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A Study on the Synthesis and Properties of an Eco-Friendly Green Detergent from Soya Bean *(Glycine Max)* Oil

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ABSTRACT

The study attempts the synthesis of green detergent from soya bean (Glycine max) oil. The objective of the study was to produce phosphate free green detergent from soyabean oil, and to produce detergent which is environment friendly and more biodegradable than the synthetic detergents. Soya bean seeds were dried in the sun until the casting split and further dried in the oven to reduce the moisture content. The oil, Soxhlet was extracted from the soya bean seed using n-hexane. The soya bean oil was alkali refined and then boiled with lemon peels for clarification. The refined oil was separated using a separating funnel. Further procedures for detergent production were carried out. Green detergent was created by combining concentrated sulphuric acid, sodium hydroxide, and hydrogen peroxide. The green detergent's properties, such as pH and foamability, were tested and compared to those of a local detergent as a control. The moisture content and oil content were calculated on a dry matter basis as 6.92% and 36.8%, respectively. The saponification value of the oil was found to be 158.48meq/kg with a golden color, a pleasant smell, and a viscous nature. The efficiency of the liquid detergent produced from soya bean oil was not satisfactory. Synthetic liquid detergent, but continued use of synthetic detergents can cause an increase in phosphate in rivers and water bodies, which leads to eutrophication and the death of fish. As an alternative, detergent can be produced from natural vegetable oils like soya bean oil and used as a solution to the problem.

KEYWORDS

Detergent, Eco-friendly, Soxhlet extraction, Soya bean.

INTRODUCTION

Surfactants or surfactant mixtures, as well as other organic and inorganic components, comprise synthetic detergents, which have cleansing properties in dilute solutions with water (Ana Carolina Kogawa et al. 2017). A detergent is always similar to soap but with a general structure of R-SO4-Na+, where R is the long chain alkyl group (Penteado et al. 2006). Detergents are classified into anionic, cationic, non-ionic, zwitterionic, and ampholytic on the basis of their electrical charge (Karsa et al. 2012; Lynn Jr et al. 2000; IbsaNemeMogosa 2016)

Detergents contain several chemical compounds like surfactants, sodium perborate, sodium silicate, sodium triophosphate, etc., which cause negative environmental effects (Kemmei et al. 2007). Excessive use of synthetic detergents affects the quality of water, soil, the health of human beings and the growth of plants (Lusas 2002). It is a natural process, but phosphate-containing detergents accelerate the growth of algae. Detergents and soap, which act as surfactants, may provoke skin damage such as scaling, dryness, roughness, and erythema. The consequences of detergent containing water when added to plants, are that the mass of the plant will decrease and the colour of the plant will fade as detergent will break down lipids found in plant cells and damage a few plant cells (Puchta 1984; Pravin 2011). When the detergent containing water reaches the soil, it damages the soil structure, kills essential bacteria and reduces the biological production of the ecosystem (Ndubuisi et al. 2015; Sapna et al. 2022). The continuous use of detergent deteriorates the environment. To overcome these impacts, an alternative to synthetic detergents should be developed (Bastigkeit et al. 2010; El Gawad 2014; Basso et al. 2017). Green detergents are produced from natural sources of plants which are non-hazardous to nature, whereas synthetic detergents are produced from petroleum compounds and cause harm to both the environment and human beings. Green detergents are biodegradable in nature and are phosphate free, so water is not polluted. Edible oils can be used to produce environmentally safe chemicals that can displace the existing petroleum based materials. Materials obtained from vegetable oils such as soya bean oil, castor oil, rapeseed oil, and palm oil have applications in various fields like green detergent synthesis, biolubricants, pharmaceuticals, biofuels, and food production. In this study, soya beans are used for the production of green detergent (Salimon et al. 2012; De et al. 2105; Mohamed et al. 2018).

Soya bean oil is a vegetable oil that is extracted from the seeds of soya bean. It contains about 19% oil. Soya bean oil contains 5 fatty acids: palmitic acid (10%), stearic acid (4%), oleic acid (18%), linoleic acid (55%), linolenic acid (13%). Production of environmentally friendly green detergent from soyabean oil has the dual advantage of using locally sourced raw materials that can be grown and generating waste that can be appetized by micro organisms (Geetu Goel and Surinderjit Kaur 2017; Sapna et al. 2020). Soya bean seeds are used for detergent production because of their easy availability and cheap rate. In the extraction of soya bean oil from the seed, soya beans are cracked, adjusted for moisture content, rolled into flakes and solvent extracted with commercial hexane (Hookgenkamp and Henk 2005; Ibsa Neme Mogosa 2016; Sapna et al 2020). The specific objective of the study was to produce phosphate-free green detergent from soyabean oil and to produce detergent that is environmentally friendly and more biodegradable than synthetic detergents.

MATERIALS AND METHODS

Soyabean seed pretreatment

The Soya bean seeds used to conduct this study were brought from the shop. The soya bean seed undergoes various processing during its preparation for extraction. The unit operations included are:

Clearing: The soya bean seeds had some foreign materials and dirt, which were separated using hand-picking.

Drying: The cleaned seeds were sun dried in the open until the casting split. The beans were further dried in the oven at 105 °C for 6 hours to a constant weight in order to reduce their moisture content, which was initially at about 5 to 7%.

Grinding (size reduction): Mortar and pestle were used to crush the seeds into a paste (cake) in order to weaken or rupture the cell walls to release soya bean fat for extraction.

(a) Determination of moisture content of seeds

100g of the cleaned sample seed was weighed and dried in an oven at 105°C and the weight was measured. The percentage of moisture content in the soya bean seed was calculated using the following formula (1):

Moisture % = W_1-W_2/W_2 × 100 ------------- (1)

Where:

W_1 = Original weight of the sample before drying;

W_2 = Weight of the sample after drying

(b) Seed size reduction and sieve analysis

The moisture was removed by placing the sample in an oven at 105°C for 6hours. The dried soya bean seeds were crushed in a mortar and pestle. The sample was sieved using a sieve of size 2.50 mm.

Solvent extraction of soyabean

Experimental work was conducted using soxhlet apparatus by a solvent extraction process. The solvent that was used in this extraction is n-hexane.

Operation of Soxhlet extraction

100 ml of normal hexane was poured into a round bottom flask and 10g of the sample was placed on the filter paper and was inserted into the centre of the extractor. The soxhlet was heated to 70°C using a water bath. This was allowed to continue for six hours. The weight of oil extracted was determined after 6 hours. At the end of the extraction, the resulting mixture (miscella) containing the oil was heated to extract solvent from the oil.

Determination of the yield of Soya bean seed oil extracted

10g (W1) of the sample was placed on the filter paper and 100 ml of normal hexane was poured into the round bottom flask. The apparatus was heated at 70°C and allowed for 6 hours of continuous extraction using the Soxhlet apparatus in formula (2).

% oil yield = W_1-W_2/W_1× 100 --------- (2)

Where:

W_1=Sample weight before extraction

W_2= sample weight after extraction and dried in the oven.

Refining Of Soyabean Oil

Oil refining is performed for the clarification of oils to avoid the presence of impurities, free fatty acids, and any unwanted odour, and the bleaching of the oil is done to remove objectionable colour. Some common methods of oil refining are:

(a) Alkali Refining

The saponification process of the oil is very difficult if there is the presence of fatty acids, water, and other impurities, which leads to the rancidity of the oil. The use of weak caustic soda solution, called alkali refining, is one of the common methods used for refining. During this process, the free fatty acids in the oil react with the weak caustic soda solution, which forms soap stock, which also absorbs some colour, odour, and impurities from the oil. The obtained oil is clean.

(b) Boiling of the oils

Clarification of the oil involves boiling the oil in half its volume of water for about 2–4 hours, depending on oil volume, with some scenting materials like lemon grass or orange peels in it. While scenting materials give scent to the oil, steam from the hot oil-water mixture takes away undesirable odours. After the boiling, the flame is put out and the mixture is allowed to cool. The clean clarified oil floats on the top of the water and is syphoned from the separator funnel while the water with the settled impurities from the oil is drained off from the bottom of the separator funnel. In this work, the extracted oil is refined by this method using lemon peel.

Characterization of refined soyabean oil

Relative to other vegetable oils, soyabean oil has different physical and chemical properties which vary with the method of extraction of the oil.

Physical properties of the oil

The physical properties of the oil, like odour, colour, and texture, were determined by visually examining and inhaling. Some of the physical and chemical characteristics of the oil are explained as follows:

Determination of pH Value

In a clean, dry 25ml beaker, 2g of the sample was taken and 13ml of hot distilled water was added to the sample in the beaker, which was stirred slowly. The solution was then cooled to 25°C. The pH electrode was standardised using buffer solution and then immersed into the sample and the pH value was recorded.

(c) Determination of saponification value

The 25ml of ethanoic potassium hydroxide (0.1M) was added to 2g of the oil in a conical flask and the mixture was allowed to boil for about 60 minutes, while it was shaken at regular intervals of 5 minutes. A few drops of phenolphthalein indicator were added to the hot solution and then titrated against 0.5M HCl. The end point is noted when the pink colour of the indicator just disappears. The same procedure was followed for the blank. The saponification value (SV) is given by (3)

SV = 56.1 × N(V_0-V_i)/m --------------- (3)

Where:

V_0 = volume of HCl solution used for the blank test
V_I = volume of HCl solution for the determination
N = actual molarity of HCl used
m = mass of sample

Production of detergent

The 0.1M NaOH solution was prepared by weighing 0.4g of sodium hydroxide pellets into a beaker containing 100ml of water and shaking vigorously. 30ml of soybean oil was put in a conical flask and heated at 350C for about 2 minutes. Caustic soda (0.1M) was added to the mixture and stirred well. With constant stirring, 2ml of 18M sulfuric acid was added, and the reaction was allowed to finish by adding 2ml of hydrogen peroxide (bleaching agent) into the reaction mixture. When the foaming had subsided, the heating was continued to allow for more vaporisation before putting off the heating system and then the solution was allowed to cool. The detergent formed was then subjected to a foamability test to ensure the effectiveness of the process (Abubakar et al. 2005).

Characterization of fabric liquid detergent

In this study, the characterization is focused on the alkalinity, foamability, and saponification.

(a) Saponification test

A "ribbon test" was performed to check whether saponification was completed or not. For this test, a small quantity of detergent sample was taken from the beaker and pressed between our thumb and forefinger. The detergent should come out in the form of firm, shiny ribbons with slight opaque ends and should be clear when it’s held against the light. The detergent is oily, and it requires more caustic if the opaque ends appear and vanish, but if the detergent is grainy, or turbid and somewhat white, it indicates a high level of unreacted caustic soda, and it requires some oil.

(b) Alkalinity test

The 5mL of the detergent solution was added to the beaker and the alkalinity of the detergent was determined using a pH meter. The electrode of the pH meter is dipped inside the detergent solution and the pH value of the solution is read and recorded.

(c) Foamability test on detergent produced

About 5 mL of the soya bean oil-based detergent was added to 20 mL of distilled water. The mixture was shaken vigorously to generate foam. After shaking for about 2 minutes, the measuring cylinder was allowed to stand for about 10 minutes. The foam height in the solution was measured and recorded. Sodium hydroxide was added to the detergent solution to retard the foam being formed during the reaction, and hydrogen peroxide was added as a bleaching agent.

Result and discussion

Determination of moisture content in soya bean seed

The 100g of soya seed was dried at 105^0C and the sample weight was reduced to 93.525 after 4 hours. The moisture content was determined as 6.92% using the equation.1. Operational efficiency was recorded high while pressing oil seeds with low moisture content (Patil and Sharman. 1998)

Determination of oil yield after Soxhlet extraction

The sample weight obtained after extraction and dried in the oven was 6.32. Total percentage yield of soyabean oil after 6 hours of Soxhlet extraction was obtained as 36.8% using the equation 2. For a seed to be considered commercially viable, the oil content of the seed must exceed 20%. In this regard the oil yield of soyabean in this study is 36.8%. When the maximum amount of extractable oil is obtained, the oil yield level remains invariable even by extending the reaction time. So that in the Soxhlet extraction the maximum oil yield could be found at an extraction time of 6 hours and above. (IbsaNemeMogosa. 2015). The Soxhlet apparatus used for extraction of oil is shown in figure 1:

Fig 1. Soxhlet apparatus

Alkali refining and boiling of oil

The obtained oil was then alkali refined and boiled with lemon peels in it. Figure 2 shows the boiling oil and it shows the refining with lemons.

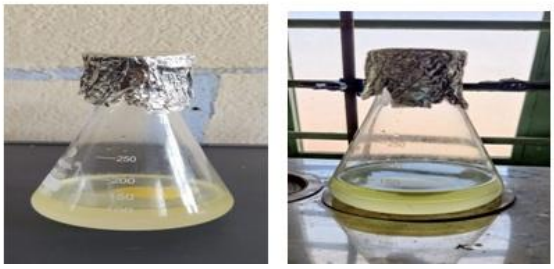

Fig 2. Boiling of oil and refining with lemon peels

Refined oil floats on the top, and the pellet is removed after separation using a separating funnel. Refined oil floating on top and separated refined oil is shown in figure 3 respectively.

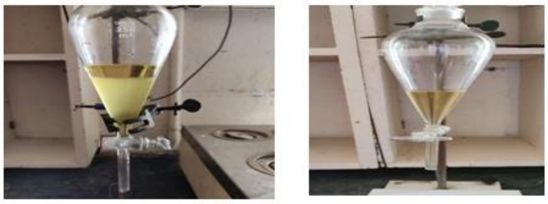

Fig 3. Oil floating on top and separated refined oil

Colour of the soya bean oil obtained was golden yellow. The smell of soya bean oil was pleasant and it was viscous in texture.

Determination of pH value

The pH electrode was standardized by buffer solution and the pH was recorded as 4.67 after immersing the electrode in 2ml of soya bean oil.

Determination of saponification value

First, the blank level changed from pink to colourless at 23.8mL titration volume. The colour at which the saponification test changed from pink to red colour was 12.50 mL of titration volume. The saponification value was determined as 158.48meq/kg using equation 3. The smaller the saponification value, the larger the average molecular weight of the triacylglycerols present and vice versa. Generally, values of 200 meq/kg and above are indicative of fatty acids of low molecular weight, while values of less than 100 meq/kg indicate fatty acids of high molecular weight (Abayeh 2015). The value obtained for soya bean oil is 158.48 mg KOH/g, which indicates a moderate average molecular weight for the fatty acids.

Characterization of detergent properties

a. Saponification test

The ribbon test performed by taking the detergent sample and pressing it between the thumb and the forefinger showed the result that the detergent sample contained slight opaque ends and was clear when held against light. The saponification value is a measure of the alkali reactive group in the fatty acid and it is expressed as the number of mg of potassium hydroxide or sodium hydroxide required to saponify 1g of fat or oil under the specified conditions (Ndubuisi et al. 2015).

b. Alkalinity Test

The end use of detergent is a pH dependent variable which can be neutral (6–8), acidic (3–4), or alkaline (8–11). Alkali detergents contain components that digest proteins, fat, or carbohydrates in clothes, mould in bathrooms, etc. Based on this study, the pH obtained for the green liquid detergent is 8.12, and that agrees with acceptable standards. Therefore, it is a suitable pH for detergency as it is not very basic or acidic.

c. Foamability test

The ability of the detergent to produce foam determines the quality of the detergent. Normally, foamability is checked by dissolving the detergent in distilled water. The height of the foam measured after shaking vigorously for 5 minutes is 0.8 cm and is shown in figure 4. A good detergent takes longer before the foam height collapses, whereas a poor detergent collapses quickly (Ugbeh et al. 2015).

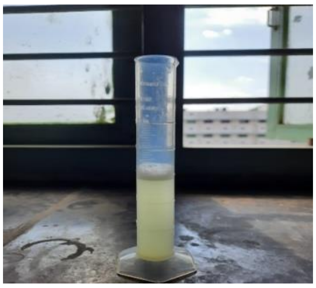

Fig 4. The foam produced

3.7. Comparison of properties of produced detergent to local detergent

The optimum value of the detergent produced was taken into account and compared with the local detergent. Alkalinity and Foamability: Alkalinity methods and foamability height parameters standardised effects were dependent on procedures given in 2.6 and 2.7, respectively.

Table 1: The alkalinity and foamability value comparison

Alkalinity (ph) value	
Produced detergent	Local detergent
8.12	8.54
Foamability Height (Cm) Value	
Produced detergent	Local detergent
0.8	8

The green detergent produced was not very favourable when compared to other local detergents. The comparative effectiveness of detergent was checked through its foaming ability. The green detergent maintained an average lathering ability in distilled water.

Conclusion

The detergent produced from natural plant source like edible oils from soya bean can be used safely because its eco-friendly, more biodegradable and cause less impact to the environment when compared to synthetic detergents. The results obtained for extraction showed an average percentage of oil extracted was 36.8%. The moisture content of the soya bean seed obtained was 6.92% and the alkalinity of the detergent obtained was 8.14 pH. The height of the foam produced was 0.8cm which is less when compared to other detergents. Physical properties of the produced detergents which were determined, with comparing one local detergent.

The produced liquid detergent from soya bean oil efficiency was not high enough as the synthetic liquid detergent but the continuous use of synthetic detergents can cause increase of phosphate in rivers and water bodies which leads to eutrophication and pollution of environment. As an alternative detergent can be produced from natural vegetable oils like soya bean oil and used as a solution for the problem. Soya beans and economically feasible and easily available. Therefore, soya bean oil can be used as a less expensive supplementary feedstock for detergent production by curing the environment and increasing agricultural earnings.

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