the surface tension of water and help to break down oils and fats. They may also contain other ingredients, such as enzymes, preservatives, and fragrances, depending on the brand and formulation. To use dish soap, you simply add a small amount to a sink or basin filled with warm water, then wash your dishes using a sponge or brush[13]. Rinse the dishes thoroughly with clean water, and then dry them with a towel or allow them to air dry. One of the key benefits of dish soap is its ability to effectively remove grease and food residue, even from tough-to-clean surfaces like pots and pans. It also helps to prevent the growth of bacteria and other microorganisms that can thrive on dirty dishes, helping to keep your kitchen clean and hygienic. When choosing a dish soap, it's important to look for one that is effective at cutting through grease and food residue, but also gentle enough to use on a variety of surfaces. Some dish soaps may be too harsh for delicate dishes or surfaces, so it's important to read the label and choose a product that is appropriate for your needs[16].

1.4.2.4 Speciality soaps:

Specialty soaps are types of soaps that are designed for specific purposes beyond basic cleaning. They may contain specialized ingredients that offer additional benefits such as moisturizing, exfoliating, or addressing certain skin conditions[33]. Moisturizing soap is type of soap is designed to hydrate and nourish the skin. It may contain ingredients such as shea butter, cocoa butter, or glycerin that help to lock in moisture and prevent dryness. Exfoliating soaps contain abrasive materials such as ground coffee, oatmeal, or pumice that help to remove dead skin cells and leave the skin feeling smooth and refreshed. Antifungal soaps are designed to help prevent or treat fungal infections on the skin, such as athlete's foot or ringworm[25].

1.5 VALIDATION OF SOURCES:

Validation of sources for soap production involves verifying that the ingredients meet certain standards and possess the desired properties. Some of the properties are oil and fats, essential oils, colorants, fragrance and other additives. The properties of oils and fats that are typically validated include their fatty acid composition, iodine value, and acid value. These properties determine the lathering, cleansing, and conditioning properties of the soap. Essential oils used in soap making are validated for their therapeutic properties, fragrance, and stability. They are tested for purity, potency, and quality. Colorants used in soap making are validated for their stability, solubility, and compatibility with the soap base. They are tested for any potential health risks, as well as for their environmental impact. Fragrances are validated for their aroma, stability, and compatibility with the soap base. They are tested for potential health risks, as well as for their environmental impact. Other additives, such as exfoliants and moisturizers, are validated for their safety, effectiveness, and compatibility with the soap base[9].

1.5.1 Validation of oils:

The validation of oil sources for soap production involves verifying that the oils possess certain properties that are desirable for soap making. There are some key properties that are typically validated for oil sources used in soap making: Fatty acid composition, Iodine value, Acid value, Peroxide value, colour and Odor, Sustainability. The fatty acid composition of the oil determines the lathering, cleansing, and conditioning properties of the soap[38]. The fatty acid profile should be balanced, with a mixture of saturated and unsaturated fatty acids. The iodine value measures the degree of unsaturation in the fatty acids of the oil. Oils with a high iodine value are more unsaturated and

produce soap with more conditioning properties, while oils with a low iodine value produce soap with more cleansing properties. The acid value measures the amount of free fatty acids in the oil. High levels of free fatty acids can lead to soap that is too harsh and drying on the skin. The peroxide value measures the degree of rancidity in the oil. Oils with a high peroxide value should be avoided, as they can produce soap with an unpleasant odor. The color and odor of the oil can affect the final color and fragrance of the soap. It is important to ensure that the oil is free of any rancid or off-odors that could affect the quality of the soap. The sustainability of the oil source should also be considered. Oils that are sustainably sourced and produced have a lower environmental impact and are more socially responsible[21].

1.5.1.1 Iodine value:

The iodine value is a measure of the unsaturation of a fat or oil, which is an important property to consider when selecting sources for soap production. Iodine value is defined as the amount of iodine, in grams, that is absorbed by 100 grams of fat or oil.[39] The iodine value is an indication of the number of double bonds present in the fatty acid chains of the oil or fat. Oils and fats with high iodine values have more unsaturated fatty acids and are more reactive, while oils and fats with low iodine values have more saturated fatty acids and are less reactive. For soap production, oils and fats with a range of iodine values can be used, but it is important to consider the properties of the final soap product. Oils and fats with high iodine values produce softer and more moisturizing soaps, while oils and fats with low iodine values produce harder and more cleansing soaps. Soap makers can select oils and fats with specific iodine values to achieve the desired properties for their soap. For example, oils with high iodine values such as soybean oil or sunflower oil can be used to create a more moisturizing soap, while oils with low iodine values such as coconut oil or palm oil can be used to create a harder, more cleansing soap.

1.5.1.2 Acid value:

The acid value is an important property to consider when selecting sources for soap production. It is a measure of the amount of free fatty acids in a fat or oil, which is an indication of the oil or fat's quality and suitability for use in soapmaking. In the context of soap production, the acid value is particularly important because free fatty acids can negatively impact the quality of the final product. When free fatty acids react with an

alkali, such as sodium hydroxide (NaOH), during the soapmaking process, they can result in the formation of excess soap and may cause the soap to be brittle, crumbly, or discolored. To determine the acid value of a fat or oil, a sample is first dissolved in a solvent, such as ethanol, and then titrated with a standard solution of potassium hydroxide (KOH). The acid value is calculated based on the amount of KOH required to neutralize the free fatty acids in the sample. Oils and fats with low acid values are preferred for soapmaking, as they contain fewer free fatty acids and are less likely to negatively impact the quality of the final product. However, some oils and fats naturally contain higher levels of free fatty acids and can still be used in soapmaking by adjusting the amount of alkali used to saponify the oil or fat.

1.5.1.3 Moisture content:

Moisture content is an important property to consider when selecting sources for soap production. Moisture content refers to the amount of water present in a raw material, such as a fat or oil. In soap production, high moisture content can negatively impact the quality of the final product by causing problems such as rancidity, spoilage, and reduced shelf life. Ideally, oils and fats used in soap production should have a low moisture content. This helps to ensure that the raw material is stable and will not spoil or deteriorate during storage or processing. High moisture content can also affect the saponification process, leading to inconsistencies in the final product's quality and performance. It's important to note that moisture content can vary depending on the source of the fat or oil, as well as the conditions under which it was harvested and processed. For this reason, it's important to test the moisture content of each batch of raw materials to ensure that they meet the desired specifications for use in soap production.

1.5.1.4 pH Value:

pH is an important property to consider when selecting sources for soap production. pH refers to the level of acidity or alkalinity of a substance, and it is measured on a scale of 0 to 14. A pH of 7 is considered neutral, while pH levels below 7 are acidic and pH levels above 7 are alkaline. In soap production, the pH of the raw materials can affect the saponification process, which is the chemical reaction that converts fats and oils into soap. The ideal pH range for soap production is typically between 9 and 10, as this is the range in which the saponification reaction occurs most efficiently. It's

important to note that the pH of oils and fats can vary depending on their source and processing methods. For example, some oils may have a naturally lower or higher pH due to the presence of organic acids or other compounds. Additionally, the pH can be affected by the conditions under which the oil or fat was harvested and processed, such as exposure to air, light, or heat.

1.5.1.5 Saponification value:

Saponification value (SV), also known as the "Koettstorfer value," is a measure of the amount of alkali needed to completely saponify a certain amount of fat or oil. In other words, it is a measure of the amount of fatty acids present in the oil or fat that can react with an alkali to form soap. The saponification value is expressed in milligrams of potassium hydroxide (KOH) required to saponify one gram of fat or oil.

1.6 ANALYTICAL CHARACTERIZATION OF SOURCES:

1.6.1 GC-MS:

Gas chromatography-mass spectrometry (GC-MS) is a powerful analytical technique used to identify and quantify the chemical composition of complex mixtures. GC analysis: The oil sample is then analyzed using gas chromatography (GC) to separate the individual components of the oil based on their boiling points and other physical properties. The resulting chromatogram provides a detailed profile of the fatty acid composition of the oil. MS analysis: The separated components are then analyzed using mass spectrometry (MS) to identify the individual compounds present in the oil. This allows for the detection of any impurities or contaminants that may be present. Data analysis: The data obtained from the GC-MS analysis is then analyzed and compared to established standards for the fatty acid composition of the particular oil source. Any deviations from the expected profile can indicate the presence of impurities or adulterants. Overall, GC-MS analysis provides a reliable and accurate method for validating oil sources for soap production by confirming the purity and quality of the oil sample[9].

1.6.2 GC-IRMS:

Gas Chromatography Isotope Ratio Mass Spectrometry (GC-IRMS) is a technique used to determine the isotopic composition of a sample. It is commonly used for the validation of oil sources for soap production to ensure the authenticity and quality of the oils. GC-IRMS works by separating the compounds in the oil sample using gas chromatography, which separates the compounds based on their physical properties. The separated compounds are then introduced into the IRMS, where the isotopic composition of each compound is measured. Each element has multiple isotopes, and the ratio of these isotopes can vary depending on the source of the compound. For example, the carbon in plants has a slightly different isotopic composition than the carbon in fossil fuels. By analysing the isotopic ratios of the compounds in the oil sample, GC-IRMS can provide information about the source and authenticity of the oil. In the case of soap production, GC-IRMS can be used to validate the source of the vegetable oils used in soap making. For example, if a soap maker claims to use only organic olive oil in their soap, GC-IRMS can confirm the authenticity of the oil by analysing its isotopic composition. This technique can also be used to detect adulteration or contamination in the oil source, which can affect the quality and properties of the final soap product.[29]

1.6.3 GC-FID:

GC-FID (Gas Chromatography-Flame Ionization Detection) is another analytical method used to validate oil sources for soap production. This technique is used to determine the types and amounts of fatty acids in the oil samples. During the GC-FID process, the oil sample is first vaporized and then injected into the GC column, which separates the individual fatty acid components based on their physical and chemical properties. The separated components are then detected by a flame ionization detector (FID), which produces a signal proportional to the amount of fatty acid present in the sample. The resulting data can be used to determine the fatty acid composition of the oil sample, which is important for determining its suitability for soap production. FID is a highly sensitive and accurate method for analysing the fatty acid composition of oil sources. It is especially useful for analysing oil samples that contain a complex mixture of fatty acids, such as vegetable oils. The results obtained from GC-FID can be used to compare different oil sources and to ensure that the oil used for soap production is of high quality and meets the desired specifications.

1.7 TYPES OF SOAP MAKING PROCESS:

1.7.1 Cold process :

Cold process soap making is a method of creating soap from scratch using oils, lye, and water. It is called a cold process because no external heat source is used to speed up the saponification process. Instead, the soap is left to cure and harden over several weeks[40]. The first step in cold process soap making is measuring and mixing the oils, lye, and water. The oils are typically melted and mixed together, and then the lye is slowly added to the water while stirring. Once both the oil mixture and lye solution are at the correct temperature, they are mixed together[41]. After the oils and lye solution are mixed, the mixture is stirred until it reaches trace. Trace is the point where the mixture has thickened to the point that when the stirring utensil is lifted out of the mixture, it leaves a visible trace behind. This is the point where any fragrance or colour additives can be added. Pouring and Molding: Once the mixture has reached trace and any additives have been added, the soap is poured into molds[42]. The molds can be made of a variety of materials, but silicone and plastic molds are popular options. The soap is left to cool and harden in the mould for several hours. After the soap has hardened in the mould, it is removed and cut into bars. The bars are then left to cure for several weeks, typically on a drying rack or in a ventilated area. During the curing process, the soap will continue to harden and any excess moisture will evaporate. Once the soap has fully cured, it can be packaged and used or sold. It is important to store the soap in a cool, dry place to prevent it from becoming soft or losing its scent[43].

1.7.2 Hot process :

Hot Process Soap Making is another method of making soap. Unlike cold process soap making, this method involves heating the soap mixture in order to speed up the saponification process. The hot process soap making method has been around for centuries and was often used to make soap before the cold process soap making method was invented. Just like with cold process soap making, you will need to gather all of your ingredients before you begin. This includes oils, lye, water, fragrances, and any colorants you plan to use. In hot process soap making, the lye and water are mixed together in a separate container from the oils. The mixture is then set aside to cool. While the lye mixture is cooling, you can start melting and mixing your oils. Once your

oils are melted and mixed, you can add any fragrances or colorants. Once the lye mixture has cooled down to about 120-130°F, you can slowly pour it into the oils[44]. Be sure to mix the two mixtures together thoroughly. Once the mixture is combined, it is time to start cooking the soap. You will need to heat the mixture to about 170-180°F and stir it frequently. The soap will start to thicken and turn translucent. At this point, you can add any additional fragrances or colorants. You can test the soap by using a pH strip to make sure it is fully saponified. Once it is fully saponified, it should have a pH of around 9-10. Once the soap is ready, you can pour it into moulds and let it cool. After it has cooled, you can remove it from the moulds and let it cure for several weeks before using it[43].

1.7.3 Melt and pour soap making process:

Melt and pour soap making is a popular method that involves melting a pre-made soap base and adding colorants, fragrances, and other additives to create unique soap bars. This method is popular among beginners and those who do not want to handle lye, a caustic chemical used in other soap-making processes. The process involves melting a pre-made soap base, usually made of glycerine, coconut oil, palm oil, or other ingredients, in a double boiler or microwave[45]. Once melted, colorants, fragrances, and other additives can be mixed in, and the soap can be poured into moulds to cool and harden. Melt and pour soap making offers a lot of creative freedom and versatility, as different soap bases and additives can be combined to create unique colours, scents, and textures. This method is also relatively quick and easy compared to other soap-making methods, as there is no need for curing or waiting for the soap to harden[46].

1.7.4 Rebatching process:

Rebatching is a soap making method that involves taking already made soap and grating or shredding it into small pieces. These small pieces of soap are then melted down and re-blended with additional ingredients before being poured into moulds to form new bars of soap. The process of rebatching is often used to salvage a batch of soap that did not turn out quite as planned[45]. For example, if a soap maker forgot to

add a fragrance or colorant, they can rebatch the soap and add those missing ingredients[47]. Rebatching can also be used to create a custom soap recipe by combining different types of soap or adding in additional ingredients like herbs, essential oils, or exfoliants. To rebatch soap, the grated soap is usually melted down in a double boiler or slow cooker until it reaches a thick, pudding-like consistency. Additional ingredients can then be added, such as essential oils, colorants, and exfoliants. The soap mixture is then stirred until all the ingredients are fully blended, and then poured into molds to cool and harden. While rebatching can be a useful method for salvaging soap batches, it does have some drawbacks[48]. The resulting bars of soap may have a slightly uneven texture or appearance, and the rebatching process can cause some loss of fragrance or other beneficial properties. Additionally, rebatched soap may not lather or perform as well as soap made using other methods.

1.7.5 Saponification process:

Saponification is the chemical process by which oils, fats, or fatty acids are converted into soap and glycerin. The process involves a reaction between the fatty acids and an alkali, typically sodium hydroxide (NaOH) or potassium hydroxide (KOH), to produce soap molecules and glycerin. This reaction is also called alkaline hydrolysis. The saponification process involves several stages. The first step in the saponification process is to weigh out the correct number of oils or fats and the correct amount of alkali needed to create the soap. The oils or fats and alkali are then mixed together in a large container, such as a stainless steel pot, and heated to a specific temperature, usually between 120-140°F (49-60°C)[49]. The mixture is stirred continuously until the oils and alkali are fully emulsified and have formed a thick, creamy consistency. The point at which the mixture thickens and becomes creamy is called trace. This is an important stage in the saponification process, as it indicates that the oils and alkali have fully reacted and that the soap is beginning to form. Once the mixture has reached trace, it is poured into molds and left to cool and harden[50]. The molds can be made of various materials such as silicone, plastic, or metal. After the soap has been poured into molds, it is left to cure for several weeks. During this time, the soap hardens and any excess moisture evaporates, resulting in a harder, longer-lasting bar of soap[51].

1.8 ANALYSIS OF SOAP:

Soap is a commonly used cleaning agent that has been in use for thousands of years. It is made by the reaction of a fat or oil with an alkali, typically sodium hydroxide or potassium hydroxide. The process of making soap is called saponification, and the resulting product is a mixture of soap molecules and glycerol.

Appearance: The soap can be visually inspected for its colour, texture, and shape. The appearance of the soap can give an indication of its quality and purity.

pH value: The pH of the soap can be measured using a pH meter. Soap should have a pH between 8 and 10, which is slightly alkaline. If the pH is too high or too low, it can cause skin irritation.

Cleansing power: The cleansing power of the soap can be tested by applying a small amount of the soap on a soiled surface and then rinsing it with water. The soap should be able to remove dirt and oil effectively.

Foaming capacity: The foaming capacity of the soap can be tested by agitating a small amount of soap in water. The soap should produce a rich lather that lasts for a reasonable amount of time.

Hardness: The hardness of the soap can be determined by pressing a small piece of the soap between the fingers. The soap should be hard enough to resist deformation but soft enough to lather easily.

Moisture content: The moisture content of the soap can be measured by weighing a sample of the soap before and after drying it in an oven. The soap should have a moisture content of less than 15%.

TFM: The TFM in the soap can be determined by dissolving a sample of the soap in alcohol and then titrating the solution with a standard solution of potassium hydroxide. The soap should have a TFM content of at least 70%[52]. Soap has been an essential part of human hygiene for thousands of years. The history of soap dates back to ancient times, where it was made using natural ingredients such as animal fat, ashes, and water. Over time, the process of soap-making has evolved, and various types of soaps have been developed to meet different needs. The different types of soaps include bar soap, liquid soap, glycerine soap, and more. These soaps can be classified based on their ingredients, production process, and application. The choice of soap depends on the intended use and personal preferences. Fatty acids are an essential

component of soap. They are derived from natural sources such as animal fat and vegetable oils. Fatty acids play a crucial role in determining the properties of the soap, including its lather, cleansing ability, and hardness. Soap can be obtained from various sources, including animal fat, vegetable oil, and synthetic sources. The source of soap affects its quality and properties. For instance, vegetable oil-based soaps are more environmentally friendly and gentle on the skin than animal fat-based soaps[53].

CHAPTER-2

LITERATURE SURVEY

- **Sakkaravarthi's** article, "History of soap," published in Cosmoderma in 2022, provides a detailed overview of the history of soap, from its early use in ancient civilizations to the modern-day varieties available on the market [1].
- **Gibbs' article**, "The history of the manufacture of soap," published in *Annals of Science* in 1939, traces the development of soap-making techniques from ancient times to the modern era, highlighting the key milestones in the history of soap[2].
- The Cosmoderma website includes an article on the "History of soap," which provides a concise overview of the origins and evolution of soap, including its early use in ancient civilizations and its role in modern society[3].
- **Konkol and Rasmussen's** book chapter, "An ancient cleanser: Soap production and use in antiquity," published in ACS Symposium Series in 2015, explores the chemical properties of soap and the techniques used to manufacture it. The chapter also provides examples of the use of soap in ancient cultures, including ancient Egypt and Mesopotamia[4].
- **Burleson et al.** (2017) focused on improving the soap-making process by considering social, cultural, and resource constraints in the engineering design process. They emphasized the importance of considering these factors in order to create sustainable and culturally appropriate soap-making processes[5].
- **Maotsela et al.** (2019) investigated the utilization of waste cooking oil and tallow for the production of toilet soap. They found that waste cooking oil and tallow could be used as alternative and inexpensive raw materials for soap production, leading to potential environmental and economic benefits[6].
- **Cholifah et al.** (2021) studied the influence of cocamide DEA on the characteristics of transparent soap. They found that cocamide DEA had a significant effect on the transparency, viscosity, and surface tension of the soap, and concluded that cocamide DEA could be used as a co-surfactant in transparent soap production[7].
- In their study, **Kostik et al.** analyzed the fatty acid composition of various edible oils and fats, including sunflower oil, soybean oil, olive oil, and others. They

found that the fatty acid composition varied greatly between different oils and fats, which could have implications for their health benefits and nutritional value[13].

- **Gervajio** focused specifically on coconut oil and its fatty acid composition. They found that coconut oil contains a high percentage of medium-chain fatty acids, which have been linked to numerous health benefits, including improved brain function and weight loss[14].
- **Chiplunkar et al.** investigated the synthesis and application of an alkyl resin based on palm fatty acid distillate in liquid detergent. They found that the resulting detergent had good emulsifying properties and could effectively remove stains from clothes. This suggests that palm fatty acid distillate could be a useful raw material for the production of detergents[15].
- **Shafie et al.** conducted a review on the application of carrageenan extract from red seaweed in cosmetic products. The review found that carrageenan extract is commonly used in the cosmetics industry as a thickening agent, emulsifier, and moisturizer. It also has several other beneficial properties, such as anti-inflammatory and antioxidant effects. The research suggests that carrageenan extract could be a valuable ingredient in cosmetic products[16].
- **Spitz** discussed the production and properties of fatty acids and their derivatives in the soap and detergent industry. The research suggests that fatty acids and their derivatives are important raw materials in the production of soaps and detergents, and their properties can be manipulated to optimize their performance in various applications[28].
- **Islamati et al.** developed an herbal paper soap from virgin coconut oil with the addition of whey kefir. The study found that the soap had good lathering and cleansing properties, and could potentially have antibacterial effects due to the presence of herbal extracts. The research suggests that this herbal paper soap could be a promising alternative to conventional soap[22].
- **Ali Ahmed et al.** reviewed the production and applications of seaweed polysaccharides. The review found that seaweed polysaccharides have a wide range of potential applications in various industries, such as food, pharmaceuticals, and cosmetics. The research suggests that seaweed

polysaccharides could be a valuable source of natural materials for various applications[23].

- **Msuya** discussed the Seaweed Cluster Initiative in Zanzibar, Tanzania. The initiative aimed to promote the sustainable cultivation and utilization of seaweed as a source of income for local communities. The research suggests that seaweed farming could be a promising economic opportunity for coastal communities in developing countries[24].
- **Sabaani et al.** investigated the antibacterial activity of liquid soap with combined Sargassum sp. and Eucheuma sp. seaweed extracts. The study found that the soap with seaweed extracts had higher antibacterial activity than the soap without extracts. The research suggests that seaweed extracts could be a valuable natural ingredient in antibacterial soap formulations[25].
- **Jurek et al.** compared the effects of Soapwort extract and synthetic surfactants on skin-mimetic models. The study found that the Soapwort extract had good cleansing properties and did not cause irritation or damage to the skin. The research suggests that Soapwort extract could be a potential alternative to synthetic surfactants in cosmetic formulations[26].
- **Nowrouzi et al.** characterized and evaluated a natural surfactant extracted from the Soapwort plant for use in alkali-surfactant-polymer (ASP) slug injection into sandstone oil reservoirs. The study found that the Soapwort extract had good surfactant properties and could potentially improve oil recovery in enhanced oil recovery processes. The research suggests that natural surfactants like Soapwort extract could be a promising alternative to synthetic surfactants in oil recovery processes[27].
- **L. Spitz**, "Bar soap packaging," discusses the packaging of bar soap and the various types of packaging materials used for bar soaps, including paper wrappers, cellophane, and plastic overwraps[29].
- **Hurst, L. W. Stuttard, and R. C. S. Woodroffe**, in their study, "Disinfectants for use in bar-soaps," explore the efficacy of various disinfectants in bar soap formulations, particularly for use in hospitals and other healthcare settings[30].
- **O. Barel, R. Lambrecht, P. Clarys, B. M. Morrison, and M. Paye's** "A comparative study of the effects on the skin of a classical bar soap and a syndet cleansing bar in normal use conditions and in the soap chamber test,"

compares the effects of a traditional bar soap and a synthetic detergent bar (syndet) on the skin. The study found that the syndet bar was less irritating to the skin and caused less dryness than the traditional bar soap[31].

- A study by **Svechnikova et al.** analyzed glycosides of *Allochruza hypochilids* in the preparation of Alloxrozid using chromatophotometry[34].
- **Rahama and Sani** reported on the production of an antiseptic tablet aloe vera soap in the International Journal of Innovative Science Research and Technology[35].
- **Mendez et al.** described the development of an indigenous liquid soap for the prevention of infectious diseases in impoverished rural communities[36].
- **Barve and Dighe** discussed hair shampoo formulation in their book chapter [37].
- **Burleson et al.** describe an engineering design process to improve the soap-making process, considering social, cultural, and resource constraints[43].
- **Prieto Vidal et al.** investigate the effects of cold saponification on the unsaponified fatty acid composition and sensory perception of commercial natural herbal soaps[51].

CHAPTER – 3

AIM AND SCOPE

3.1 Aim

- To collect the edible and non-edible oil sources and evaluating using GC-FID
- To categorize the oil samples for detergent and toilet soaps application based on the comparison studies.
- To prepare detergent soaps from waste cooking oil(non-edible) samples collected from various food outlets in Chengelpet
- To prepare toilet soaps with medicinal value using coconut oil base(edible oil)
- To compare the Properties of detergent and toilet soaps synthesized and also determine the usage of washed water
- To translate the Waste Cooking Oil detergent soaps making process SHG women of Kumizhi village, Chengalpattu for their livelihood enhancement

3.2 Scope

- Based on the cleansing applications soaps have been manufactured categorically over the years
- Dirt removal efficiency, dermal safety, solubilizing nature etc being an important parameters for evaluating the soap ,the wash water generated during the usage of a soap for a specific application will be monitored in this study
- Further an evaluation of oil source(raw material) will be made in understanding the role of its composition in selecting the oil for a specific cleaning application will be made
- Additionally mechanisms will be designed to derive soaps for different cleansing applications with better cleaning efficiency, reduced rinsing water requirements, improved wash water quality to reduce the loading in the effluent treatment plant reduced pathogenic interferences etc.,

CHAPTER-4

MATERIALS AND METHODS

4.1 MATERIALS AND CHEMICALS:

The collection of various edible and non-edible oils from the local restaurants. The waste cooking oil sources like palm oil, sunflower oil and coconut oil. The edible oil sources like cold pressed coconut oil and almond oils. The validation method used here is gas chromatography -Flame ionisation detector. Fragrance which are added to the soap is night jasmine scent. The natural filler like Kaolin clay which is eco-Friendly and safer to the skin. For medicinal soaps the extracts like neem extract, aloe vera extract and herbal extract. The base for the soap is sodium Hydroxide or calcium carbonate.

4.2 COLLECTION OF OILS:

Collecting waste cooking oils for the production of soap is a wonderful way to both reduce waste and create a useful product. Find a local company or organization that collects used cooking oil. Many cities and towns have programs for this, or you may be able to find a local business that collects oil for biodiesel production. Gather used cooking oil from your own kitchen and from friends and family. Be sure to strain the oil to remove any food particles. Store the collected oil in a sealed container, preferably airtight, until you have enough to begin making soap. Here are some oil samples we collected that are tabulated

TABLE 4.1 Collection of Sources and Details of the sources

ITEM	DETAILS
RESTAURANT DETAILS WITH ADDRESS	BAKERIES AND RESTAURANTS
BRAND OF OILS USED	SVS –PALM OIL, SUNFLOWER OIL, COCONUT
PLACE OF BUYING	CHENGULPET, AMBATHUR

ITEMS COOKED	SAMOSAS, PAPADAM, POTATO CHIPS AND BANANA CHIPS
NO. OF TIMES REPEATED USED	MORE THAN 4 TIMES
AMOUNT OF OIL COLLECTED	1 LITRE
RATE EXPECTED FROM SHOPKEEPER	FREE OF COST

4.3 VALIDATION OF OIL SOURCES USING GC-FID:

Gas Chromatography-Flame Ionization Detector (GC-FID) is a common method used to validate oil sources. ASTM (ASTM) has developed a standard procedure for the GC-FID analysis of oil source validation, which is known as ASTM D6584. Here are the general steps for the ASTM D6584 procedure for oil source validation using GC-FID. The oil sample needs to be properly prepared before running it on the GC-FID. This involves weighing out a specific amount of the oil sample and dissolving it in a suitable solvent. Hexane is commonly used for this purpose. Before running the sample, the GC-FID needs to be calibrated using known standards to ensure accurate measurement of the oil components. The prepared sample is injected into the GC-FID using an auto sampler or manually with a syringe. The sample is then vaporized and separated into its individual components by the GC column. The separated components are then detected using the FID detector, which measures the amount of carbon atoms in the sample. Each component will produce a unique signal on the detector. The data obtained from the detector is analyzed using software to identify the different components and their amounts. This data is then compared to a database of known oil sources to identify the origin of the oil sample. The results of the analysis are reported along with any limitations or uncertainties in the data. The ASTM D6584 standard specifies the reporting requirements, including the use of a standard format and terminology. The results for the oil sources which are done in the GC-FID are listed below. It's important to note that the ASTM D6584 procedure is a standardized method that has been validated for oil source validation using GC-FID.

4.4 INTERPRETATION OF GRAPHS OBTAINED:

Interpreting GC-FID graphs generated from the ASTM D6584 procedure for oil source validation involves analyzing the peak areas and retention times of the different components in the sample. Here are some key points to consider when interpreting GC-FID graphs. The peak area represents the amount of each component present in the sample. The larger the peak area, the greater the amount of that component in the sample. Retention Times is next point, The retention time represents the amount of time it takes for each component to travel through the GC column and reach the detector. Each component has a unique retention time, which can be used to identify it. The ASTM D6584 procedure recommends using a standard library to compare the retention times and peak areas of the sample components to known oil sources. The standard library contains retention times and peak areas for a variety of different oil sources.: Qualitative analysis involves comparing the retention times of the sample components to those in the standard library to identify the origin of the oil source. If the retention times of the sample components match those of a known oil source in the standard library, it can be concluded that the sample originated from that source. Quantitative analysis involves comparing the peak areas of the sample components to those in the standard library to determine the relative amounts of each component in the sample. This can be used to identify any adulteration or contamination of the sample. It's important to note that interpretation of GC-FID graphs requires expertise in chromatography and familiarity with the ASTM D6584 standard.

4.5 MOISTURE CONTENT OF OIL:

- Weigh a clean, dry, and empty crucible and record its weight as "A". Add a small quantity of the oil sample to the crucible and weigh the crucible and oil sample together. Record the weight as "B".
- Place the crucible with the oil sample in an oven at a temperature of 105°C to 110°C for 1 to 2 hours until the sample is completely dry. Remove the crucible from the oven and allow it to cool in a desiccator to avoid moisture from the air entering the crucible. Weigh the crucible and dried oil sample and record the weight as "C".
- Calculation: The moisture content of the oil can be calculated using the following formula:

$$\text{Moisture content (\%)} = [(C - A) / (B - A)] \times 100$$

Where:

A = Weight of empty crucible

B = Weight of crucible and oil sample

C = Weight of crucible and dried oil sample

The result will give you the percentage of moisture present in the oil sample.

TABLE 4.2 Moisture Content of the sources

NAME OF THE PROPERTY	VALUE OF PROPERTY (WCO-SUNFLOWER OIL)	VALUE OF PROPERTY (WCO-PALM OIL)	VALUE OF PROPERTY (WCO-COCONUT OIL)	VALUE OF PROPERTY (COLD PRESSED COCONUT OIL)	VALUE OF PROPERTY (PURE ALMOND OIL)
MOISTURE CONTENT (wt.%)	0.88	0.65	0.98	1.01	0.69

4.6 SAPONIFICATION VALUE:

Procedure

1. About 2 g of the given oil is taken in a conical flask but weighed accurately (w g). 2
2. The oil is dissolved in 25 ml of 0.5 N alcoholic potassium-hydroxide solution.
3. Then the reaction mixture is refluxed using a water condenser on a water-bath for half an hour.
4. The resulting solution is cooled and titrated against a 0.5 N HCl solution adding 1 ml of phenolphthalein.
5. The number of ml of acid required is noted (a). An exactly identical blank experiment (leaving the fat or oil) is performed. Number of ml of hydrochloric acid required is noted (b)

TABLE 4.3 Saponification value of the sources

NAME OF THE PROPERTY	VALUE OF PROPERTY (WCO-SUNFLOWER OIL)	VALUE OF PROPERTY (WCO-PALM OIL)	VALUE OF PROPERTY(W CO-COCONUT OIL)	VALUE OF PROPERTY(PURE COCONUT OIL)	VALUE OF PROPERTY (PURE ALMOND OIL)
SAPONIFICATION VALUE(Mg KOH/gm)	190	202	240	242	185

$$\frac{(A - B) \times N \times 56.1}{W}$$

Calculation of Saponification Value = $\frac{(A - B) \times N \times 56.1}{W}$

where:

A = H₂SO₄, for blank, mL

B =H₂SO₄, for sample, mL

W =weight of sample (dry basis), g

N = normality H₂SO₄ solution

56.1 =equivalent weight of potassium hydroxide

4.7 SAPONIFICATION PROCESS:

Sample Preparation: The waste cooking oil is collected and filtered to remove any impurities or food particles. The kaolin clay is also weighed and ground to a fine powder.

Mixing: The waste cooking oil and kaolin clay are mixed together in a container. The mixture is then heated to a specific temperature to melt the oils and ensure uniform mixing 60 D.

Addition of Sodium Hydroxide: Sodium hydroxide (NaOH) is dissolved in water and added to the mixture. The mixture is stirred continuously to ensure thorough mixing and reaction. Mix for 30 minutes

Monitoring the Reaction: The mixture is monitored to determine when the saponification reaction is complete. This is typically done using a pH indicator or by monitoring the viscosity of the mixture.

Pouring and Moulding: Once the saponification reaction is complete, the soap mixture is poured into moulds and allowed to cool and harden.

Testing and Quality Control: The soap is tested for quality control, including testing for pH, texture, and fragrance.

CHAPTER -5

RESULTS AND DISCUSSIONS

5.1 GRAPHS AND INTERPRETATION OBTAINED FROM GC-FID:

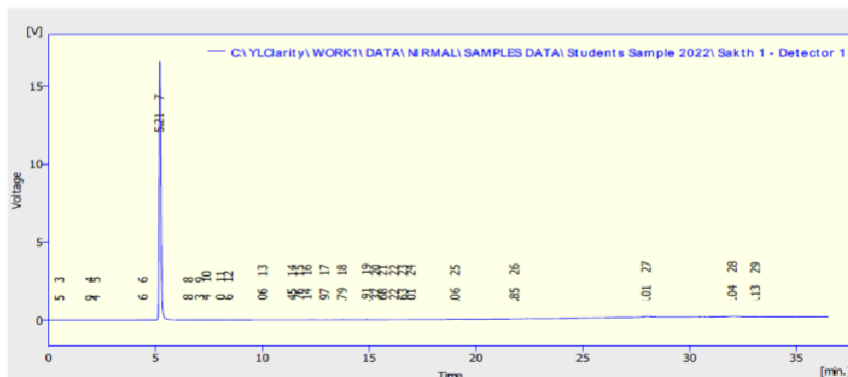


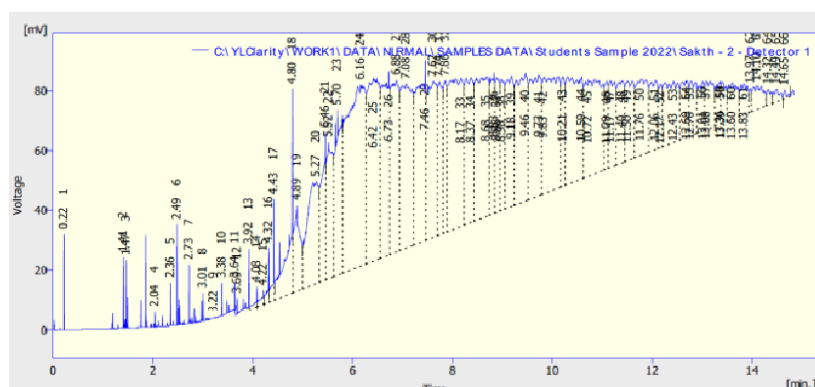
Fig 5.1: GC-FID for the waste cooking coconut oil

Table 5.1 Interpretation of waste cooking coconut oil graph

S.NO	RETENTION TIME	TYPE OF FATTY ACID	COMPOUND NAME
1	0.147	Saturated Fatty Acid	Undecanoic Acid
2	0.553	Unsaturated Fatty Acid	Octadecanoic acid
3	1.993	Unsaturated Fatty Acid	Iso-caproic acid
4	2.243	Unsaturated Fatty Acid	Iso-caprylic acid
5	4.463	Saturated Fatty Acid	Butyric acid
6	5.213	Saturated Fatty Acid	Caprylic acid
7	6.577	Saturated Fatty Acid	Caproic acid
8	7.134	Unsaturated Fatty Acid	Octadecanoic acid
9	7.437	Saturated Fatty Acid	Capric acid
10	8.097	Saturated Fatty Acid	Tridecanoic acid
11	8.463	Saturated Fatty Acid	Decanoic acid
12	10.060	Saturated Fatty Acid	Lauric acid

13	11.447	Saturated Fatty Acid	Myristic acid
14	11.750	UnSaturated Fatty Acid	IsoMyristic acid
15	12.140	UnSaturated Fatty Acid	Mysteriolic acid
16	12.967	Saturated Fatty Acid	Trideconic acid
17	13.787	UnSaturated Fatty Acid	Pentadecanoic acid
18	14.907	UnSaturated Fatty Acid	Palmitoleic Acid
19	15.367	Saturated Fatty Acid	Eladic acid
20	15.680	UnSaturated Fatty Acid	Oleic acid
21	16.220	Saturated Fatty Acid	Arachidic acid
22	16.220	UnSaturated Fatty Acid	Pentadecanoic acid
23	16.633	UnSaturated Fatty Acid	Eicosenic acid
24	17.01	Saturated Fatty Acid	Stearic acid
25	19.063	UnSaturated Fatty Acid	Linoleic acid
26	21.853	UnSaturated Fatty Acid	Linolenic acid
27	28.013	Saturated Fatty Acid	Palmitic acid
28	32.043	Saturated Fatty Acid	Lignoceric acid

Note: The fatty acid Tabulated Above Is the Standard Fatty acids of the Coconut oil. But For production of Soaps Specific Fatty acids are needed, For the Following Interpretation The Specific Fatty acids are Tabulated along with their GC-FID Graphs.



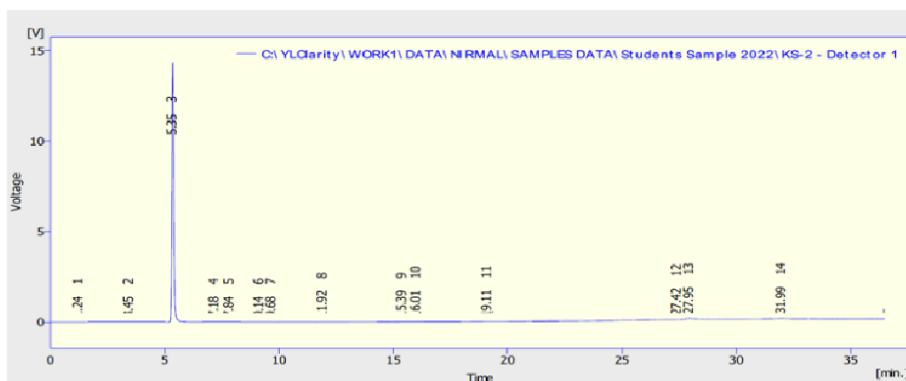


Fig 5.3: GC-FID for the waste cooking oil-sunflower oil

Table 5.3 Interpretation of waste cooking sunflower oil graph

S.NO	RETENTION TIME	TYPE OF FATTY ACID	COMPOUND NAME
1	9.4	Saturated fatty acid	Myristic acid
2	11.6	Saturated Fatty acid	Palmitic acid
3	12.9	Unsaturated Fatty acid	Palmitoleic acid
4	14.8	Saturated fatty acid	Stearic acid
5	17.0	Unsaturated fatty acid	Oleic acid
6	18.5	Unsaturated fatty acid	Linoleic acid
7	19.7	Unsaturated fatty acid	Linolenic acid
8	24.3	Unsaturated fatty acid	Eicosenic acid
9	26.6	Saturated fatty acid	Behenic acid
10	22.3	Saturated Fatty acid	Arachidic acid

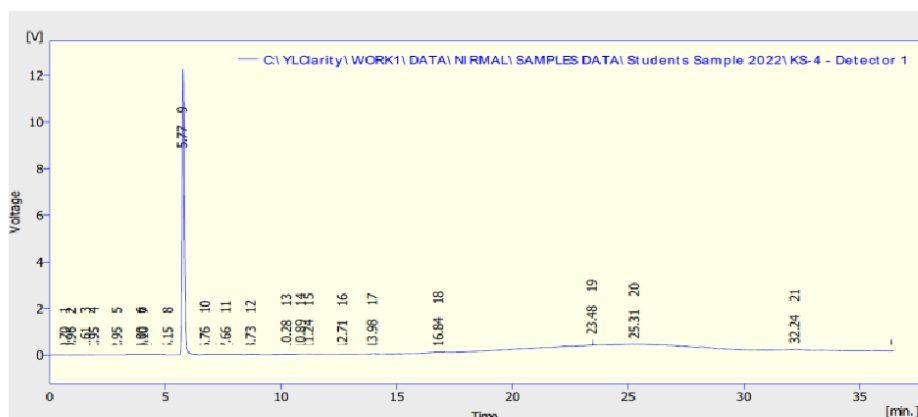
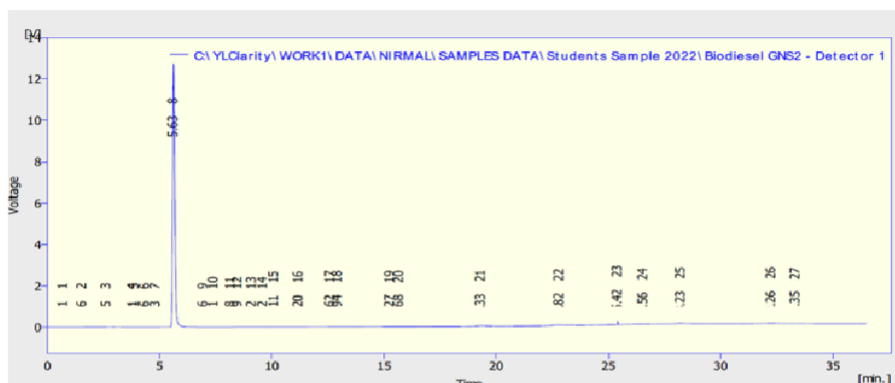


Table 5.4 Interpretation of cold pressed coconut oil graph

S.NO	RETENATION TIME	TYPE OF FATTY ACID	COMPOUND NAME
1	5.4	Saturated fatty acid	Caprylic acid
2	6.5	Saturated Fatty acid	Capric acid
3	7.6	Saturated Fatty acid	Lauric acid
4	8.8	Saturated fatty acid	Myristic acid
5	14.4	saturated fatty acid	Palmitic acid
6	18.6	saturated fatty acid	Stearic acid
7	20.5	Unsaturated fatty acid	Oleic acid
8	21.4	Unsaturated fatty acid	Linoleic acid



Fig

5.5: GC-FID for the Edible-almond oil

Table5.5 Interpretation of almond oil graph

S.NO	RETENATION TIME	TYPE OF FATTY ACID	COMPOUND NAME
1	12.5	Saturated fatty acid	Palmitic acid
2	14.7	Saturated Fatty acid	Stearic acid
3	17.3	Unsaturated Fatty acid	Oleic acid
4	18.8	Unsaturated fatty acid	Linoleic acid
5	20.3	Unsaturated fatty acid	Linolenic acid

GC-FID is a commonly used analytical technique for the identification and quantification of organic compounds in complex mixtures such as waste cooking oils. The graph obtained from this analysis typically shows the retention time on the x-axis and the detector response (peak area) on the y-axis. By analyzing the peaks on the graph, we can identify the individual components present in the waste cooking oil sample. The area under each peak is proportional to the amount of the corresponding compound in the sample. The retention time can also be used to help identify the compound, as each compound has a characteristic retention time. Additionally, the shape of the peaks can provide information on the quality and purity of the sample. For example, a well-defined peak with a narrow base indicates a pure compound, while a broad peak with a sloping baseline may indicate the presence of impurities. Overall, the GC-FID graph can provide valuable information on the composition and quality of waste cooking oils, which can help inform decisions on appropriate disposal or recycling methods.

5.2 SOAPS DERIVED FROM DIFFERENT OIL SOURCES:

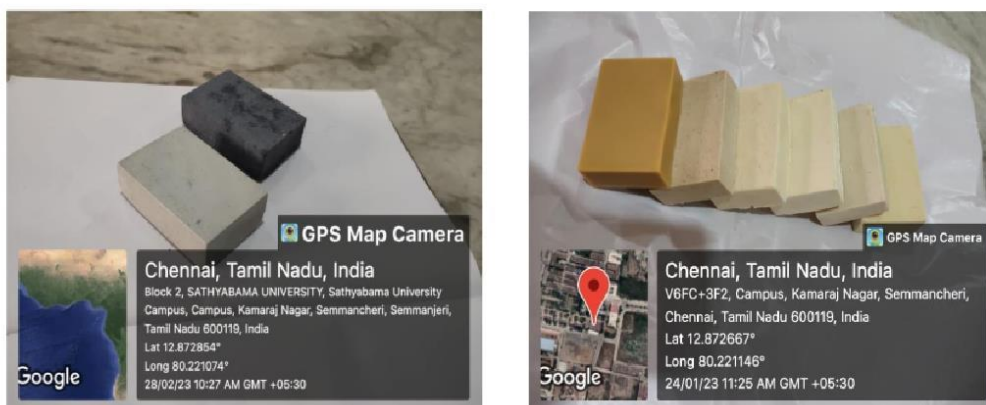


Fig.5.6: Soaps prepared from waste cooking oils.



Fig.5.7: Soaps prepared from the edible oils by adding herbal extracts.

5.2.1 Properties of Soaps

5.2.1.1 Total Fatty matter:

TFM is an important parameter to determine the quality of soap. TFM represents the amount of fatty acid or oil present in the soap. It is the percentage of the mass of the soap which is composed of fatty acids and other oils. The TFM value of soap is used to determine its cleansing properties and can indicate the amount of lather produced by the soap. A higher TFM value indicates a higher number of fatty acids present in the soap, which results in a better cleansing property and more lather. Hence, the TFM value is an important parameter to determine the quality of soap's (ASTM) procedure D 5558-94 is used for the determination of TFM (TFM) in soaps. The procedure involves the following steps:

Sample Preparation: A representative sample of the soap is collected and crushed to a uniform size.

Drying: A 2-gram sample of the crushed soap is weighed accurately and dried in a stifling air oven at 105°C for 1 hour. The sample is then cooled in a desiccator.

Weighing: The dry soap sample is weighed accurately to the nearest 0.0001 gram.

Titration: The weighed sample is dissolved in a mixture of 50 ml of ethanol and 50 ml of water. 1 ml of phenolphthalein indicator is added to the solution. The solution is then titrated with 0.5 N alcoholic KOH solution until a faint pink color appears.

Calculation: The TFM content of the soap is calculated using the following formula:

$$\text{TFM} = [(B - A) \times 28.2 \times 100] / W$$

Where,

A = volume of 0.5 N alcoholic KOH solution used for blank

B = volume of 0.5 N alcoholic KOH solution used for sample

W = weight of the sample in grams

The TFM content of the soap is expressed as a percentage of the weight of the soap. The minimum TFM content required for a soap to be considered as a toilet soap is 76% as per the Bureau of Indian Standards (BIS).

5.2.1.2 Total Alkalinity Content:

TAC in soap refers to the total amount of alkali (mainly sodium hydroxide or potassium hydroxide) present in the soap sample. The determination of TAC is an important quality control test in soap manufacturing because the amount of alkali used in the soap-making process can affect the properties of the soap, such as hardness, lather, and cleansing ability. The TAC in soap refers to the amount of alkali present in the soap, which is usually in the form of sodium or potassium hydroxide. It is important to determine the alkaline content in soap as it affects the pH level and overall quality of the soap. ASTM has provided a standard procedure for the determination of TAC in soap, which is ASTM D555-88 (2018) Standard Test Method for Total Alkali in Soaps and Detergents. The procedure involves the titration of a soap solution with hydrochloric acid (HCl) to determine the amount of free alkali present in the soap. The steps involved in the procedure are as follows:

Weigh accurately about 10 g of the soap sample and dissolve it in 50 mL of hot distilled water. Add phenolphthalein as an indicator to the soap solution.

Titrate the soap solution with 0.1 N hydrochloric acid (HCl) until a pink color appears, indicating the endpoint of the titration. The titration should be performed slowly to ensure accurate results.

Record the volume of HCl used for the titration.

Calculate the TAC in the soap using the following formula:

$$\text{TAC (\%)} = [(V1 - V2) \times N \times 40.01 \times 100] / W$$

Where,

V1 = volume of HCl used for the titration of the soap solution (mL)

V2 = volume of HCl used for the blank (mL)

N = normality of the HCl solution

40.01 = molecular weight of potassium hydroxide (KOH)

W = weight of the soap sample taken (g)

The result obtained from this test method indicates the TAC in terms of percentage by weight of the sample. The typical range of TAC in soap is between 0.1% and 1.0%, depending on the type and quality of the soap.

5.2.1.3 Glycerine:

Glycerine is a valuable by-product of the soap making process, and its presence in the soap can indicate that the soap has been properly formulated and processed. Checking the glycerine content ensures that the soap is of excellent quality and has not been over-processed, which can result in a lower glycerine content. Glycerine is a natural humectant, which means it attracts and retains moisture in the skin. Soaps with a higher glycerine content are often preferred by consumers for their moisturizing properties, which can help prevent dryness and irritation. Glycerine is a valuable commodity, and soaps with a higher glycerine content can command a higher price. Checking the glycerine content can help manufacturers ensure that they are getting the maximum economic value from their soap making process. The ASTM procedure for determining the glycerine content in soap is ASTM D4590. This method involves the extraction of glycerine from the soap sample using a solvent and then measuring the amount of glycerine present in the extract using gas chromatography.

Preparation of sample: The soap sample is first melted and then allowed to cool to room temperature. A small quantity of the cooled soap is then weighed and transferred to a glass extraction thimble.

Extraction: The extraction thimble containing the soap sample is then placed in a Soxhlet extractor. The extractor is filled with a solvent (such as chloroform) that is immiscible with water. The Soxhlet extractor is then connected to a condenser and the solvent is heated to reflux.

Collection of extract: The solvent will dissolve the glycerine present in the soap sample and the extract will drip down into a collection flask. The extraction process is continued for several hours until all of the glycerine has been extracted from the soap.

Analysis of extract: The extract containing glycerine is then analyzed using gas chromatography. A known quantity of the extract is injected into the chromatograph and the glycerine is separated from other components of the extract using a suitable column.

Calculation of glycerine content: The amount of glycerine present in the extract is determined by comparing its peak area to that of a known standard. The glycerine content of the soap is then calculated as a percentage of the total weight of the soap sample. The glycerine content in soap is an important parameter as it is a by-product of the saponification process and has important properties such as moisturizing and emollient properties.

5.2.1.4 pH of the soap:

The (ASTM) provides a standard procedure for determining the pH of soap produced from waste cooking oil, which is known as ASTM D1287-91(2015) "Standard Test Method for pH of Alkaline Detergents. "The procedure involves preparing a 10% (w/v) solution of the soap in distilled water and measuring the pH of the solution using a pH meter calibrated with buffer solutions of known pH values. The soap solution is first diluted with distilled water to obtain a pH in the range of 8 to 10, which is then adjusted to a pH of 8.5 ± 0.1 with 0.1 N hydrochloric acid or 0.1 N sodium hydroxide solution. The pH meter electrode is then immersed in the solution and allowed to stabilize, and the pH value is recorded. The measurement is repeated three times, and the average value is reported as the pH of the soap solution. The pH of soap is an important parameter as it affects the skin's natural pH balance, and soaps with a pH value of 7 or slightly acidic are considered better for the skin. Soap with a high pH value can cause irritation and dryness of the skin. Additionally, the pH value can affect the performance of the soap in cleaning, and soaps with a pH value that is too high or too low may not clean as effectively.

5.2.1.5 Moisture Content:

The moisture content in soap from waste cooking oil can be determined using the ASTM D 460-92 standard test method. The procedure involves weighing a sample of soap and heating it in an oven at a temperature of 105 ± 2 °C until it reaches a constant weight. The weight loss during the heating process indicates the amount of moisture in the sample.

Weigh a clean and dry aluminum dish to the nearest 0.0001 g and record the weight as W1.

Weigh approximately 2 g of the sample of soap to the nearest 0.0001 g into the dish. Record the weight as W2.

Place the dish with the sample into an oven and heat it at a temperature of 105 ± 2 °C for 2 hours.

Remove the dish from the oven and allow it to cool to room temperature in a desiccator.

Weigh the dish and the dried sample to the nearest 0.0001 g and record the weight as W3.

Calculate the moisture content of the sample using the following formula:

$$\text{Moisture content} = ((W2 - W3) / (W2 - W1)) \times 100$$

where:

W1 = weight of the dish

W2 = weight of the dish and the sample

W3 = weight of the dish and the dried sample

The moisture content in soap should typically be less than 10% by weight. High moisture content can lead to the growth of bacteria and mold, spoilage of the soap, and reduced shelf life.

5.2.1.6 Insoluble Matter in Alcohol:

ASTM D801-16 is the standard test method for insoluble matter in alcohol for soaps.

Here is a summary of the procedure:

- Weigh about 5g of the soap sample into a 250 mL beaker.
- Add 50 mL of 95% ethanol to the beaker.
- Heat the beaker on a hot plate or water bath until the soap is completely dissolved.
- Remove the beaker from the heat source and let it cool to room temperature.
- Add 50 mL of 95% ethanol to the beaker and mix well.
- Pour the mixture through a weighed sintered glass or porcelain filtering crucible.
- Rinse the beaker with 25 mL of 95% ethanol and pour the rinse through the filter.
- Wash the residue on the filter with three 25 mL portions of 95% ethanol.
- Dry the filter and its contents in an oven at 105°C for at least 1 hour.
- Cool the filter and its contents to room temperature in a desiccator and weigh it.
- Calculate the percentage of insoluble matter in the soap sample by dividing the weight of the residue by the weight of the soap sample and multiplying by 100.

Note: The test method specifies the use of 95% ethanol, but other alcohols or solvent systems may be used if they are shown to give equivalent results.

TABLE 5.6 Properties of Soap Produced From Waste Cooking Palm Oil

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (PALM OIL)
TFM	22%
TAC	11.84%
Glycerine	9.5%
Ph	7.9
Moisture Content	1.09%
Insoluable Matter in Alcohol	9%

TABLE 5.7 Properties of Soap Produced from Waste Cooking Coconut Oil

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (COCONUT OIL)
TFM	35%
TAC	8.5%
Glycerine	15.4%
pH	7.64
Moisture Content	0.98%
Insoluable Matter in Alcohol	7.34%

TABLE 5.8 Properties of Soap Produced from Waste Cooking Sunflower Oil

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (SUNFLOWER OIL)
TFM	30%
TAC	7.9%
Glycerine	14.4%
pH	6.5
Moisture Content	0.88%
Insoluable Matter in Alcohol	8.5%

TABLE 5.9 Properties of Soap Produced From cold pressed coconut Oil.

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (COCONUT OIL)
TFM	68%
TAC	10.84%
Glycerine	10.45%
pH	7.38
Moisture Content	1.09%
Insoluable Matter in Alcohol	8.04%

TABLE 5.10 Properties Of Soap Produced From edible almond Oil

NAME OF THE PROPERTY	VALUES OF THE PROPERTY (ALMOND OIL)
TFM	65%
TAC	9.8%
Glycerine	13.4%
pH	7.64
Moisture Content	0.98%
Insoluble Matter in Alcohol	7.2%

5.3 CLEANSING EFFICIENCY:

To compare the cleansing activity between Rin soap and the soap prepared from waste cooking oil with natural filler, several factors need to be considered, including the composition of the soap, the type of natural filler used, and the testing method for cleansing activity. In terms of composition, Rin soap is a commercial detergent bar that contains synthetic surfactants, whereas the soap prepared from waste cooking oil with natural filler is a handmade soap that uses natural oils and lye as the primary ingredients. The addition of natural filler can enhance the cleansing activity of the soap by providing additional abrasive or absorbent properties, depending on the type of filler used. In terms of water consumption, the soap prepared from waste cooking oil with natural filler is likely to have a lower environmental impact as it is a handmade product that can be produced using less energy and water compared to the industrial manufacturing process used for Rin soap. Additionally, waste cooking oil is a readily available and inexpensive raw material, which can help to reduce the environmental impact of soap production by diverting waste from landfills and reducing the need for virgin oils. In conclusion, while the composition and testing methods may differ, the soap prepared from waste cooking oil with natural filler has the potential to offer comparable or even superior cleansing activity to commercial detergents such as Rin

soap, while also providing a more sustainable and eco-friendly option with lower water consumption.



Fig 5.8: Cleaning of dirtied clothes using soap prepared by using natural filler.

5.4 COMPARITIVE STUDIES:

5.4.1: *Water consumption*

Water is commonly used to clean dirt and stains from clothes. When you wash your clothes with water, the water molecules help to loosen and remove dirt, sweat, and other contaminants from the fabric.

The usage of water can also vary between natural filler waste cooking oil soap and commercial soap when washing. Here are some points of comparison:

Lather: Natural filler waste cooking oil soap may produce less lather than commercial soap, which can mean that less water is needed to rinse off the soap during washing.

Residue: Commercial soap may leave behind more residue on clothes, requiring more water to remove it completely. In contrast, natural filler waste cooking oil soap may rinse off more easily, using less water during the washing process.

Water temperature: Commercial soap may require higher water temperatures to effectively dissolve and remove dirt and stains from clothes, using more energy to heat the water. Natural filler waste cooking oil soap, on the other hand, may work effectively with cooler water, using less energy overall.

Sudsing: Commercial soap may produce more suds than natural filler waste cooking oil soap, which can lead to the need for more water to rinse off the suds and any remaining soap residue.

Environmental impact: As mentioned before, natural filler waste cooking oil soap is biodegradable and will not harm the environment. Commercial soap, depending on its formulation, may contain chemicals that can harm the environment if they enter waterways.

TABLE 5.11 Water Consumption Comparison Between waste cooking oil Soap and Commercial Soap.

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPAED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED
Water Consumption for washing the clothes	1.6 litres	2 litres	1.2 litres	2.4 litres

Soap made from waste palm oil required the least amount of water (1.2 litres) for washing clothes compared to soap made from waste cooking coconut oil (1.6 litres), soap made from waste cooking sunflower oil (2 litres), and commercial soap (2.4 litres). This suggests that soap made from waste palm oil may be more efficient in terms of water usage during laundry compared to other types of soap. However, it is important to consider other factors such as the quality and effectiveness of the soap in cleaning clothes, as well as its environmental impact and sustainability.

5.4.2 pH of washed water:

To check the pH range of washed water of waste cooking oil soap and commercial soaps using ASTM method, We followed the following procedure:

- Collect a sample of the washed water from the laundry cycle that has been completed using the soap in question
- .Using a pH meter or pH indicator strips, measure the pH of the washed water sample
- .Follow the ASTM method for pH testing, which may involve preparing a calibration curve using standard buffer solutions of known pH, and then measuring the pH of the sample against the curve. Record the pH value obtained from the sample.
- Repeat the procedure for each type of soap being tested (waste cooking oil soap and commercial soap). Compare the pH values obtained for each type of soap and analyze the results.

TABLE 5.12 pH Comparison of Washed water

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPARED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED
pH range of washed water	7.3(at 4 th wash)	7.54(at 5 th wash)	7.44(at 4 th wash)	7.9(at 6 th wash)

Soap made from waste cooking coconut oil resulted in washed water with a pH range of 7.3 (at the 4th wash), while soap made from waste cooking sunflower oil resulted in washed water with a slightly higher pH range of 7.54 (at the 5th wash). Soap made from waste palm oil resulted in washed water with a pH range of 7.44 (at the 4th wash), and commercial soap resulted in washed water with the highest pH range of 7.9 (at the 6th wash). The pH range of the washed water can be an important factor to consider as it may affect the fabric's softness, color retention, and overall quality. Typically, a pH range of 7 is considered neutral, while values below 7 are acidic and values above 7 are basic. The results suggest that all types of soap tested resulted in washed water with a neutral to slightly basic pH range. However, it is important to note that other factors such as water hardness and fabric type may also influence the pH of washed water. Overall, the table suggests that soap made from waste cooking coconut oil resulted in washed water with a slightly lower pH range compared to the other types of soap tested, while commercial soap resulted in washed water with the highest pH range.

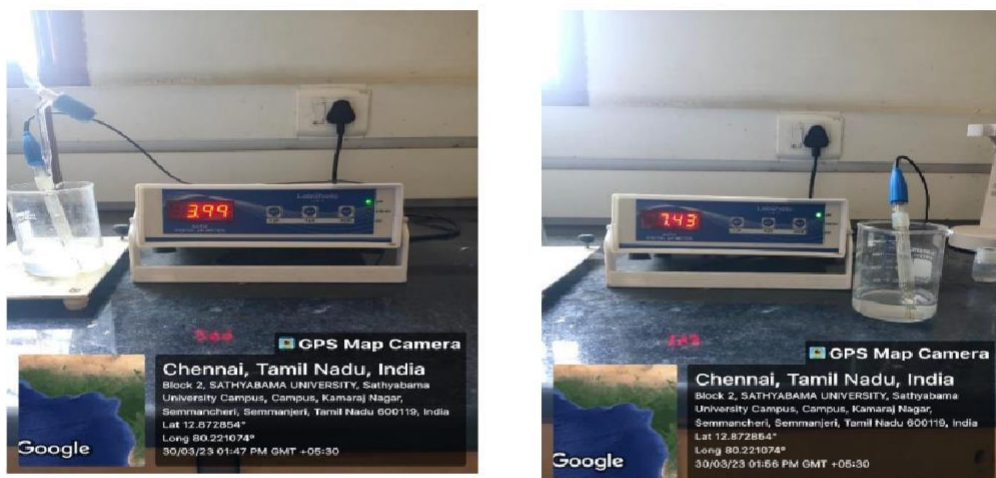


Fig 5.10: Checking pH range of washed water.

5.4.3 Alkalinity range of washed water:

To check the alkalinity range of washed water of waste cooking oil soap and commercial soaps using an ASTM method, we followed the following procedure:

- Collect a sample of the washed water from the laundry cycle that has been completed using the soap in question.
- Prepare a known volume of the washed water sample (typically 50 mL or 100 mL) in a clean glass beaker. Add a few drops of phenolphthalein indicator solution to the washed water sample
- . Titrate the washed water sample with standardized hydrochloric acid (HCl) solution until the color of the solution changes from pink to colorless. Record the volume of HCl solution used for titration.
- Calculate the alkalinity of the washed water sample using the following formula:

$$\text{Alkalinity (mg/L as CaCO}_3\text{)} = \frac{(\text{Volume of HCl used} \times \text{Normality of HCl} \times 50,000)}{\text{Sample volume in mL}}$$

- Repeat the procedure for each type of soap being tested (waste cooking oil soap and commercial soap).
- Compare the alkalinity values obtained for each type of soap and analyze the results.

TABLE 5.13 Alkalinity Comparison of washed water

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPARED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED
Alkalinity range of used water	180mg/l (at 4 th wash)	189mg/l (at 5 th wash)	190mg/l (at 4 th wash)	280mg/l (at 6 th wash)



Fig 5.11: Checking alkalinity range of washed water.

Soap made from waste cooking coconut oil resulted in used water with an alkalinity range of 180 mg/L (at the 4th wash), while soap made from waste cooking sunflower oil resulted in used water with an alkalinity range of 189 mg/L (at the 5th wash). Soap made from waste palm oil resulted in used water with an alkalinity range of 190 mg/L (at the 4th wash), and the commercial soap resulted in used water with the highest alkalinity range of 280 mg/L (at the 6th wash). Alkalinity is a measure of the water's ability to neutralize acids, and it can affect the performance of detergents in removing dirt and stains from clothes. A higher alkalinity range may indicate that more soap is required to achieve the same level of cleaning compared to water with a lower alkalinity range. The results suggest that soap made from waste cooking coconut oil resulted in used water with the lowest alkalinity range, while commercial soap resulted in used water with the highest alkalinity range. However, it is important to note that other factors such as water hardness and detergent dosage can also influence the alkalinity of the used water. Overall, the table suggests that the type of oil used to make soap can affect the alkalinity range of the used water during laundry, with waste cooking coconut oil soap resulting in the lowest alkalinity range.

5.4.4 Turbidity range of washed water:

The ASTM method for measuring turbidity in washed water involves using a nephelometer, which is a device that measures the amount of light scattered by suspended particles in the water.

To check the turbidity range of washed water of waste cooking oil soap and commercial soaps using the ASTM method, the following steps can be taken:

- Collect a sample of the washed water from the washing machine after the clothes have been washed with the soap.
- Pour the sample into a clean, clear glass container.
- Insert the nephelometer probe into the sample and turn on the device.
- Record the turbidity reading displayed on the device.
- Repeat steps 1-4 for each soap sample being tested.

The results obtained will show the turbidity range of the washed water for each soap sample tested.

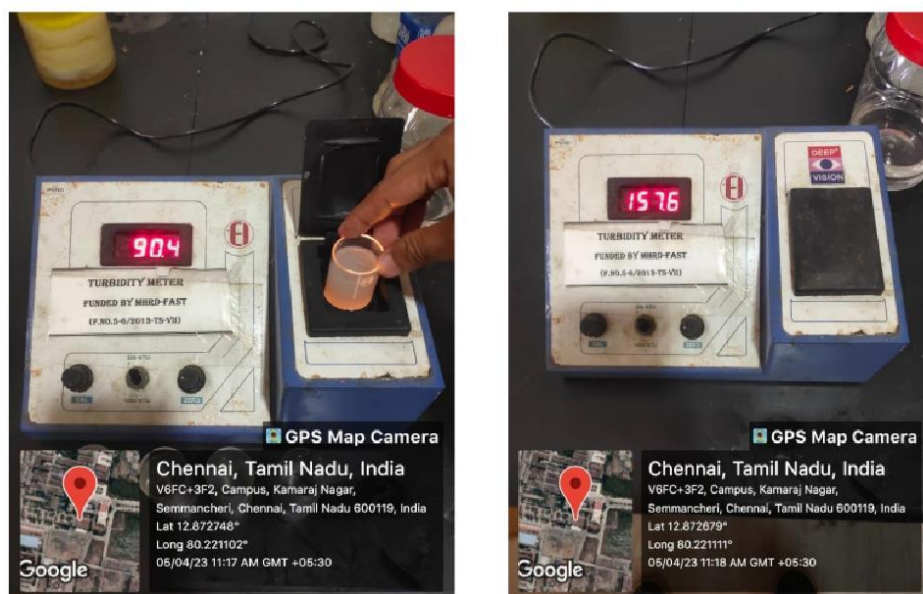


Fig 5.11: Checking turbidity range of washed water.

TABLE 5.14 Turbidity range Comparison of washed water

NAME OF THE TEST	SOAP PREPARED BY ADDING FILLER AND DYE (WASTE COOKING COCONUT OIL)	SOAP PREPARED FROM WASTE COOKING SUNFLOWER OIL	SOAP PREPARED FROM WASTE PALM OIL	COMMERCIAL SOAP THAT WE USED

Turbidity of used water	-01.7 NTU (at 4 th wash)	-02.1 (at 5 th wash)	-02.23 (at 4 th wash)	-03.8 NTU (at 6 th wash)
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From above discussions, it can be inferred that the turbidity of the washed water for all soap samples is very low, as indicated by the negative values. This suggests that the water is clear and contains very few suspended particles. Among the soap samples, the waste cooking coconut oil soap had the lowest turbidity reading at the 4th wash, followed by the waste cooking sunflower oil soap and waste palm oil soap, while the commercial soap had the highest turbidity reading at the 6th wash. The comparison of different types of soaps prepared from waste cooking oils and a commercial soap based on their performance in terms of water consumption, pH, alkalinity, and turbidity of the washed water revealed several interesting findings. Firstly, the waste cooking coconut oil soap and waste palm oil soap consumed less water compared to the commercial soap, which could be attributed to the composition of the soap and the ability of the soap to generate suds. Secondly, all soap samples showed a similar pH range in the washed water, indicating that they were all effective in removing soil and dirt from the clothes without altering the pH of the water significantly. Thirdly, the waste cooking sunflower oil soap showed higher alkalinity in the washed water compared to the other soap samples, which could be attributed to the presence of residual fatty acids in the soap. Finally, all soap samples showed very low turbidity readings in the washed water, suggesting that they were all effective in removing suspended particles from the water and leaving it clear. Overall, the comparison suggests that soaps prepared from waste cooking oils can be a sustainable and effective alternative to commercial soaps in terms of their performance in washing clothes and reducing water consumption.

5.5 LIVELIHOOD ENHANCEMENT OF SHG WOMEN:

The term "livelihood enhancement" refers to activities or programs that aim to improve the economic well-being and social status of individuals or communities. In this case, the program is focused on enhancing the livelihoods of Self Help Group (SHG) women through the production of waste cooking oil soaps. Waste cooking oil is a by-product of cooking and is often discarded as waste. By using this waste cooking oil to produce soap, the SHG women can generate income and contribute to the local economy. This

program not only provides a source of income for the SHG women but also helps to reduce environmental pollution by promoting the recycling of waste cooking oil.

CHAPTER 6

CONCLUSION

In conclusion, the validation of oil sources for soap production using GC-FID is an effective method for determining the fatty acid composition of different oils. By analyzing the retention times and types of fatty acids present in each oil sample, it is possible to identify and compare their quality and suitability for soap production. This information can be used to optimize soap formulations and ensure consistent quality in the final product. Additionally, the use of GC-FID for oil validation is a reliable and cost-effective technique that can be easily implemented in soap manufacturing facilities. Overall, this method can contribute to the development of more sustainable and efficient soap production processes. Based on the GC-FID analysis of the soap samples, it can be concluded that the saponification process was successful in converting the different types of fatty acids present in the oil sources into their corresponding soap products. The retention times and peak areas of the fatty acid methyl esters obtained from the soap samples matched with those of the pure standards, indicating the presence of the expected fatty acid compositions in the soap samples. The results also suggest that the type and proportion of the fatty acids present in the oil sources used for soap production can significantly affect the properties of the resulting soap products. Hence, careful selection of oil sources with desired fatty acid compositions and optimization of the saponification process parameters can be crucial in achieving soap products with desired characteristics such as good lather, cleansing ability, and skin compatibility. Based on the literature reviewed, it can be concluded that the production of soaps from waste cooking oil and medicinal extracts can be a viable option for sustainable and eco-friendly soap production. The use of waste cooking oil not only helps in reducing environmental pollution but also reduces the cost of raw materials, making the soap production process more cost-effective. Additionally, the incorporation of medicinal extracts in soap formulation can provide added health benefits to the users, such as moisturizing, antibacterial, and antifungal properties. The literature suggests that the saponification process, which is the conversion of fats and oils into soap, can be optimized by controlling process parameters such as temperature, concentration of reactants, and mixing rate. The GC-FID analysis has proven to be an effective method for determining the quality of the soap produced, as well as the composition of fatty acids present in

the soap. Overall, the production of soaps from waste cooking oil and medicinal extracts has the potential to contribute to sustainable development and create a circular economy by reducing waste and utilizing natural resources efficiently. Based on the results of the study comparing the cleansing efficiency of soaps made from waste cooking oil and commercial soaps, it can be concluded that soaps made from waste cooking oil can be a viable alternative to commercial soaps. The study showed that the soaps made from waste cooking oil had comparable or even better cleansing efficiency than the commercial soaps tested. Furthermore, the use of medicinal extracts in the soap-making process resulted in additional benefits such as antimicrobial and antioxidant properties. This suggests that the use of waste cooking oil and medicinal extracts can lead to the production of eco-friendly and potentially healthier soaps. Overall, the study highlights the potential of waste cooking oil and medicinal extracts as alternative and sustainable sources for soap production.

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