Production of Calcium Stearate Using Cow Bone and Palm Oil Extract

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Abstract This research was conducted to produce calcium stearate using cow bone and palm oil extract. The cow bone and palm oil used for this study were sourced within Rivers State metropolis. Atomic Absorption Spectroscopy (AAS) was used to analyze the elemental composition of the bone. Gas chromatogram (GC) was used to analyze the chemical composition of the cow bone powder produced and the palm oil for the purpose of characterization. The GC analysis revealed the presence of the following component parameters, which include C8 component, lauric acid (C_{12}), myristic acid (C_{14}), palmitic acid (C_{16}) Behenic acid (C_{20}), stearic acid (C_{18}), oleic acid ($C_{18:1}$), linoleic acid ($C_{18:2}$), magaric acid (C_{17}). The concentration of the produced calcium stearate was 48.3602PPM while that of industrial was 53.743PPM (difference of 5.3828PPM). This difference was highly reduced after stabilization. The conversion for possible utilization of agricultural waste such as cow bone and palm oil residues is important in not only protecting the environment but also in minimizing the cost of disposal, conservation of cow bones and palm oil residues for other purposes and reduction in the conversion into the production of calcium stearate in Nigeria for economic diversification is a welcome development. The research demonstrates the usefulness of cow bone and palm oil in the production of calcium stearates.

Keywords Production, calcium stearate, Cow Bone, Palm Oil, Extract

Introduction

Most of the calcium stearates used today are petroleum based types of which their reliability is very high when used as an additive for PVC production, stabilizing agent for lead and origination production, and as lubricant in most industrial processes. useful in the window and technical profile techniques, useful in the production of cables and wires, useful in the production of calendared films and sheets production, useful in the production of palstisol, useful in the production of sheets and foamed profiles and useful in the production of pipes and fittings. In most cases, the term reliability is more acceptable and understandable when defined in terms of monetary values as well as in terms of the characteristics and properties of the reactants or reagents to given the desired products that are reliable to meet up the international recommended standard of any given products. Therefore, reliability can be defined as the probability that any given product obtained from reactants will possess the tendency to perform its described function adequately, especially when, the process is subjected into the necessary conditions of operation.

The usefulness of calcium stearates in today's activity is numerous, there is need to produce calcium stearates using local raw materials that is reliable, efficient and cost effective (cheap) and will meet the international standards. The application of locally made raw materials for the production of calcium stearates is a new technology, since most of the calcium stearates in the market today are calcium stearates of petroleum based.

The metallic stearates production products such as sodium stearates ($C_{17}H_{35}COO^-Na^+$) metal stearate ($C_{17}H_{35}COO^-$) M^{2+} where M = Zn^{2+}, Ca^{2+} etc, can be obtained from direct or fusion reaction mechanism as well as the magnesium stearate ($C_{17}H_{35}COO^-$)$_2$ Mg^{2+} . H_2O can be obtained from the concepts of the AV process. The growing rate of production of calcium stearates is due to its usefulness to various reactions as well can be

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handled easily and safely, the reaction of stearic acid with calcium hydroxide to yield calcium stearate as a desired product as well water molecules as a by-product.

In the production of drugs, plastic, food processing, cements etc calcium stearate has been found useful by these industries. It provides the required need for optimum performance of the industrial operation with less friction. However, most of these calcium stearates are imported from outside country even though the major raw materials for the formulation are available in Nigeria. This can be attributed to governmental policy within the country to obtain other useful constituents present in the black gold (crude oil). It is also obvious that the cost of purchasing these substances or chemical that are predominant on the black gold cannot be equated to the cost of selling the crude oil. This research work is aimed at producing calcium stearate using local raw materials (cow bone and palm oil).

They compared the melting point characteristics of the process and their results revealed that the melting point of metal salts is higher than the mixture of the predominantly stearic and palmitic acids [1-7].

In the case of fatty acid with shorter chain, in which characteristics of laureates are rapidly influenced by the individual metal base. The characteristics of the metallic stearate in terms of the gelation and water repellence are maintained through the process, whereas the separating and lubricating properties induced the process significantly.

The presence of the double bond in the fatty acid, oleates contributes to the low melting point in the stearates compounds as well as improved the solubility of the product slightly. In most cases, the recommended properties of metallic stearate considered by various research groups include the following: the lubricating and separating properties, water repellence, and gelling capacity, stabilizing effect and foam inhibition properties [8-12].

The metallic stearate characteristic can be also attributed to the lubrication as well as the release properties in terms of water repellency; hence the influence of these characteristics can be determined based on the concentration of cation, fatty acid chain length as well as other functional parameters and properties that control the system that is the water crystallization composition [13].

Materials and Methods
Sampling
In the study of calcium stearate production, the following sample materials were used: cow bone and palm oil. The bone was collected from an abattoir in Port Harcourt and transported to Laboratory of the Department of Chemical/Petrochemical Engineering, Rivers State University for onward processing.

Equipment and Materials Used for the Analysis
The materials used for this study are: cow bone, palm oil, reactor, jaw crusher, sieve, electric furnace, ball mill, hammer, litmus paper, digital measurement balance, heating mantle, distillation flask, receiving flask, condenser, water hose, acid resistance bottle, measuring cylinder, beakers and conical flask and thermometer

Reagents Used for the Analysis
The following reagents were used during the production of calcium stearate: sodium hydroxide, concentrated hydrochloric acid, ethanol and distilled water

Procedure for Extraction of Calcium from Cow Bone
The following procedure was used in the extraction of calcium from the cow bone. 3.0 kg of grinded cow bone was measured using a technical measuring balance provided in the Chemical/Petrochemical Laboratory.

The weighed grinded cow bone was sieved to obtain a known particular size for calcium extraction. 2.0kg of cow bone powder of 0.8mm particle size obtained from the sieving was measured into a transparent acid resistant, four litre glass container and 1.5 litres of concentrated HCl was added with low heating mantle for 1 hour to enable the bone powder dissolve in the acid. The solution cooled to room temperature and then neutralized using base (NaOH) to pH of 7. The neutralized solution contains high calcium oxide (about 99.5%)

in liquid form. To transform the liquid calcium oxide into solid, the liquid was evaporated under low temperature and solid calcium oxide was obtained which was then grinded into powder form.

Production of Stearic Acid from Palm Oil

The following procedure was used in the production of stearic acid from palm oil. 9.5gm of base (NaOH) was measured and introduced into 3 litres acid resistant transparent plastic container. In the solution 1 litre of alcohol (ethanol) was added and tightly cocked and agitated for 10min until a base pallet dissolved forming ethanozide solution.

The enthonizide solution was mixed with 500ml of dissolved palm oil and solution was stirred and heated to about $55^{o}C$ with continuous stirring for a period of 1 hour. After preheating, the oil was stirred and turned to separating funnel which allows settlement within 48 hrs.

After 48 hours, two layers were observed and were separated through decantation. The lower layer was triglycerine and the upper stearic acid which was subjected to distillation process to remove the volatile components. The stearic acid was allowed in the distillation flask to cool to room temperature. The stearic acid was further dehydrated and crushed to powder.

Analysis Procedures

a) Density of calcium stearate

Apparatus: Density bottle, digital balance, insoluble solvent

Procedure: An empty density bottle was weighed and weight recorded (W1) and then the calcium stearate up to one-third was measured into a bottle and the weight recorded (W2) and the remaining space in the bottle was filled with the insoluble solvent and the solution was shake vigorously to remove air bubble and the stopper was inserted and wiped away excess displaced solvent on the body of the bottle and weighed again (W3). The solvent and the sample from the bottle was removed and the bottle was filled with only the solvent, stopper inserted, wiped away the excess displaced solvent, weighed again (W4).

$$\rho = \frac{W2 - W1}{(W4 - W1) - (W3 - W2)} \quad x\, W5$$

ρ of solvent = W5

Determination of Viscosity of Calcium Stearate

Apparatus: Viscosity cup, Brook field Viscometer, Spindle and adjustable stand

Procedure: The viscometer was plugged to power source and the speed selected in RPM as well as spindle size. The required quantity of the sample was put into the cup and the motor button switched on to enable the spindle rotate and thr result obtained recorded in centipoises.

Determination of Moisture Content of Calcium Stearate

Apparatus: Temperature regulated oven, digital weighing balance, crucible, tonge desiccator, heat resistant pan

Procedure: The crucible was washed and dried to remove dirt and moisture weight (d1) and 5gm of the sample was measured into the crucible and weighed to obtain the weight of the crucible and sample (d2) and then the crucible containing the sample was inserted into the oven and then the oven switched on.

The temperature of the oven was set at $60^{o}C$ and then the sample in the oven was allowed for 3 hrs and after drying period of 3 hrs, the sample was removed from the oven into a desiccator where it was cooled close to room temperature and then the sample was removed from the desiccator and weighed (d3)

$$Moisture\ content\ (\%) = \frac{d2 - d3}{d2 - d1} \quad x\ 100$$

Analysis of Compounds in the Calcium Stearate Using G.C. Method

Apparatus: GC machine, monitor, CPU, GC syringe, beakers, pipettes etc

Procedure

1.   Solid samples were prepared using acid extraction method

2.   The compounds were extracted into liquid form
3.   The extract of the sample was injected into the GC
4.   The GC picks the sample and sends the compounds concentrations to the computer
5.   The computer prints out the results in graphical as well in concentration in a given unit.

Analysis of Trace and Heavy Metal/Elements in Calcium Stearate Using AAS Method
Apparatus: Air compressor, fume chamber, graphite furnace, table lamp, carrier gas (Argon), oxygen, Dvought fan, water separator, computer system, printer, beaker, pipette, sucker, reagents of known concentrations
Procedure
The AAS machine was powered and all the require processes for elemental analysis including the wave length needed for each metal/elements were set and the standard curve test was run, recorded and plotted against the standard curve. Again, the equipment (AAS) was simply set to give direct reading in concentration.Sample for analysis was prepared by acid extraction method and the after extraction, the required reagents for each element were made available as well as the reagents were added according to the procedures for each element and the results obtained recorded the concentration.

Analysis of Weight Loss of Calcium Stearate
Apparatus: Digital balance, crucible, temperature regulated oven, spatula

Procedure
It was ensured that the balance use is in good order and then process was plugged into power source which led in the measuring of the crucible and the empty weight. 10gms was measured of the sample and the weight recorded for both the sample and crucible. The temperature of the oven was set at $60^{o}C$ and sample dried for 4 hrs, after that the sample was removed from the oven after drying into a desiccator and was allowed to cool and then the cooled the sample in the desiccator to room temperature and reweighed
% Wt loss = initial Wt – final wt x 100

Analysis of Thermo gravimetric Analyses (TGA) of Calcium Stearate
Apparatus: Simultaneous thermal analyzed (STA)
Procedure
1.   The calcium stearate sample was placed in the Simultaneous Thermal Analyzer CSTA machine
2.   The STA machine displayed the DTA measuring the sample voltage changes
3.   The TGA test was also performed simultaneously by putting 10gm of the sample into an alumina crucible and heated from room temperature to $1200^{o}C$
4.   The STA monitors the mass and voltage changes of the sample. Where the mass changes indicates the TGA and the voltage changes indicates the DTA

Determination of Melting Point of Calcium Stearate
Apparatus: Melting point apparatus, $0\text{-}360^{o}C$ Thermometer, melting point tube, stopwatch, reference substance, cooling plug
Procedure
The top of one melting point tube was broken and filled with the sample up to a height of 3-5mm by sliding it alongside a smooth paper on which the substance was placed into the 3 holes in the heating block and thermometers were inserted, and the holes were blocked off with empty melting point tubes. The control switch was turned knob to zero and the heater and lamp was switched on allowed the booster heater and turned the temperature control knob to 10 and the process was observed until the substance through the lines until became molten and then the temperature at which the sample became molten was recorded, that is the melting point.

Preparation of Samples for Gas Chromatogram Analysis
Soxhlet Extraction Method
Five gram (5g) of the homogenized sample was weighed and then mixed with 20g of anhydrous sodium sulphate in a mortar to absorb moisture. The solution was placed homogenate into a 500ml beaker and 300ml of

hexane was added as well as covered properly to allow the extraction for 48h.The crude extract obtained was evaporated using a rotary vacuum evaporator at 40^0c, just to dryness.

Florisil Clean Up

Florisil (magnesium silicate) was heated in an oven at 130^0C over night (activation) and then transferred into a 250ml size beaker and placed in a desiccator.0.5g anhydrous $NaSO_4$ was added to 1.0g of activated florisil (magnesium silicate) (60 – 100nm mesh) on a column plugged with glass wool, and then a packed column filled with 5ml n – hexane for conditioning with an opened stopcock to allow N – hexane run out until it just reaches top of sodium sulphate into a receiving vessel whilst tapping gently the top of the column till the florisil settled well in the column. The solution was then transferred (extract) on to the column from an evaporating flask as well as each evaporating flask was rinsed twice with 1ml portions of n – hexane and added to column.Elute collected was dried using rotary evaporator as well as dried elute was dissolved in 1ml n – hexane.

The 1ml n-hexane extract was dissolved in 50ml of CCl_4 (chloroform) and introduced into a 100ml volumetric flask up to the required level by the mechanism of dilution. Most of the chloroform at room temperature were evaporated and1 ml of inter-esterification reagent {20 vol% benzene and 55 vol% methanol} were added. The process was sealed and heated up to 40^0c for 30 minutes.

Organic samples were extracted after inter-esterification using hexane, water, etc for the purpose of obtaining 1:1:1 mixture and reagent, hexane and water. 1ml of mixture solution (water and hexane) was allowed to react and process or solution was shake vigorously for 2 minutes and emulsion stability was obtained and further centrifugation was used after transferring half of the hexane mixture component into a small reactor for the purpose of injection.

Fixed Setting: The concept ofgas flow adjustment in the column to allow inlets, component detectors as well as the split ratio analyzers. The temperature of the detector as well as the injector was programmed for action. The detectors are aimed at minimizing risk of formation of high precipitate formed as a result of high oven temperature. The above described point controls the values, as well as double check all functional parameters and components of the instrument. 530model gas chromatograph was used for the automatic injector column as well as the ionization detector flame. The column of HP88 capillary made of 100m x 0.25μm thickness of the film was used.

Temperature of detector used was 250^0C.

Temperature of injector used was 22^0C

Chart speed of integrator used was 2cm/min

The temperature used was 180^0C which allowed the application of GC to set up as warming process continues. Set:

Table 1: Temperature Condition

Initial Temp	Hold	Ramp	Final Temp
70^0C	5min	10min	220^0C
220^0C	2min	5min	280^0C

When the instrument was ready, the ''NOT READY'' light was turned off, and the run was started.

1 microliter sample was injected into the column using proper injection technique.

Flow Diagram for Cow Bone and Palm Oil Processing (Extraction of Calcium for cow bone and Stearic Acid from Palm Oil)

The following are steps for extraction of Calcium from Cow bone: 1. Purchase of cow bone from abattoir, 2. 1st washing of the cow bone, 3. 1st drying of the bones atmospherically, 4.Breaking of the bones, 5. 2nd washing of the bone, 6. Heating processes upto 80^oC for fat removal, 7. 3rd washing for 2nd fat removal, 8. 2nd drying upto 80^oC, 9. 3rd heating of the bone upto120^oC, 10. Crushing of the bone using jaw crusher, 11. Sieving the crushed bone to get 0.8mm size, 12. Reaction process using Conc. Acid, 13. Neutralization of the product, 14. Separation process (decantation) (Calcium & Chaff), 15. Calcium recovery (Paste), 16. Dehydration of the paste calcium, 17. Solid calcium is formed, 18. Crushing of the solid calcium using ball mill and19. Final product-powder calcium in a container.
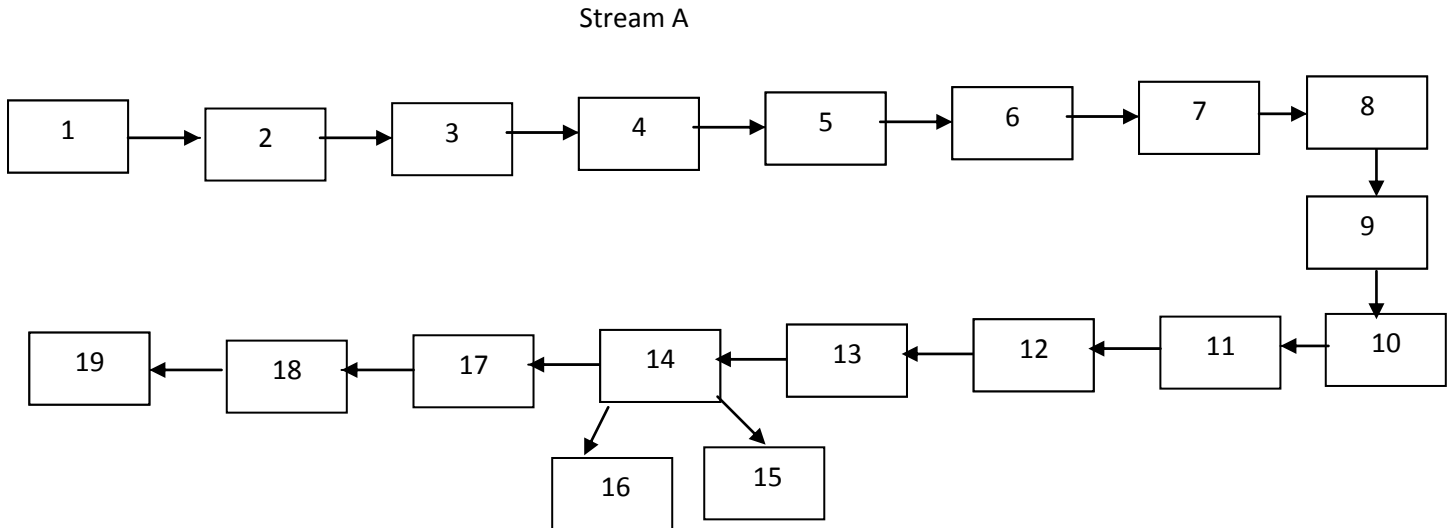
Stream A

Figure 1: Flow Diagram for Extraction of Calcium from Cow Bone Process
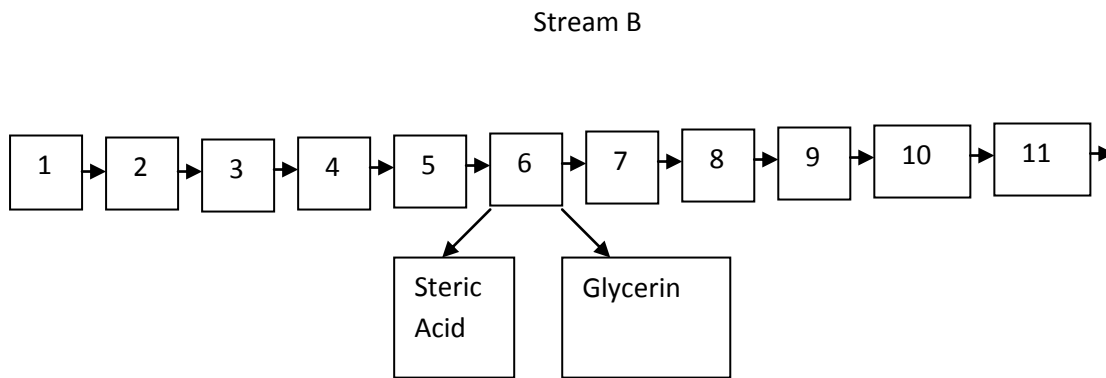
Stream B

Figure 2: Flow Diagram for Extraction of Stearic Acid from Palm Oil

The following are Steps for extraction of Stearate from Palm Oil

1. Purchase of palm oil, 2. Storage of palm oil, 3. Heating (bleaching), 4. Addition of additives (base), 5. Reaction of the additives with the bleached oil, 6. Formation of Glycerin and Stearic acid, 7. Separation of the products (decantation), 8. Recovering of stearic acid (paste), 9. Dehydration of the stearic acid to solid, 10. Crushing of solid stearate to powder form, 11. Final production (Stearate) in a container

Stream A + Stream B

Gave the calcium Stearate
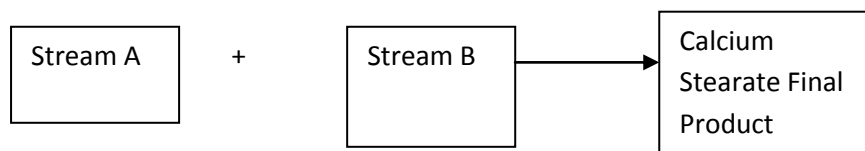
Figure 3: Flow Diagram for Calcium Stearate Production

$$2C_a^{2+} + \left(C_{17}H_{35}COO-\right)_2 \rightarrow 2C_{17}H_{35}COOC_a + H_2 \uparrow$$
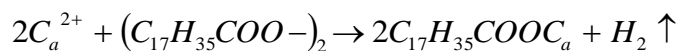
Results and Discussion

The results obtained from this research work is presented in Figures
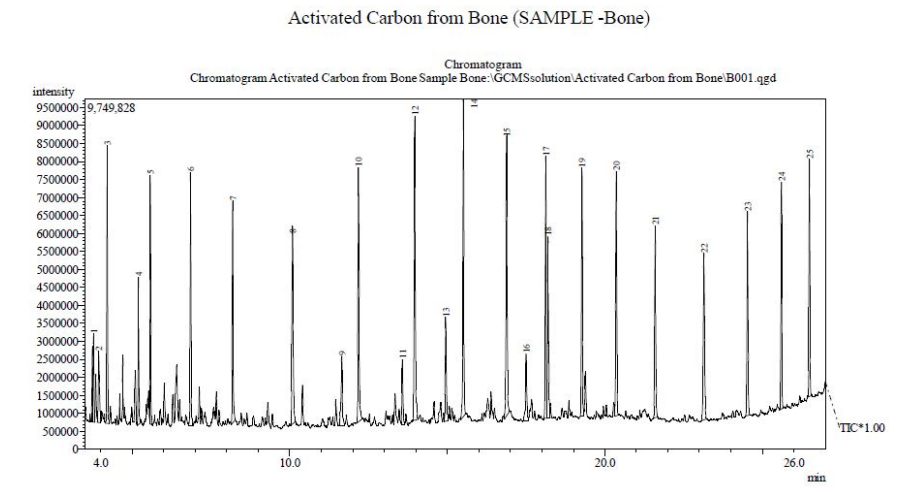
Figure 4 Activated Carbon GC Analysis Result

Result presented in Figure 4 illustrates the characteristics of activated carbon obtained from the processing of the cow bone to achieve the production of calcium stearate. The intensity of individual component was determined with increase in time.

GC – 2010 with the following information was used in obtaining the data column over temperature (45^oC), 25^oC injection, split mode (injection), flow control mode (linear velocity, pressure - 04.3kpa), total flow 21.0ml/min, linear velocity (46.3cm/sec), column flow (1.6ml/mm), purge flow (3,0ml/min), split ratio (10.0) whereas the high pressure injection carrier gas saver and splitter hold was off during the process. Analytical line of AOC – 20i was applied in the process with the following description of operation, number of rinses with presolvent (4) number of rinses with sample (3), plunger speed (injection) (high), syringe insertion speed (high) injection mode (normal), pumping times (5), injection port dwell time (0.3sec), terminal air gap (No), plunger washing speed (high) washing volume (8μl), syringe suction position (0.0mm) syringe /injection position (0.0mm) and use 3 solvent vial (1 vial).
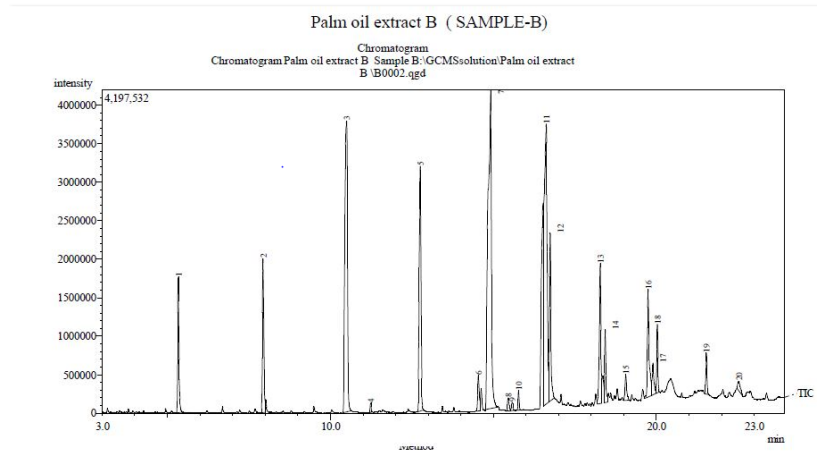

Figure 5: Palm Oil Extract GC Analysis Result

Figure 5 illustrates the characterization of palm oil extract intensity using the chromatogram (GCMS solution). The GC – 2010 analysis with the following information was used, column over temperature (70^oc), injection temperature (250^oC). The over temperature programme is within the range of 0-10.00 of rate, 70^oC to 280^oC for temperature and 0.00 – 5.00min for the holding time.

The various individual compounds obtained from the chromatogram (GCMS solution) on the palm oil extract is illustrated in the appendix E.
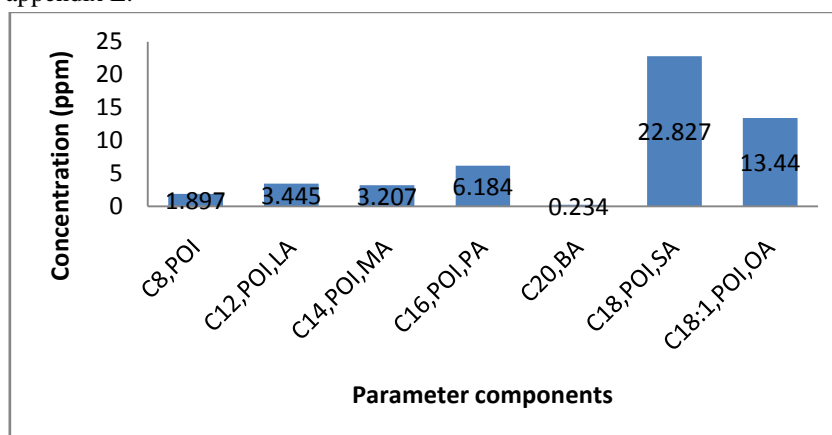

Figure 6: Concentration of Individual compound versus Parameter Components for Palm Oil Initial

The result presented in Figure 6 illustrates the individual compound concentration against parameter components for palm oil initial concentration. The analysis on the characterization of the initial palm oil concentration revealed that C_8, POI = 1.897ppm C_{12} POI, LA (laurie acid) = 3.445ppm, C_{14}, POI, MA (myristic acid) = 3. 207ppm, C_{16}, POI, PA (palmitic acid) = 6.184ppm, C20 POI, BA (Behenic acid) = 0. 234ppm, C_{18}, POI, SA (stearic acid) = 22.82ppm and C_{18}:1, POI, OA (oleic acid) = 13.44ppm. The order of magnitude of the individual parameter components revealed that stearic acid (C_{18}, POI, SA)>oleric acid ($C_{18:1}$, POI, OA) >palmitic acid (C_{16}, POI, PA) >Lauric acid (C_{12}, POI, IA) >myristic acid (C_{14}, POI, MA) > C_8, POI, EA >Behenic acid (C_{20}, POI, BA). It is also seen that stearic acid has the highest concentration indicating the presence of such substance in palm oil component.
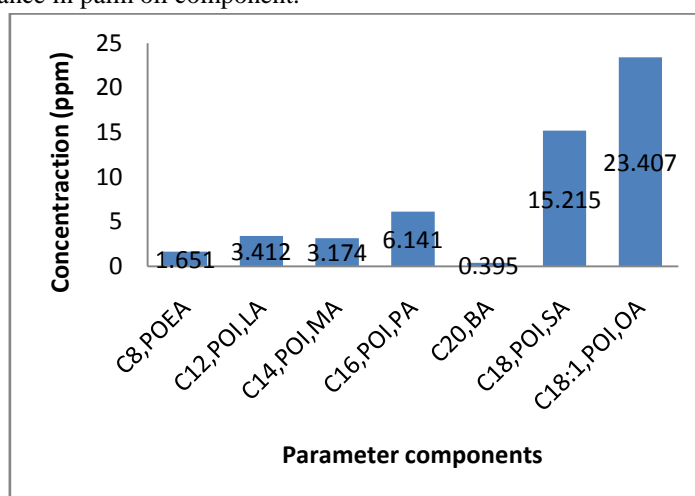

Figure 7: Concentration of Individual compound versus Parameter Components for Palm Oil Extract A Top Sediment

From Figure 7 it is seen that the concentration of individual compound varies with parameter components for palm oil extracted from sample A. In this case, the concentration of oleic acid is higher than others indicating higher conversion of other individual compound into the yield of oleic acid under the influence of heating and the solvent used for the extraction. Also from Figure 7, it is seen that the order of magnitude of parameter component concentration revealed that oleic acid > stearic acid >palmitic acid >lauric acid >myristic acid > C_8 POI EA >Behenic acid.
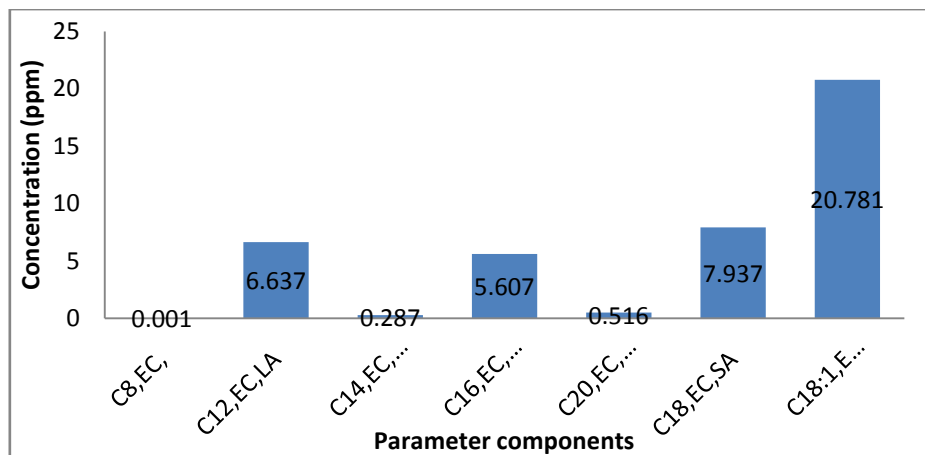
Figure 8: Concentration of Individual compound versus Parameter Components in Extracted Calcium from Animal Bone

Figure 8 illustrates the concentration of individual compound in relation to parameter component in extracted calcium from animal bone. The result reveals that Oleic acid has the highest value of 20.781ppm, stearic acid value is 7.937ppm Lauric acid value is 6.637ppm, palmitic acid value is 5.607ppm, Behenic acid value is 0.516, myristic acid value is 0. 287ppm and C_8 value is 0.001ppm. The order of magnitude in terms of individual components concentration is oleic acid > stearic acid >Lauric acid >myristic acid > C_8 component. The result presented in Figure 8 revealed that high percentage of oleic acid is still present in the extracted calcium, which shows that more extraction process can be carried out to extract more of the useful components that can be used in the production of calcium stearate.
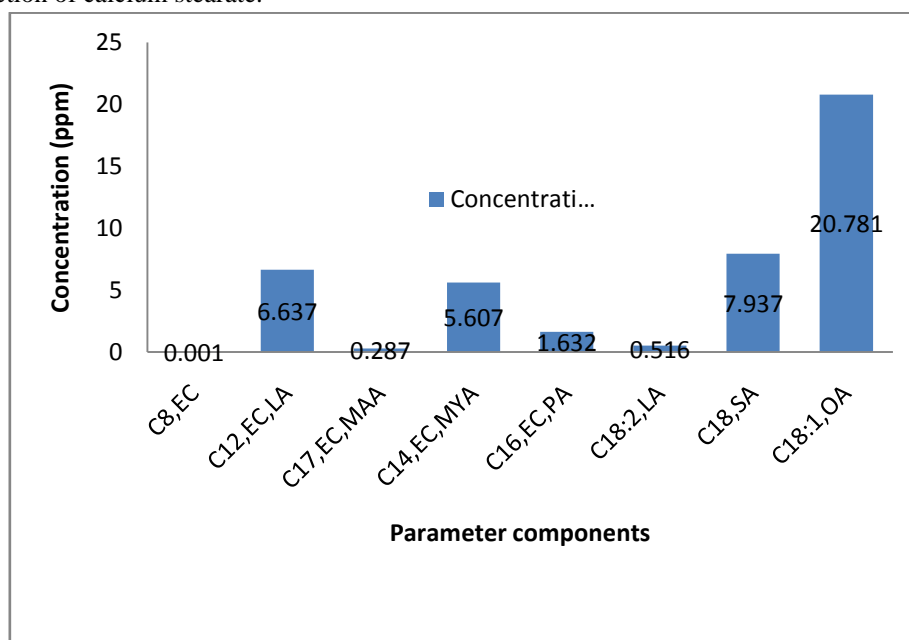

Figure 9: Concentration of Individual Compound versus Parameter Components for Extracted Calcium from Animal Bone

From Figure 9 the relationship between the individual compound concentration and parameter components for extracted calcium from animal bone (cow bone) was investigated. The result obtained is presented in Figure 9 and it revealed that animal bone (cow bone) contains high percentage of oleic acid with a value of 20.781ppm. The result presented in figure 9 illustrates that all the required parameter component present in the activated carbon was extracted remaining none as can be seen in Figure 8 and 9. The total extracted of these parameter components is necessary as to prepare the activated carbon ready for adsorption process, as well as to avoid the presence of other substance that may induce the process if used in effluent water treatment.
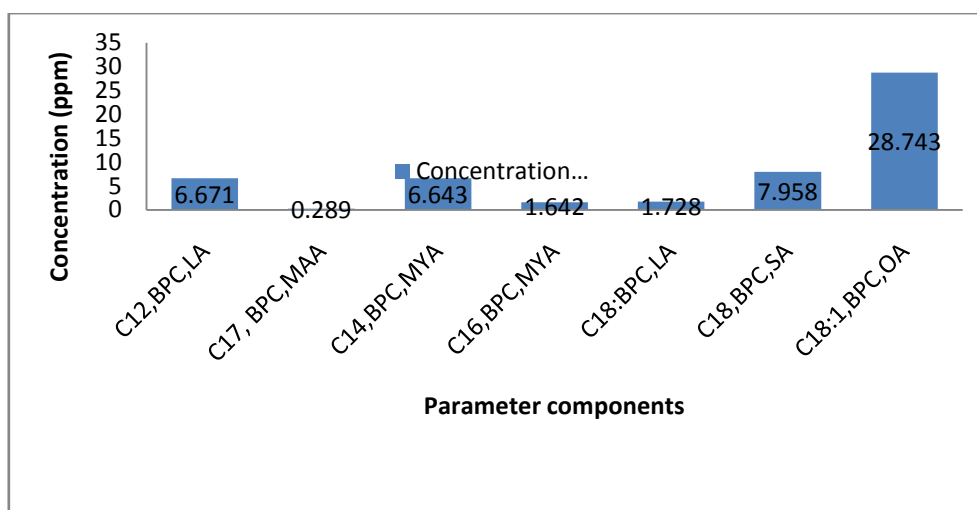
Figure 10: Concentration of Individual Compound versus Parameter Components for Bone Powder Crushed

The results presented in Figure 10 demonstrate the relationship of individual compound concentration and parameter components bone powder crushed. The analysis result revealed that Oleic acid has the highest concentration of 28.743ppm and the lowest concentration of component presence is magaric acid with its value as 0. 289ppm.The compound concentration is oleic acid (28,743ppm) > stearic acid (7.958ppm) >Lauric acid (6.671ppm) >myristic acid (6.6.43ppm) >Behenic acid (1.728ppm) >palmitic acid (1.642ppm) >magaric acid (0, 289ppm). It is observed that the crushed animal bone (cow bone) contains the presence of magaric acid with a very low value of 0. 289ppm and this component was lost during the processing of the raw material (crushed cow bone) as well as no trace of the component was found in the end product obtained. This can be attributed to the high volatility in terms of temperature influence as well as instability in end product.
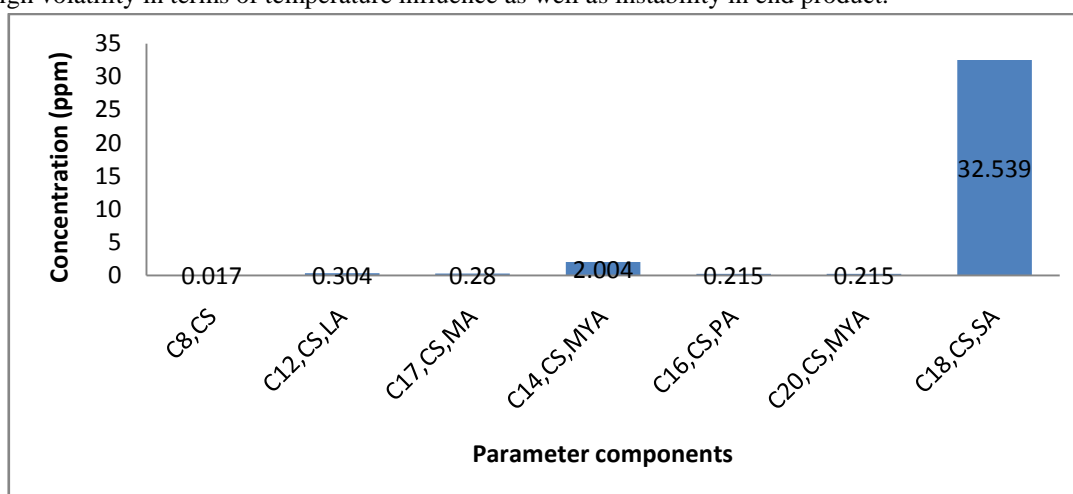

Figure 11: Concentration of Individual Compound versus Parameter Components for Calcium Stearate

Figure 11 demonstrates the relationship between the concentration of individual compound and the parameter components for calcium stearate production. The calcium stearate produced contains high percentage of stearic acid of 32.539ppm with other components of low values as shown in Figure 11. The result obtained reveals that stearic acid is one of the major components used in the production of calcium stearate and it can be obtained in quantity from the extraction process of animal bone (cow bone) as investigated. However, other components present in it are as stated: myristic acid (2.004ppm in concentration), Lauric acid (0.304ppm in concentration), magari acid (0. 28ppm in concentration), palmitic acid and behenic acid (0. 215ppm) and C_8 (0.017ppm in concentration). The order of magnitude in terms of calcium stearate individual components concentration is stearic acid >myristic acid >lauric acid >magaric acid >Palmitic and Beheric acid > C_8 as presented in Figure 8.
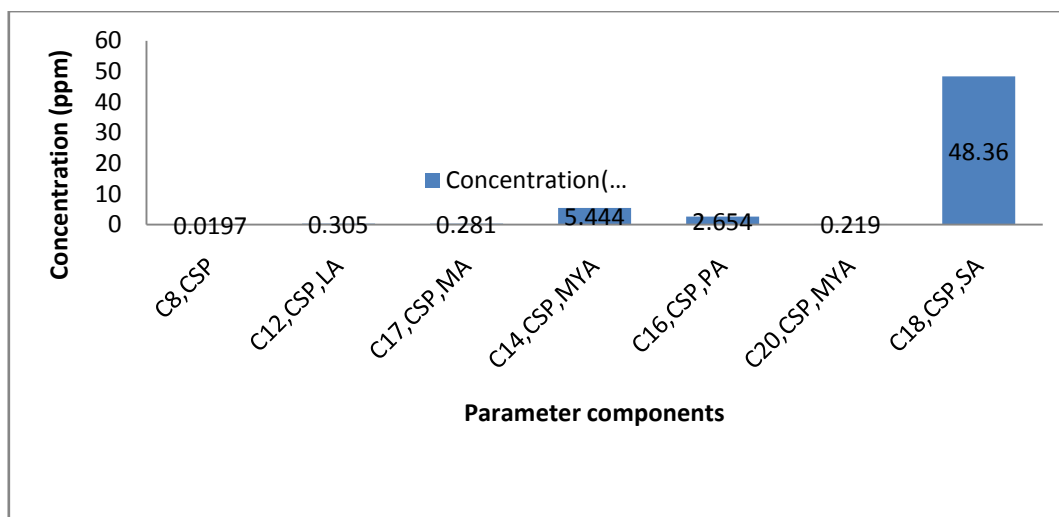
Figure 12: Concentration of Individual Compound versus Parameter Components for Calcium Stearate Produced

The result presented in Figure 12 illustrates the end product of calcium stearate produced using animal bone (cow bone) and palm oil extract. The result obtained revealed increase in stearic acid concentration to a value of 48.36ppm, 5.444ppm for myristic acid, 2.654ppm for palmitic acid, 0.305ppm for lauricacid, 0. 281ppm for magaric acid, 0. 219ppm behenic acid and 0.0197ppm for C_8 component. The order of magnitude in terms of concentration of newly formulated and produced calcium stearate myristic acid concentration >palmitic concentration >lauric acid concentration >magaric acid concentration >behenic acid concentration > C_8 component concentration.

The results obtained as presented in Figure 12 was compared with the industrial calcium stearate use in petrochemical, food processing drug production industries etc. And the result obtained revealed acceptability and reliability to perform the same function if used by these industries. Further classification and understanding can be viewed in comparison to Figure 13 which states the characterization concentration of individual compound concentration upon the parameter components investigated.
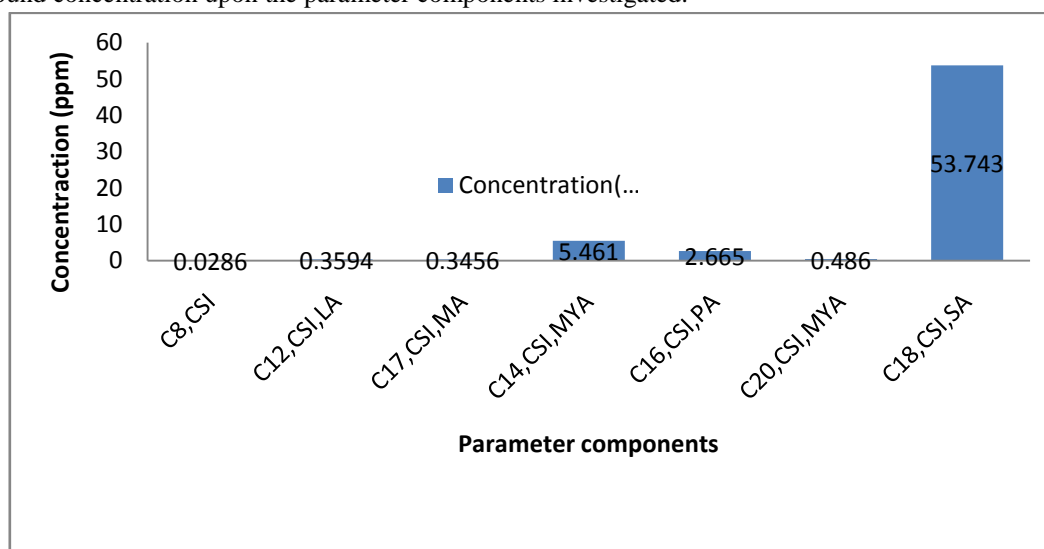

Figure 13: Concentration of Individual Compound versus Parameter Components for Calcium Stearate Industrial

Figure 13 illustrates the relationship between concentration of individual compound and the parameter components of industrial calcium stearate used by petrochemical company in Nigeria. Analysis carried out on the concentration of individual compound on parameter components revealed that the industrial calcium stearate contains high percentage of stearic acid of 53.743ppm and the lowest concentration is C_8 component with its

value as 0.028ppm. The order of magnitude for industrial calcium stearate used by various petrochemical industries revealed that stearic acid concentration >myristic acid concentration >palmitic acid concentration >behenic acid concentration >Lauric acid concentration >magaric acid concentration > C_8 component.
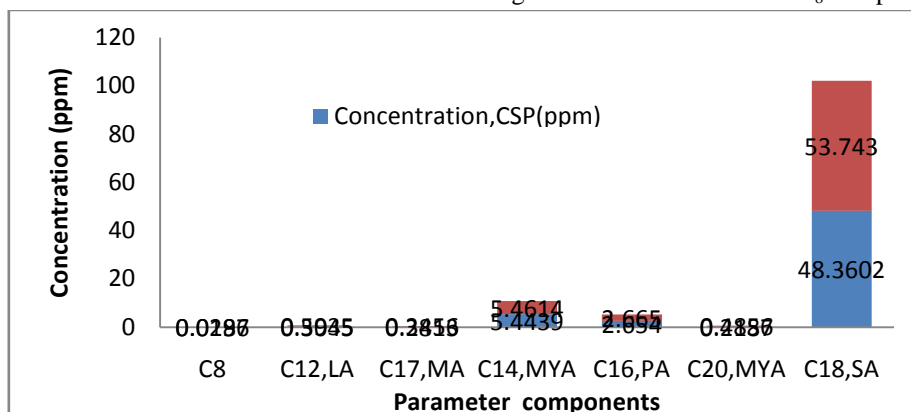

Figure 14: Comparison of Formulated and Industrial Calcium Stearate Concentration of Individual compound versus Parameter Components

From Figure 14 illustrates the relationship between the formulated calcium stearate produced using animal bone (cow bone) and palm oil extracts and industrial calcium stearate concentration of individual compound against parameter components. The comparison of the locally formulated calcium stearate with the industrial calcium stearate shows a good match indicating the acceptability and reliability of the locally produced product. From Figure 14 it is seen that each of the individual compound value is very close when considering the locally formulated and the industrial calcium stearate produced. The comparison of the values revealed that stearic acid has the value as 48.3802ppm for formulated whereas industrial value is 53.743ppm,, myristic acid value of 5.4439ppm for formulated whereas industrial value is 5.4614ppm, palmitic acid value of 2,654ppm for formulated whereas industrial value is 2.665ppm, lauric acid value is 0.3045ppm for formulated whereas industrial value is 0.5935ppm, magaric acid value is 0. 2813ppm for formulated whereas industrial value is 0.3456ppm, behenic acid value is 0. 2187ppm for formulated whereas industrial value is 0.4856ppm and C_8 component value is 0.0197ppm for formulated whereas industrial value is 0.0286ppm. The result obtained from this research indicate that the locally formulated materials for the production of calcium stearate are reliable as well as the chemical composition and their concentration revealed that the calcium stearate produced can be used for the same purpose as of that of the industrial ones. It is noted that the industrial one is based on raw material from petroleum products whereas the formulated one produced from this research is based on locally raw material made of animal bone (cow bone) and palm oil extracts.
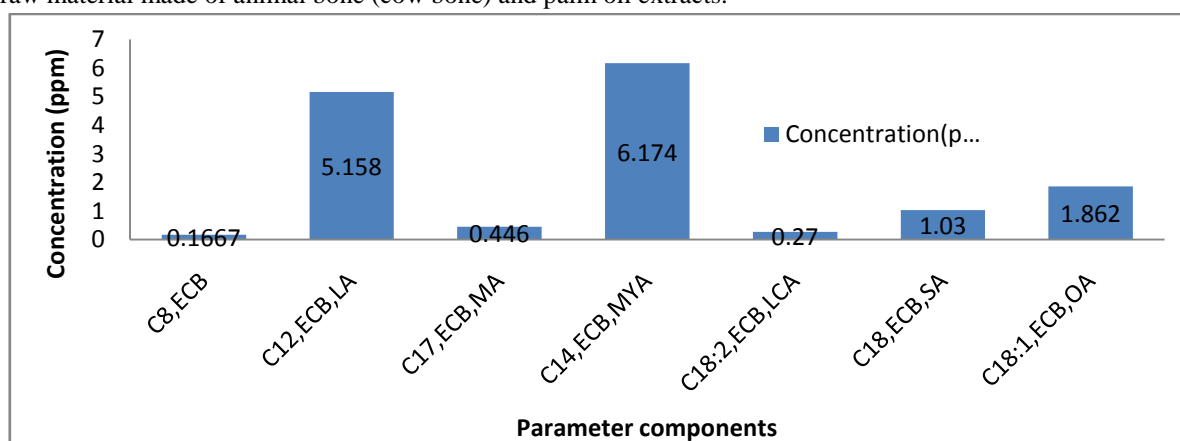

Figure 15: Concentration of Individual compound versus Parameter Components for Extracted Calcium from B Base Sediment

In Figure 15 it is seen that the relationship between concentration of individual compound and parameter components for extracted calcium from B base sediment. The result obtained revealed that the myristic acid has

the highest concentration of 6.174ppm whereas the lauric acid value is 5.158ppm, Oleic acid value of 1.862ppm stearic acid value of 1.03ppm, magaric acid value of 0.446ppm, behenic acid value of 0. 27ppm and C8 component value of 0.1667ppm was observed and recorded as presented in Figure 15. It is also observed that the percentage of the stearic acid in this residual product is very low indicating high extraction of the useful raw material (stearic acid component) from the process. The order of magnitude in terms of individual compound concentration for further extraction of calcium from B base sediment (residual product) is as stated: C_{14}, ECB MYA (Myristic acid) > C_{12}, ECB LA (lauric acid) > $C_{18:1}$, ECB, OA (oleic acid) > C_{18}, ECB, SA (stearic acid) > C_{17}, ECB, MA (magaric acid) > C_{20} ECB, BA (Behenic acid) > C_8, ECB component. It is seen that the concentration of the stearic acid in this case, was very low, therefore there is no need of further extraction to be carried out, but such invent will cause more money with less output value achieved at the end of the process. The base sediment (residual product) obtained at this time is still useful since other component of industrial interest is of high concentration.
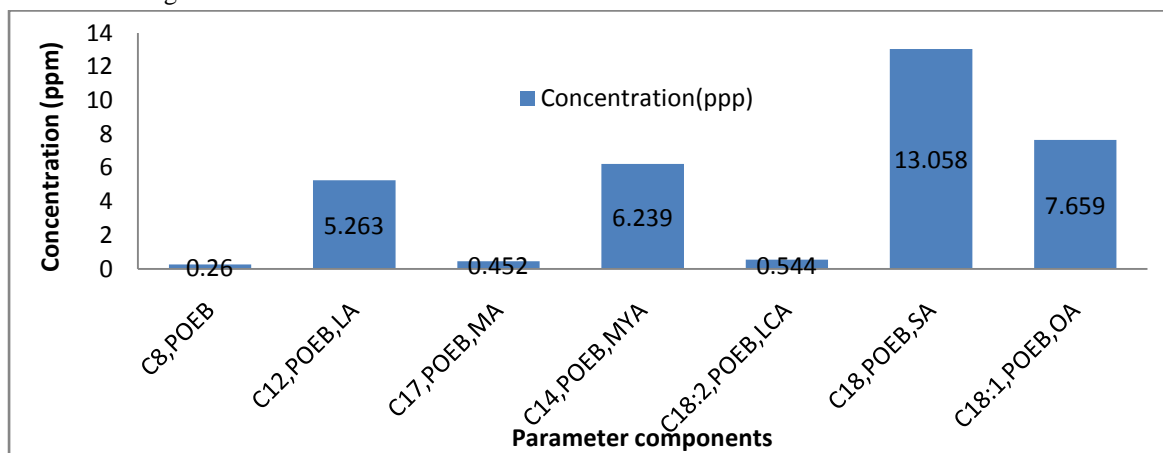

Figure 16: Concentration of Individual Compound versus Parameter Components for Palm Oil Extract B Base Sediment

Figure 16 illustrates the relationship between the concentration of individual compound and parameter components for palm oil extract B base sediment. The result presented in Figure 16 revealed that the concentration of stearic acid is high compared to other components. It is noted that stearic acid concentration in the palm oil extract B base sediment is high meaning that further extraction process can be carried out to obtain more of the stearic acid, since it is the major raw material needed for the production of the calcium stearate. Although, the percentage of stearic acid is high other useful component such as oleic acid, myristic acid and lauric acid still contain high concentration as well. The palm oil B base sediment can further be processed to extract more of the useful components from it. The order of magnitude in terms of the concentration of palm oil extract B base sediment is an shown, C_{18}, POEB, SA (stearic acid) > $C_{18:1}$ POEB, OA (oleic acid) > C_{14}, POEB, MYA (myritic acid) > C_{12}, POEB, LA (lauric acid) > C_{20}, POEB, BA (behenic acid) > C_{17}, POEB, MA (magaric acid) > C_8, POEB component.
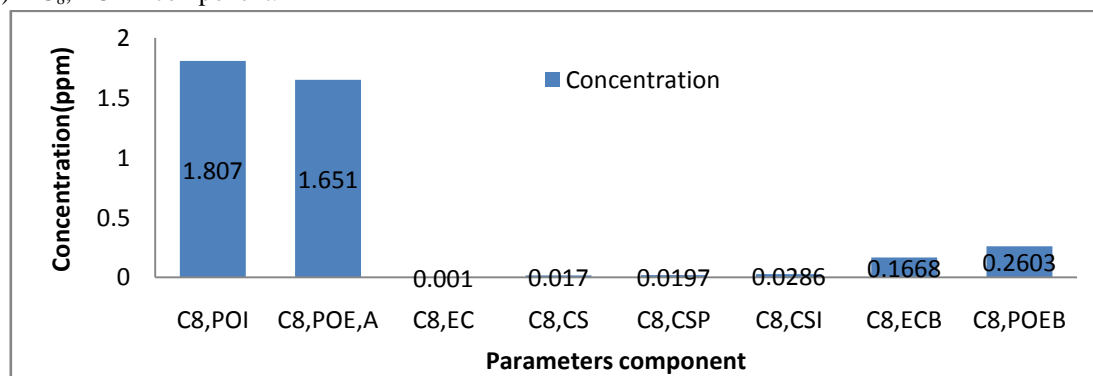

Figure 17: Concentration of C_8 Compound versus Parameters Component of C_8 Obtained from the various Processes of Palm Oil and Animal Bone for Calcium Stearate Production

The result presented in Figure 17 illustrates the concentration of C8 compound obtained from different experimental run up on the various processes of palm oil and animal bone (cow bone) for calcium state production. High percentage of C_8 component was obtained from palm oil initial and palm oil extract from sample A base sediment. The C_8 concentration was low in other component processed indicating high extraction of the C_8 component from them as shown in Figure 14. The order of magnitude in terms of C_8 concentration is given as C_8, POI > C_8 POE, A > C_8 POEV > C_8 ECB > C_8, CSI > C_8, CSP > C_8, CS > C_8, EC.
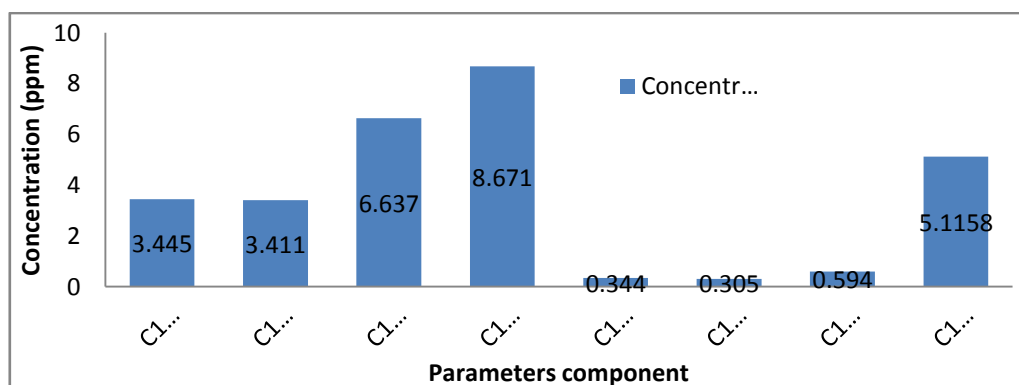

Figure 18: Concentration of C_{12} Compound (Lauric Acid) versus Parameters Component of C_{12} Obtained from the various Processes of Palm Oil and Animal Bone for Calcium Stearate Production

Figure 18 demonstrates the concentration of C_{12} compound (lauric acid) extracted from the various components sampled. High concentration in lauric acid was obtained in the animal bone product crushed (C_{12}, BPC, LA), indicating the presence of high deposit of lauric acid in animal bone, follow by the contents present in the extract calcium in the activated carbon (C_{12}, EC, LA) produced as residual product. Also high concentration was observed in extracted calcium in B base sediment (C_{12}, ECB, LA) as well as the component obtained from C_{12}, POI La (palm oil initial) and C_{12}, POEA, La (palm oil extracted from A base sediment whereas the C_{12}, CS, LA, C_{12}, CSP, LA and C_{12}, CI LA are small in quantity.
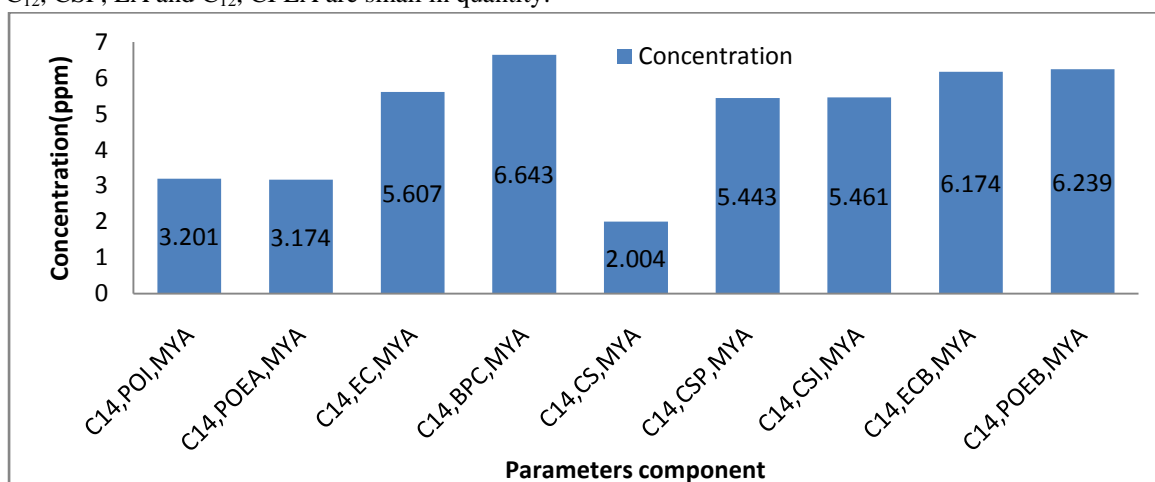

Figure 19: Concentration of C_{14} Compound (Myristic Acid) versus Parameters Component of C_{14} Obtained from the various Processes of Palm Oil and Animal Bone for Calcium Stearate Production

The result presented in Figure 19 illustrates the myristic acid concentration extracted from various processes of sampling on various materials used during this investigation. The results obtained revealed that high percentage of myristic acid (C_{14}) concentration was obtained from C_{14}, BPC, MYA (from animal bone powder crunched). Other areas where high percentage of myristic acid was obtained in order of magnitude is C_{14}, EC, MYA (Extracted activated carbon) > C_{14}, POEB, MYA (palm oil extract from B based sediment) > C_{14}, ECB, MYA (extracted calcium from B sediment) > C_{14}, POEB, MYA (palm oil extracted from B base sediment) > C_{14}CSI, MYA (calcium stearate industrial) > C_{14}CSP, MYA (calcium stearate produced) > C_{14}, POI, MYA (palm oil initial) > C_{14}, POEA, MYA (palm oil extracted from A base sediment) > C_{14}CS, MYA (calcium stearate).
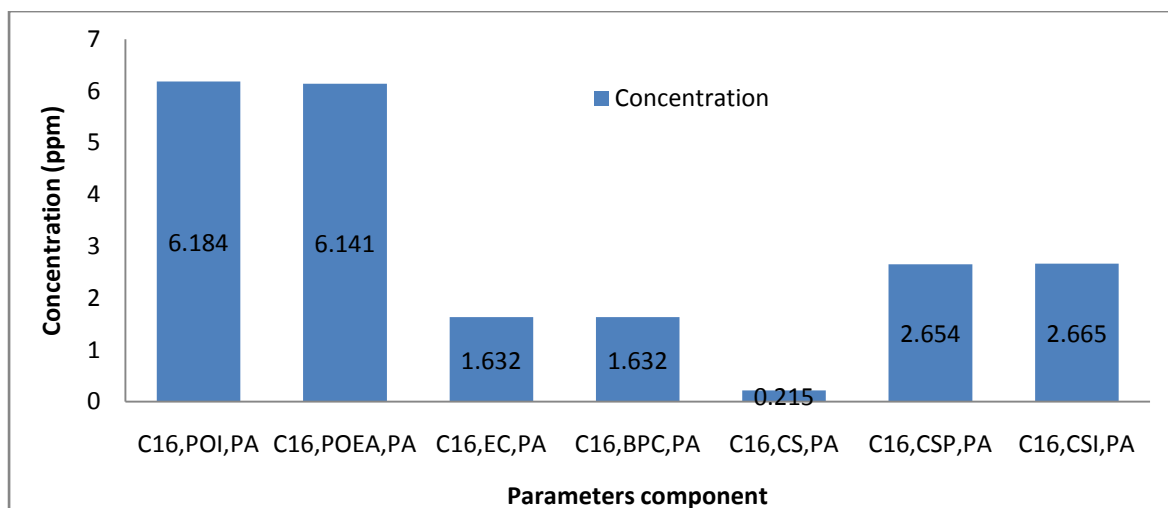
Figure 20: Concentration of C$_{16}$ Compound (Palmitic Acid) versus Parameters Component of C$_{16}$ Obtained from the various Processes of Palm Oil and Animal Bone for Calcium Stearate Production

From Figure 20 it is seen that the concentration of palmitic acid is high in percentage for C$_{11}$, POI, PA (palm oil initiate) and also in palm oil extracted from A base sediment (C$_{16}$, POEA, PA). The result further reveals that more content was achieved on processing other residual end products. The order of magnitude in term of production field is C$_{16}$, POL, PA > C$_{16}$, POEA, PA > C$_{16}$, CSI, PA > C$_{16}$, CSP, PA > C$_{16}$, BPC, PA > C$_{16}$, EC, PA > C$_{16}$, CS, PA (Palmitic acid – palm oil initial > palm oil extracted from A base sediment > calcium stearate industrial > calcium stearate produced > bone powder crushed > extracted calcium < calcium stearate. From this analysis result, it is revealed that the concentration of the palmitic acid present in the calcium stearate produced is of small quantity.
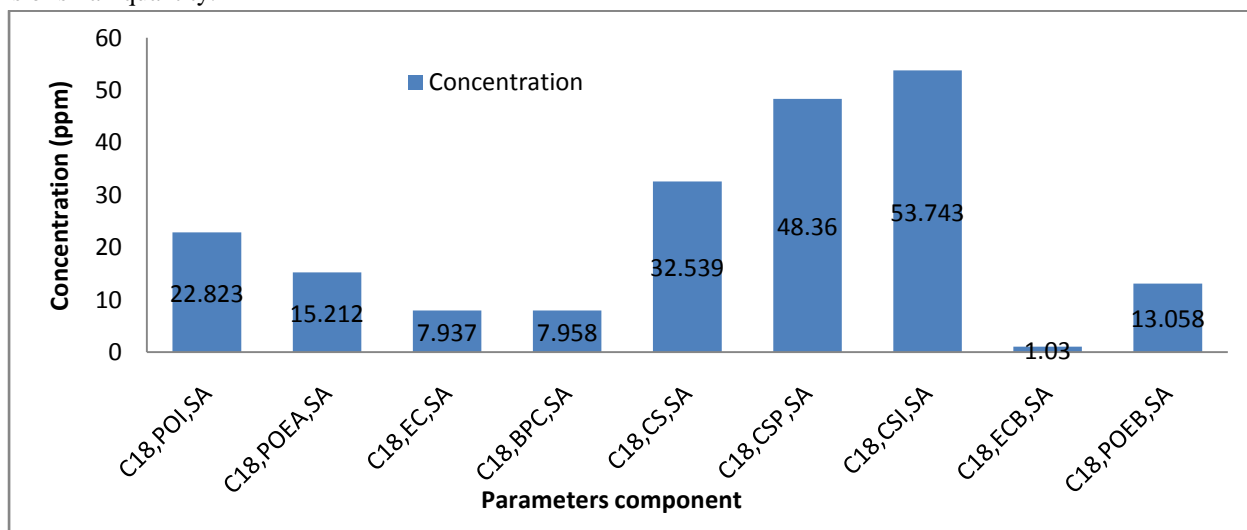

Figure 21: Concentration of C$_{18}$ Compound (Stearic Acid) versus Parameters Component of C$_{18}$ Obtained from the various Processes of Palm Oil and Animal Bone for Calcium Stearate Production

The result presented in Figure 21 demonstrates the relationship of stearic acid obtained from the various sampled component and the percentage yield or concentration. High percentage of the stearic acid is obtained in C$_{18}$, CSi, SA (calcium stearic industrial) and followed by C$_{18}$, CSP, SA (Calcium stearic produced formulated). High quantity was also obtained from C$_{18}$, CS, SA (Calcium stearate). The result presented in Figure 21 revealed that the major component on calcium stearate is the presence of stearic acid and more components are extracted from the residual base sediment. The result also revealed that the concentration of stearic acid is a major contributing factor to determination on active characteristic of the end product achieved when used from industrial purposes.
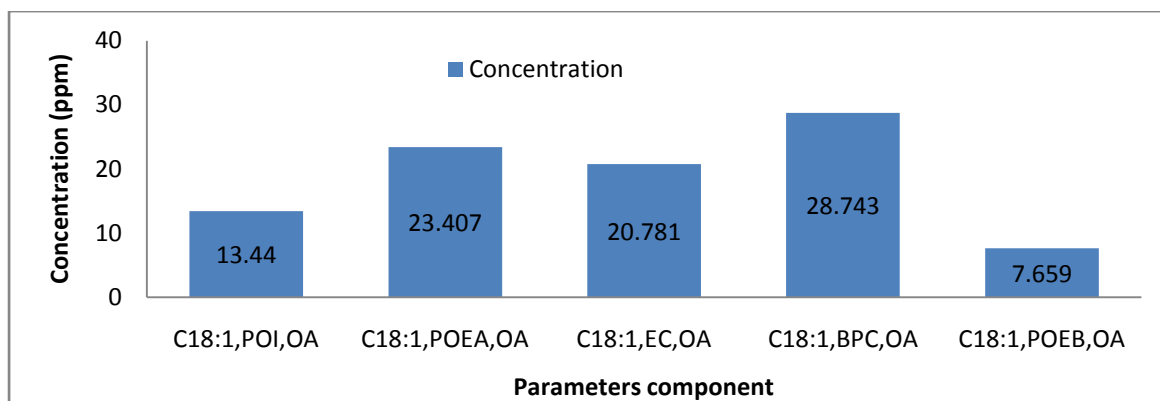
Figure 22: Concentration of $C_{18:1}$ Compound (Oleic Acid) versus Parameters Component of $C_{18:1}$ Obtained from the various Processes of Palm Oil and Animal Bone for Calcium Stearate Production

Figure 22 demonstrates concentration of oleic acid obtained from the various process of sampling.

It is seen that high concentration of oleic acid ($C_{18:1}$) was obtained from bone powder crushed ($C_{18:1}$, BPC, OA), followed by palm oil extracted from A base sediment as well as high percentage still obtained from extracted activated carbon residual ($C_{18:1}$, EC, OA) whereas more extraction was carried on palm oil initial ($C_{18:1}$, POI, OA) as well as $C_{18:1}$, POEB (palm oil extract from B base sediment). The result obtained in this figure 22 reveals the absent of oleic acid in the production of calcium stearate and the present of the oleic acid will inhibit the performance of the calcium stearate produced when employed for industrial uses.
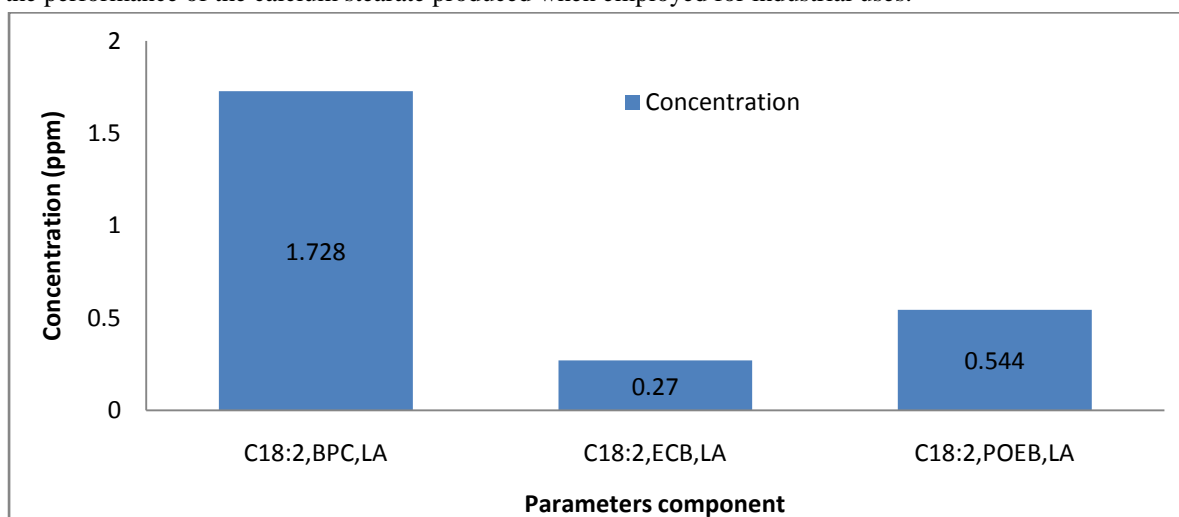

Figure 23: Concentration of $C_{18:2}$ Compound (Linoleic Acid) versus Parameters Component of $C_{18:2}$ Obtained from the various processes of Palm Oil and Animal Bone for Calcium Stearate Production

The result presented in Figure 23 illustrates the presence of Linoleic acid $C_{18:2}$ compound in some of the component sampled. The result obtained revealed that concentration of Linoleic acid was on high quantity in the $C_{18:2}$, BPC LA (bone powder crushed) and in palm oil extract from B base sediment indicating the formation as a result of effect of heating of the palm oil initial as well as some obtained from further processing of the extracted calcium from B base sediment. This component of $C_{18:2}$ is not found in the final components parameter of calcium stearate produced. Its absence may be attributed to the effect of heat or the operating temperature. The order of magnitude for Linoleic acid production is as shown, that is $C_{18:2}$, BPC, LA (bone powder crunched) > $C_{18:2}$, POEV, LA (palm oil extract from B base sediment) > $C_{18:2}$, ECB, LA (extracted calcium from bone) sediment. The component linoleic acid can be found useful in other area of chemical engineering processing.
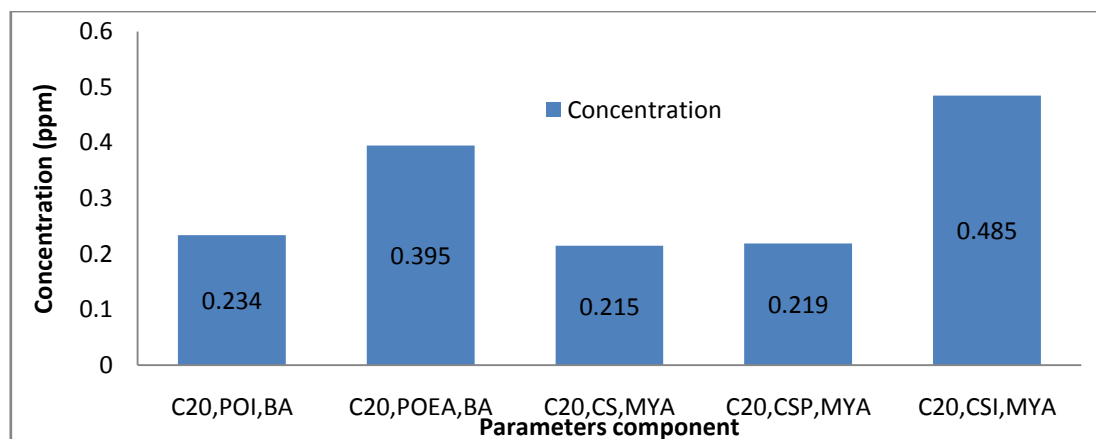
Figure 24: Concentration of C_{20} Compound (Behenic Acid) versus Parameters Component of C_{20} Obtained from the various Processes of Palm Oil and Animal Bone for Calcium Stearate Production

The result presented in Figure 24 demonstrates the concentration of C_{20} compound (Behenic acid) obtained from various mechanism of sampling of the raw materials and the residual product obtained during the investigation. The analysis result revealed that high concentration is observed in the industrial product (C_{20}, CSI, MYA) followed by palm oil extract from A base sediment indicating more extraction to be carried out to recover the presence of high deposit of the behenic acid found in the palm oil extract from A base sediment. The concentration of behenic acid present in the calcium stearate produced – formulated using the local raw materials indicates that the concentration of behenic acid in the end product is recommendable and acceptable. The concentration of behenic acid present in the calcium stearate is small compared to stearic acid concentration.

Conclusion

In view of the uses of calcium stearate in the industries today, there is need to diversify on the sources of the raw materials to be used in the production of calcium stearate. Most of the calcium stearates used today by various industries are petroleum based products of calcium stearate. The evaluation of the possible utilization of agricultural waste such as animal (cow) bone and residual product of palm oil is important in the production of calcium stearate for industrial uses. The objective of this study titled "Production of Calcium Stearate using cow bone and palm oil" will enhance the reduction of cow bone and palm oil wastes and find a means of converting these wastes to useful products. Cow bones were obtained from abattoir whereas the palm oil was obtained in the Faculty of Agricultural Science, Rivers State University, Port Harcourt.

The following conclusions were drawn from the research work:

1. Animal bone (cow bone) contains high percentage of calcium as well as lauric acid (C_{12} – 6.6714ppm), magaric acid (C_{17} – 0.2887ppm) myristic acid (C_{14} – 6.6.429pmm), palmitic acid (C_{16} – 16423ppm), linoleic acid ($C_{18:2}$ – 1.7276ppm), stearic acid (C_{18} – 7.9583ppm) and oleic acid ($C_{18:1}$ – 28.742ppm).

2. It was observed that the animal bone (cow bone) contains high percentage of oleic acid

3. The GC analysis on palm oil revealed that the characteristics of the palm oil is as stated: C_8 component is 1.8972ppm, C_{12} (Lauric acid is 3.4449ppm), C_{14} (myristic acid is 3.2017ppm), C_{16} (Palmitic acid is 6.1841ppm), C_{20} (behenic acid is 0.2338ppm), C_{18} (steatic acid is 22.8227ppm) and $C_{18:1}$ (Oleic acid is 13.4397ppm).

4. it is observed that as the palm oil is subjected into extraction mechanism more of individual compound present in the palm oil is converted into $C_{18:1}$ (oleic acid of value 234065ppm against 13.4397ppm). This can be attributed to the effect of heating or increase in temperature.

5. The GC analysis on the extraction of calcium from the crushed animal bone powder revealed the following characteristics of parameter components as stated: C8 component is 0.0010PPM, C_{12} (lauric acid is 6.6.368PPM), C_{17} (Magaric acid) is 0.2866PPM, C_{14} (myristic acid) is 5.6073ppm,

C_{16} (palmitic acid) is 1.6321ppm, $C_{18:2}$ (linoleic acid) is 0.5157ppm, C_{18} (stearic acid) is 7.9369ppm and $C_{18:1}$ (oleic acid) is 20.7514

6. It is revealed that the formulated calcium stearate produced using local raw materials (cow bone and palm oil) is within the acceptable limit and can be used for the same purpose with the petroleum based calcium stearate

7. An emerging technology that will fast track industrial development in Nigeria has been identified in this research work for the production of calcium stearate.

8. This research suggests diversifying into production of calcium stearate by promoting indigenous engineering works, innovations and creativity, ensuring the conversion of waste into wet commercial scale as a way to stimulate the economy in the face of the economic downturn occasioned by the fallen of oil exploitation, exploration and processing.

9. The results showed that the animal (cow) bone and palm oil are major determinants in calcium stearate production.

10. The physicochemical parameters of the formulated calcium stearate produced using animal (cow) bone and palm oil was compared with the industrial (standard) and the result obtained shows a good match indicating the acceptability and reliability of the product obtained.

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