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Production of Detergent from Castor Seed and Optimization of Parameters Affecting Its Productivity

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Abstract This project work was to carry out with the objective of extraction of oil from castor seeds and its utilization to produce a synthetic detergent. The detergent production was obtained from castor beans by using pre-treatment of castor seed, extraction of castor oil, neutralization and sulphation methods. Chemical extraction method was employed in extracting the oil and the total percent oil yield was 38%. The detergent efficiency was determined as a measure of the foamability of the detergent. The pH tests revealed mildly basic properties. The colour, scent and efficiency of the detergent were improved with the addition of bleaching agent, perfume and foaming agents respectively. The result obtained for the extraction showed an average percent oil extracted was 38%.This value is low relative to the literature; using N-hexane 46% up to 55% oil was extracted. The low yield was attributed to the nature of the seeds and difference in solvent. Moreover, the sulphation and neutralization gave a powered detergent of high enough efficiently as seen from the result of the foamability test. Usually, the efficiency of washing power was assessed through the amount of foam its capability of producing. The presence of persistent foam exemplifies a good detergent. The foam height of 2.5cm persisted for about 4 minutes and this is good relative to the literature 2.6cm with the standard value. The detergent formed was the result of esterification of the castor oil.

Keywords: *detergent, castor seed, esterification, sulphation, parameters, foamability*

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1. Introduction

Detergent is a cleaning agent that helps to remove dirt and grease from porous surfaces such as fabrics, clothes, and/or non-porous surface such as metal plastics. All detergents are made principally of soap or surfactants. Detergent was produced from fat of animals, but we are proposing to produce from castor seeds by extracting using methanol and with saponification of castor oil in batch reactor using KOH as catalyst. We will consider other variables like residence time, concentration, and reaction temperature. The effect of these variables on the viscosity, PH, and foamability of detergent will study. We are also study the raw material, methods, material and energy balance, equipment selection, and techno-economic feasibilities of the project. The washing industry, usually known as soap industry, however, among the many chemical process industries, none has experienced such a fundamental change in raw material. But after a time different technologies are applies for the production of detergent among these are vegetable oil, like olive oil, palm oil, coconut oil and castor oil are basic raw materials for the production of detergent. Among these vegetable oil castor bean is a fast growing ever-green shrub that produces seeds with high oil content up to 55%. [1]

Castor oil has long been used as lubricant in engines but only recently has research on the use of Castor oil as a detergent started. The seeds contain extremely poisonous substances that remain in the press cake which can therefore not be used for animal feed. The oil is non-toxic. Scientifically, the term detergent covers both soap and synthetic detergent, but it is widely used to indicate synthetic cleaning compounds as distinguished from soap. Detergent differs from soap in their action in hard water. Although soaps are excellent cleansers, they do have disadvantages. As salts of weak acids, they are converted by mineral acids into free fatty acids. [4]

These fatty acids are less soluble than the sodium or potassium salts and form precipitate or soap scum. Because of this, soaps are ineffective in acidic water. Also soaps form insoluble salt in hard water such as water containing magnesium, calcium or iron. Synthetic detergents, however, may be soluble in both acidic and alkaline solutions and do not form insoluble precipitate in hard water.

The detergent and soap making industries are no exceptions, for while they provide us with cleansing agents, their processing and by-products are also a cause of public nuisance. For instance, detergents, unlike soaps, have proved very effective cleansing agents in hard and cool water whereas soap is often wholly ineffective under such condition. [8]

This project work is aimed at studying the replacement made to the non –biodegradable detergents.

Production of environmentally friendly synthetic detergents from castor oil has the dual advantage of using locally sourced raw material that can be grown and generating wastes that are appetizing to microorganisms (bacteria). This research project work is aimed at studying the replacement made to the non –biodegradable detergents. [9]

Production of environmentally friendly synthetic detergents from castor oil has the dual advantage of using locally sourced raw material that can be grown and generating wastes that are appetizing to microorganisms. [1]

The standard physicochemical characteristics of castor oil were listed as follow. These characteristics are moisture content, PH, specific gravity, viscosity, percentage of yield oil and their values are; 5-7%, 6-7, 0.959, 332 Pc, 46-55 respectively. Also the standard physicochemical characteristics of castor oil detergent were PH (7-8.5), foamability (2.6 cm), viscosity (120 pc) specific gravity (0.961). [3]

Detergents are anionic surfactants used in conjunction with water for washing and cleaning, but they are also used in textile spinning and are important components of lubricants. Detergents for cleansing are obtained by treating vegetable or animal oils and fats with strongly alkaline solution. Fats and oils are composed of triglycerides; three molecules of fatty acids are attached to a single molecule of glycerol. It consist of sodium or potassium salts of fatty acids and is obtained by reacting common oils or fats with a strong alkaline solution in a process known as saponification. Soap belongs to the family of detergents which is a substance which improves the cleaning properties of water. [2]

2. Materials and Methods

2.1. Materials

Materials used were:

a. Test tubes:-used to measure the liquid ingredients
b. Soxhlet extractor: -used to extract the castor oil from castor bean
c. Beakers:-used to mix the ingredients
d. Stand:-used to carry the stirrer motor
e. Indicator:-used to identify the pH media of the product weather it is acidic or basic.
f. Mixer:-used to mix the ingredients and reduced the amount of unconverted ingredient by producing perfect mixing.
g. Thermometer:-used to measure the temperature.
h. Ball viscometer:-used to measure the viscosity of the product
i. Analytical balance:-used to measure the required amount of ingredient that used to produce the product
j. PH meter:-used to measure the acidity of the detergent

2.1.1. Raw Materials

Raw materials used were:

a. Castor seed:-as a raw material
b. Water:-used to dilute the ingredients and act as the reaction media.

2.1.2. Chemical Additives

Chemicals used were:

a. Sodium silicate:-used to adjust the viscosity of the product, to adjust the pH of the product because it is strong basic chemical, and also used to increase the brightness of the product.
b. Potassium hydro oxide:-was also strong base but the main important of these chemical is to neutralize the fatty acid.
c. Sodium chloride:-was used to increase the brightness of the product and change the product to semi solid.
d. Sulphuric acid:-used to produce the detergent
e. Perfume:-used to give a good odder to the product
f. Colorant:-used to attract the customer need
g. Hydrogen per oxide:-used as bleaching agent

2.2. Methods

The castor seeds (or beans) are harvested from the local area. The seeds are collected when ripe as the capsules dry, they open and discharge the seeds. The seeds are then cleaned, decorticated, cooked and dried prior to extraction. Cooking is done in order to coagulate protein, which is necessary to permit efficient extraction, and to free the oil for efficient pressing. It is done at 80°C, under airtight conditions. After cooking, the material is dried at 100°C, to reach a moisture content of approximately 5-7percent. [11]

2.2.1. Pre-treatment of Castor Seeds

The pre-treatment involved the preliminary preparations of the seeds in the following: [8,9,12,14]

Shelling: this involves the removal of the shells to obtain the seeds. It will do manually.

Clearing: this involves the removal of foreign matter introduced during the sun drying and any unshelled seed.

Drying: the moisture content of the seed will reduce using the electric oven. The oven may operate at 80^{o}C for about three hours.

Crushing: Mortar and pestle are used to reduce the sizes of the dry seeds so as to increase the interfacial area between the solvent and the seeds. This helps to weaken the cell walls to release castor fat for extraction. [6]

2.2.2. Extraction of Castor Oil

Extraction of oil from caster seeds is done in a manner similar to that most other oil seeds. The ripe seeds are allowed to dry when they split open and discharge the seeds. The seeds are dehulled after harvesting. Dehulling can be done by hand (laborious) or, more commonly by machine. Small scale hand operated dehullers are also available. The dehulled seeds are cleaned, cooked and dried prior to oil extraction. Cooking is done to coagulate protein (necessary to permit efficient extraction) and for efficient press. [10]

The first stage of oil extraction is pre-pressing, normally using a high pressure continuous screw press-called the expeller. Extraction oil is filtered, and the material removed from the oil is feedback in to the stream along with the fresh material. Material finally discharge from the press, called castor cake. [6]

2.2.3. Refining of the Oil

Once the oil has been extracted from the seed, it is necessary to remove any impurities from the oil that makes it such an important commodity. The oil is essentially a pure triglyceride, and contains almost 90% of glycerol tricinoleate. It is the ricin oleic triglyceride that is needed in order to produce high quality castor oil that will be used for the chemical industry. Characterizing properties of castor oil include a higher density, viscosity, and reactivity than common triglycerides found in other vegetable oils. These properties are exploited when refining the oil from the impurities. The steps to refining the crude oil include settling and degumming of the oil, bleaching, neutralization, and deodorization of the oil. [3]

The settling and degumming of the crude oil is done to remove the aqueous phase from the lipid (boiling water will add to the oil and the mixture stirred for some mints and allowed to stand in the separating funnel) and to remove phospholipids from the oil. Bleaching of the oil results in the removal of colouring materials and the removal of remaining phospholipids and oxidation products through the adsorption of the impurities to neutral clay. Care must be taken because highly acid activated clay can react with the oil and cause an undesirable dehydration reaction. [5] Neutralization can be done in one of two ways: by alkali (chemical) or steam stripping (physical) means. The neutralization step is necessary to remove free fatty acids from the oil. [6]

2.2.4. Production of Detergent

Potassium hydroxide solution would be prepared by weighing 40g of KOH Pellets into a beaker containing 200ml of water and shaking vigorously. The electric hot plate would switch on; 30ml of castor oil in a stainless steel plate was placed on it and heated at 35^0C for about 120 minutes. Caustic potash was add and the mixture stirred with a glass rod. 18M sulphuric acid will then add with constant stirring, and the reaction allowed to completion after which hydrogen peroxide (Bleaching agent) is introduced into the reaction mixture. Finally, perfume was added and the system would allow cool. The liquid detergent formed was subjected to foam ability test to ensure the effectiveness of the process. The same steps were followed, but this time palm kernel was used as the base material. The resulting liquid detergent formed was again collected and tested as above. [6]

2.2.5. Experimental Works

To produce detergent the following experimental activities were done.

1. 300ml of methanol was poured into round bottom flask
2. 60g of the sample was placed in the thimble and inserted in the centre of the extractor.
3. The Soxhlet is heated at 60^oc
4. The extracted (cake) was then removed from the tube
5. Then dried in the oven, cooled in the desiccators and weighed to determine the amount of oil extracted
6. At the end of the extraction, the resulting mixture containing the oil was heated to recover solvent from the oil.

2.2.6. Characterization of Products

Determination of extracted oil (yield) was determined as follows

Table 1. Determination of oil yield

Parameters	Value (g)
Weight of empty flask (M_1)	108.6
Weight of single close (thimble) (W_1)	7
Weight of sample + single close (thimble) (W_2)	87
Weight of Sample (W_2-W_1)	80
Weight of empty flask +Oil (M_2)	139
Weight of oil (M_2-M_1)	30.4

Percentage of extracted oil can be calculated by using the following formula.

Percentage of extracted oil

$$=\frac{M2-M1}{W2-W1}*100\%$$

$$=\frac{30.4}{80}*100\%=38\%.$$

Determination of oil viscosity

a. Ball viscometer was filled with castor oil sample
b. The distance of the viscometer was measured and recorded the length
c. Temperature of the castor oil at room temperature (in °C) was measured and recorded in the data table
d. Using a stopwatch to time the Teflon ball as it dropped through the castor oil. Teflon ball was dropped into the oil and measure the time it took the ball to travel from the top line to the bottom line of oil
e. Viscosity was calculated using the following formula which correlates density and ball diameter

$$\mu=K*(\rho s-\rho f)*t,\text{ where }K=\frac{g*d2}{181}$$

Where μ = viscosity, ρs= density of solid (falling ball), ρf = density of liquid (oil) and d=ball diameter.

Table 2. Determination of oil viscosity

Parameters	Values(g)
Mass of oil (g)	30.9
Volume of oil (ml)	33
Density of oil at 20°C (kg/m^3)	914
Density of the ball (kg/m^3)	7820
Diameter of the ball (m)	0.01272
Time taken (sec)	17

$$K=\frac{9.81*(0.01272)2}{18l}2.272*10^{-}4\,m^2/s^2$$

$$=2.272*10^{-}4m^2/s^2*(7820-914)*17$$

$$\mu=32.2\,pas.$$

Determination of Specific Gravity

Empty specific gravity bottle was weighed (Mc), castor oil was poured into the specific gravity bottle and was weighed to get (Mo). The oil was then substituted with water of the same volume and reweighed to give Mw.

a. Density bottle was used to determining the density of the oil.
b. A clean and dry bottle of 25ml capacity was weighed (Wb=9.59) and then filled with the oil and reweighed to give (W_1=12.59).
c. The oil was substituted with water after washing and drying the bottle and weighed to give (W_2=12.72). The expression for specific gravity (Sp.gr): Sp.gr = (W_1-W_b)/(W_2-W_b)

Sp.gr=Mass of the substance / Mass of an equal volume of water

$$Sp.gr = (12.59 - 9.59)/(12.72 - 9.59) = 0.9587.$$

Table 3. The summarized characterized parameters of oil are as follows

Properties	Characterized values of Castor Oil
Moisture content of beans (%)	5.3
Yield of oil (%)	38
Specific gravity	0.9587
Viscosity at 25°C (pc)	322
pH	6
Color	Orange

2.3. Effect of Concentration on Detergent Processes

The following were procedures used in studying effect of concentration.

a. Obtain three glass blenders or mixers and set the blenders properly
b. Potassium hydroxide solution would prepare by weighing 30g, 40g, and 50g of KOH Pellets into a beaker containing 200ml of water and shaking vigorously
c. Heat 90 ml of castor oil to 35°c and add 30 ml of the hot castor oil to each mixture, for blender 1, 2 and 3 respectively
d. Heat the solution and let it boil during 1 hr. with perfectly mixing at 35°c
e. Pour the mixture into a wide mouthed glass container
f. Allow the mixture to sit for several hours. Dispose of the glycerine properly and add 20 ml of sodium silicate with 10ml of hydrogen peroxide until the desired PH is satisfied
g. Add perfumes

2.3.1. Effect of Residence Time and Temperature on Detergent Processes

The following were procedures used in studying effect of Effect of residence time and temperature

a. Three glass blenders or mixers were set
b. 200 ml water to each glass blenders or mixers
c. 40 gram of sodium hydroxide were added to each glasses.
d. Potassium hydroxide was completely dissolved in the water
e. 30 ml of the castor oil were added each mixture. Mixtures were blended for [60min, 30°c], [90min, 35°c] and [120min, 60°c] for blender 1, 2 and 3 respectively.
f. The mixtures were sit for several hours
g. Glycerine was properly added to 20 ml of sodium silicate with 10ml of hydrogen peroxide until the desired PH is satisfied
h. Finally perfumes was added

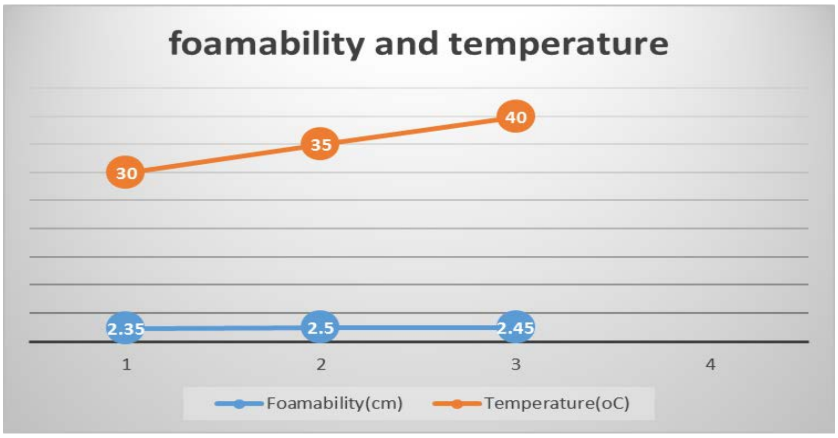
2.3.2. Foamability Tests on Detergents Produced

About 60ml of the detergent was added to a 500ml measuring cylinder containing 100ml of distilled water. The mixture was shaken vigorously so as to production of detergent from castor oil generate foams. After shaken for about 2minutes, the cylinder was allowed to stand for about 10mins. The height of the foam in the solution was measured and recorded. The same steps were followed using the detergent produced with the castor oil so that the foamability of the two could be compared. The results obtained were recorded in the result section of this work. [8]

Table 4. The effect of concentration of potash on production of detergent

Time (min)	Temperature(°C)	Amount of potash (g)	Foamability(cm)
60	30	30	2.20
60	30	40	2.30
60	60	50	2.35

As the concentration of temperature and potash were increased its foamability was increased.



Graph 1. Effect of temperature

As we have seen from the above experimental result the optimum foamability factor was 2.5 cm on the 90min, 35^{o}c and 40g, time, temperature and KOH respectively.

3. Result and Discussions

The results obtained for the moisture content, percent volume of oil extracted and its physical and chemical properties, determination of viscosity and other characteristics as well as the foamability tests of the detergent produced are showed below.

Moisture content

$$= \frac{\text{initial mass of the sample} - \text{dried sample mass*100\%}}{\text{initial mass of the sample}}$$

$$\text{Moisture content} = \frac{(2-1.894)*100\%}{2} = 5.3\%.$$

Weight of Sample ($W_{2)}$ =80g, Weight of oil (M_1) =30.4g; thus percentage of extracted oil was calculated by using the following formulas.

Percentage of extracted oil

$$= \frac{M1}{M2}*100\% = \frac{30.4}{80}*100\% = 38\%.$$

Table 5. The summarized characterized parameters of oil

Properties	Characterized values of castor oil
Moisture content of beans (%)	5.3
Yield of oil (%)	38
Specific gravity	0.9587
Viscosity at 25°C [pc]	322
pH	6
Free fatty acid value (%)	76.2
Colour	Orange

Table 6. Determination of viscosity of detergent

Mass of detergent sample taken (g)	17
Volume of detergent sample taken (ml)	18
Density of detergent at room temp (kg/m^3)	940
Density of the ball (kg/m^3)	7820
Diameter of the ball (m)	0.01272
Time taken (sec)	7

$$K \frac{9.81*(0.01272)2}{18*0.33} = 2.672*10^{-4} m^2/s^2$$

$$= 0.0002672* \ (7820-940)*7 = 13\text{pas}.$$

PH value was read from the pH meter as 8.2 and viscosity of detergent produced at residence time of 90min and 35^{o}c from the experiment was 130pc.

4. Conclusion

The result obtained for the extraction showed an average percent oil extracted was 38%.This value is low relative to the literature; using N-hexane 46% up to 55% oil was extracted. The low yield was attributed to the nature of the seeds and difference in solvent. Moreover, the sulphation and neutralization gave a powered detergent of high enough efficiently as seen from the result of the foamability test. Usually, the efficiency of washing power was assessed through the amount of foam its capability of producing. The presence of persistent foam exemplifies a good detergent. The foam height of 2.5cm persisted for about 4 minutes and this is good relative to the literature 2.6cm with the standard value. The detergent formed was the result of esterification of the castor oil. When castor oil was treated with concentrated $H_2SO_{4,}$ it gave a complex mixture consisting of hydrogen sulphate of ricin oleic acid in which the hydroxyl group is esterified and a compound in which the H_2SO_4 has added to the double bond. The product is known as sulphated castor oil. Neutralization of this aqueous KOH gave a detergent plus water .The reaction proceed at temperatures between 35-40°C. The bleaching agent (H_2O_2) added helped to bleach the colour of the castor oil so that semi milk colour detergent was produced. PH tests showed that the detergent exhibited basic property. This project have been under taken to extract castor oil from its seed, refined this and used to produce a detergent. The extraction was done using methanol as a solvent. The oil was refined by degumming to remove most gums. Sulphating and neutralization of the refined oil gives a detergent. Other operations like bleaching where performing to improve colour, scent and texture of the detergent. The production of synthetic detergent from castor oil was successively done. The desirable intrinsic quantities of castor oil made it very useful in the industry, thus castor oil could serve as a good cleaning agent.

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