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Production of Dental Polishing Rouge using Chromium (III) Oxide and Cera Alba extracted from Beehives in Enugu, Nigeria

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Abstract

Introduction: *Cera alba* is a product of honey comb produced by honey bees of the genus *Apis mallifera* frequently called Beeswax. It serves as a binder when formulated with chromium (III) Oxide and water in the presence of heat to form Dental Polishing Rouge. Dental Polishing Rouge is a polishing compound used especially for achieving a high smooth and shine with precious metal such as silver and gold. This study aimed at production of dental polishing rouge using Chromium (III) oxide and *Cera alba* extracted from Beehives in Enugu, Nigeria. The research was carried out between September and December, 2019 in Enugu, Nigeria. Methods: The study adopted a two phased experimental approach using the same procedures but different weight and volume compositions. Structured pretested Product Evaluation Data Sheet (PEDS) was used to evaluate the product by selected Practicing Dental Technologists in Enugu State, Nigeria. Results: The resultant Dental Polishing Rouge from experiment II with the following compositions: *Cera alba* 224.82g, Chromium (III) Oxide 183g and water 3 litres and 2 litres respectively. There was significant excellent agreement among the respondents on the hardness of the product using Mohs scale (5.5-6) 10(40%), excellent product texture 15 (60%); 20 (80%) were in agreement on the colour stability of the product and 13 (52%) were in an excellent agreement on the product effectiveness. Conclusion: These findings suggests that dental polishing rouge can be produced locally in Enugu, Nigeria. Therefore, more attention needs to be paid to the production process, which will facilitate easy practice of Dental Technology, and also conserve huge foreign exchange being spent in the importation of rouge in Nigeria.

Keywords – Beehives, Beeswax, Cera alba, Chromium (III) Oxide, Dental, Polishing Rouge.

I. INTRODUCTION

Cera alba also known as a Beeswax is a natural product produced by worker honey bees from special glands and molded through the use of their mouthparts, into comb. Comb is a pure beeswax cells that are six-sided facing opposite directions from midrib [1]. When produced by worker honeybees, *Cera alba* is white but it quickly darkens from contamination with pollen and contact with the bees in the beehive. Beeswax taken from the bees and melted by beekeeper generally is lemon yellow in colour [1].

Sanford and Dietz (2000) stated that ***Cera alba*** is a product of honey comb produced by honey bees of the genus

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Apis mallifera frequently called Beeswax, which is a plate-like, white, secretions of the wax gland of the honey bees, which it uses to build honeycomb cells [2]. The wax is formed into scales by eight wax-producing glands in the abdominal segment of workers bees which discard it in or at the hive; this is collected by the hive workers for protection within the beehive [2]. Beeswax is used in a number of industries such as automotive, textiles and shoe manufacturing. It produces soft but highly glossy wax for furniture and floors. Some specific uses are as follows: waxing nails, wax molding, preservation, wax polish, to strengthen threads used in darning and sewing, Candle making and in pharmaceutical preparations [1]. Beeswax serves as a binder when formulated appropriately with distilled water and chromium (III) oxide.

Chromium (III) Oxide is an inorganic compound gotten from plant with the formula Cr2O and highly insoluble thermally stable Chromium source *suitable* for glass, optic and ceramic applications. Chromium oxide is a green, hygroscopic solid found in nature as the rare mineral escalate [3]. They are typically insoluble in aqueous solutions (water) and extremely stable making them useful in ceramic structures as simple as producing clay bowls to advanced electronics and in light weight structural components in aerospace and electrochemical applications such as fuel cells in which they exhibit ionic conductivity [4]. It is characterized by many good qualities needed in polishing compound. Whitehurst *et al.* (2005) made it clear that one of the difficulties in using and understanding tooth polisher or abrasive compound is that each manufacturer uses his own recipe to make the finished material. Whitehurst further state that the manufacturer has the choice of quantity of the binder (*Cera alba*) and texture of chromium oxide to be used [5]. Thus, in dental technology practices, design, construction and fabrication of dental prostheses cannot be achieved without its final stage, polishing.

Tooth polishing is a procedure carried out as a part of oral prophylaxis. It is an act of making the *tooth* surface to look glossy and lustrous. Although the term polishing has been used to describe the professional removal of soft deposits and stains from the tooth surfaces, in reality, this includes both cleaning and polishing [6]. Years back many other rough substances discovered by Pierre Fauchard where used in smoothening and polishing jobs till the 18th century when rouge was *discovered*. The word rouge was coined from Latin word “Rubeus” and commonly called its French name rouge meaning red [7]. The polishing compound is specifically called polishing rouge or Jeweler’s rouge.

Cooksongold (2018) defines polishing rouge as a polishing compound used especially for achieving a high shine with precious metal such as silver and gold [8]. Today the rouge is a term used to primarily identify blush of any color including: brown, pink, red and many more. Rouge is a very fine compound originally developed by the Jewelry trade for buffing Precious metals to bring out the maximum luster and a mirror like finish in Jewelry and other items made of soft metals [9]. Its application is usually on a finished piece of prosthesis by attaching the buffy wheel to the bench grinder or to a drill; Turn on the grinder or drill to start the buffing wheel rotation apply rouge sparingly to the force of a revolving buffing wheel, repeat application of compound as needed during buffing and polishing operation. Use only sight pressure in applying the revolving buff to the work surface thereby allowing the buffing wheel and the rouge to do the work [10].

In 2000, Philips stated the various types of rouge in use, which include; **Green Rouge** designed for high shine polishing of precious metals and chrome cobalt framework and use on acrylic denture [11]. A very fine compound used for final polish. Green rouge is thus a metal polishing compound that comes in a wax, paraffin oil or grease-based block/bar ([12], [13], [14])**.**

Considering the impacts of importation of various dental polishing rouge on the economy of Nigeria as a nation, production of dental polishing rouge using locally sourced materials in Enugu, Nigeria has become paramount.

II. Materials and Methods

Study area

The study was conducted at the Federal College of Dental Technology and Therapy, Enugu, Nigeria. The raw materials were sourced from the state. Enugu state is one of the 36 states in Nigeria. Located in the southeastern part of the country, Enugu spreads its borders to the states of Kogi and Benue to the north, Ebonyi to the east, Abia and Imo to the south and Anambra to the west, covering an area of around 8,730 km^2.

Its landscape changes from tropical dense rain forest in the south to small round-topped hills covered by open grasslands with occasional clusters of *woodland* in the middle to sometimes almost sandy savannah in the north. The state includes most of the Udi-Nsukka plateau, a pair of plateaus that form a nearly continuous elevated area. The Nsukka plateau extends about 130 km from Nsukka in the north, to Enugu in the south and continues southward for about 160 km to Okigwe. It rises more than 300 metres and its highest part

is found 20 km northwest of Enugu. The steep slopes form spectacular views of the hills and lowlands, broken up by numerous streams and rivulets feeding the Niger and Benue rivers.

Farming and trading constitute the key occupations in the state's economy: yam, cassava and *palm*-oil produce are the main crops, but corn, rice, pumpkin, melon, beans, okra, avocado, pineapple and even cashew nuts are cultivated as well. Besides coal, new mineral deposits have recently been discovered in Enugu State. These include limestone, iron ore, crude oil, natural gas and bauxite.

Study Design

This *study* is an experimental study design that focuses on the production of dental polishing rouge using Chromium (III) Oxide and *Cera alba* extracted from Beehives in Enugu, Nigeria.

Raw Materials for the production

Honeycomb and Chromium (III) Oxide used were purchased from the *popular* Ogbete Market in Enugu, Enugu North, Enugu state, Nigeria. The distilled water was obtained from the Chemistry laboratory of the Department of Applied Sciences of the Federal College of Dental Technology and Therapy, Enugu, Nigeria.

Instrument for the production

Spatula, Weighing balance, Beakers, Bunsen burner, Water bath, Mould (Conformers), Face mask, Hand gloves, Measuring cylinder/jug, Plastic paddles for mixing, and Plastic mixing bowl were obtained from the both the Chemistry Laboratory of Federal College of Dental Technology and Therapy, Enugu, Nigeria.

(a) **(b)**

Figure 1a and b: Laboratory preparation process

Preparations of Cera alba, Chromium (III) Oxide samples and Mould (Conformer)

***Cera alba* (Beeswax) extraction**

Food and Agriculture Organisation, FAO, (1990) stipulated various ways of *extracting Cera alba* from a honeycomb, which included, traditional methods, solar vex melter method, Ocloo's method and Hot bath method [15]. But for the purpose of this research, hot bath method was used.

Hot bath method

In the absence of a wax-melter, the hot-water bath process now in use by some *African* beekeepers was adopted. This is the quickest method of obtaining the wax, but it was only employed after the combs have been crushed and the honey removed ([15], [16])

Equipment:

1. a cooking pot
2. a sackcloth or a sack (preferably jute)
3. a string or twine (2-3 metres)
4. a stick or a discarded top-bar
5. a large spoon or ladle
6. a mould for the wax

Procedure:

1. 3 litres of water was poured into the cooking pot and heated over a fire.
2. Washed crushed bee combs were place in the sack.
3. A good package was made by tightening the string around the sack.
4. At the temperature of 38°C. (Warm nature), the package was put into the pot and the stick was used to push it down to the bottom.
5. At above 59°C, the wax seen to melt and a waxy scum formed on top of the water.
6. The stick was used to press the package. More wax was found floating to the top of the Water.
7. The ladle was used to skim off the melted wax and poured into a mould. The process was continued until wax no longer rises to the surface.

Chromium (III) Oxide

Chromium (III) Oxide (Abrasive Grade) green powder was further sieved to get a more fine crystals.

Mould (Conformer) formation

Plastic containers were prepared to desired shapes to serve as a conformer, which the produced rouge will be formed. This is achieved when the material is in hot stage and it is allowed for 24hours to fully cake.

III. Production Process

***Experiment I*:** The raw materials used in this experiment were measured to the following specifications: 229.39g of *Cera alba*, 183g of Chromium (III) Oxide and 3 litres of distilled water. These *measured* materials were mixed in a stainless steel contained in a water bath and stirred vigorously until bound together and block form is observed. The processes was observed closely and recorded.

***Experiment II*:** The raw materials used in this experiment were measured to the following specifications: 224.82g of *Cera alba*, 153g of Chromium (III) Oxide and 2 litres of distilled water. These *measured* materials were mixed in a stainless steel contained in a water bath and stirred vigorously until bound together and block form is observed. The processes were observed closely and recorded.

Statistical Analysis

Data from the Product Assessment Form distributed to practicing Dental *Technologists* in Enugu State who are the end users of dental polishing rouge were presented using frequency and percentages tables, figures, and analyzed using SPSS Statistics version 20®.

IV. Results

Production of Dental Polishing Rouge using Chromium (III) Oxide and *Cera alba* extracted from Beehive in Enugu, Nigeria in the Chemistry Laboratory of Federal College of Dental Technology and Therapy, Enugu was done in two (2) experimental stages using Honeycomb, Chromium (III) oxide and distilled water.

Tables 1 and 2 below present the *experimental* materials and quantity, procedures and observations of the two (2) phases of experiment in the production of dental rouge using Chromium (III) Oxide and *Cera alba* extracted from Beehive in Enugu, Nigeria.

Table 1: Experiment 1

Experiment Procedures	Observations
3 litres of distilled water was poured into a cooking pot and heated over a fire to a temperature of 38°C.	Water became warm.

Already washed and crushed honeycomb in package was added into the pot with stick to push the package into the bottom and was allowed to heat for 59ºC.	Honeycomb melted and wax scum was formed on top of the water.
The melted wax scum was skimmed and poured into a mould and left to cool for 2 hours with the help of an electric fan.	It was observed that the wax took the form of the mould. On withdrawal from the mould, the wax was found to be more brittle in texture and pale in colour and developed crack. Its weight was 229.36grams.
229.36grams of produced beeswax was cut into pieces into a plastic bowl and was gently introduced into 3 litres of water in a stainless steel fixed in the water bath and allowed for temperature above 55ºC.	The wax began to melt and was settling on top of the stainless steel with pale colour.
183grams of prepared Chromium (III) oxide was added to already melted wax in the bath and stirred vigorously for about 10 minutes for up to 64ºC.	The resultant mixture was observed to be considerably stable as there is binding together of the wax and the chromium (III) oxide and a colour change from yellow to purple green.
The resultant mixture was then poured into a mould (Conformer) and allowed to cool for about 8 hours.	The resultant product became block but brittle and was conformed to the mould.
The product was used to polish a partial metallic and acrylic denture.	It was observed that at the end of the process, there is less shinny and glossy polishing but the product remains crack and brittle.

Table 2: Experiment 2

Experiment Procedures	**Observations**
3 litres of distilled water was poured into a cooking pot and heated over a fire to a temperature of 38ºC.	Water became warm.
Already washed and crushed honeycomb in package was added into the pot with stick to push the package into the bottom and allowed to heat for 59ºC.	Honeycomb melted and wax scum was formed on top of the water.
The melted wax scum was skimmed and poured into a mould and left to cool slowly for about 24 hours.	It was observed that the wax took the form of the mould. On withdrawal from the mould was found less brittle in texture and yellowish in colour and weighs 224.82gram.
224.82grams of produced beeswax was cut into pieces into a plastic bowl and was gently introduced into 2 litres of water in a stainless steel in a water bath and allowed for 55ºC.	The wax was seen to melt and settling on top of the stainless steel with yellowish colour
153grams of prepared Chromium (III) oxide was added to the already melted wax in the bath and stirred vigorously for about 10 minutes for upto 64ºC	The resultant mixture was observed to be considerably stable as there is binding together of the wax and the chromium (III) oxide and a colour change from yellow to green.
The resultant mixture was then poured into a mould (Conformer) and allowed to slowly cool for about 24 hours.	The resultant product became indurate and was conformed to the mould.
The product was used to polish a partial metallic and acrylic denture.	It was observed that at the end of the process, there were shinny and glossy polish of the denture.

Figure 2: Produced Dental Rouge

Part B: Quality Control Assessment using Evaluation Sheet

Socio-demographic characteristics

Table 4 presents the socio-demographic characteristics of study respondents. As seen, a total of 25 practicing Dental Technologists were involved in the study of which 20 (80%) were male while 5 (20%) were females. 10 (40%) has age range of 26-35. 19 (76%) are married. Amongst the respondents, 15 (60%) had basic qualification (HND/BSc) while 10 (40%) had different higher educational qualifications. Similarly, the post-qualification experience of respondents show that practitioners of 5 years and below were 7 (28%); 6 – 10 years were 3 (12%); 11 – 15 years were 5 (20%); 16 – 20 years were 3 (12%); 21 – 25 years were 5 (20%), and above 25 years were 2 (08%).

Product Evaluation characteristics

Tables 4, 5 and Figures 3 and 4 show the results of the properties/characteristics of the product (Dental Polishing Rouge) in *terms* of Hardness, Texture, Colour stability and effectiveness respectively.

Hardness of the product

Table 4 *showed* that 10 (40%) evaluted the product as excellent under Mohs scale 5.5-6; 10 (40%) very good under Mohs scale 4.5-5 and 5 (20%) good under Mohs scale 3.5-4.

Texture of the product

As seen in Table 5, 15 (60%) responded excellent in texture while 5 (20%) adjudged it to be very good; similarly, 4 (10%) evaluated it as good, and 1 (4%) assessed it as being average.

Colour Stability of the product

As seen in Figure 3, 20 (80%) responded excellent in colour stability while 4 (16%) adjudged it to be very good; similarly, 1 (4%) evaluated it as good

Effectiveness of the product

Figure 4 presents the assessment of the effectiveness of the *dental* polishing rouge as 13 (52%) of the respondents evaluated the dental polishing rouge excellent; 9 (36%) very good, 2 (8%) good , and 1 (4%) average.

Table 3: Socio-Demographic characteristics of Practicing Dental Technologists

Variables	Frequency	Percentage
Sex		
Male	20	80
Female	05	20
Age group		
<26yrs	02	08
26-35yrs	10	40
36-45yrs	05	20
46-55yrs	05	20
56-75yrs	03	12
Marital status		
Single	06	24
Married	19	76
Widow	00	00
Widower	00	00
Level of Education		
PhD	00	00
MSc	05	20
PGD	05	20
HND/BSc	15	60
Years of Experience		
< 5yrs	07	28
6-10 yrs	03	12
11-15 yrs	05	20
16-20 yrs	03	12
21- 25 yrs	05	20
>25 yrs	02	08

Table 4: Hardness Evaluation of the Product (Using Mohs scale)

Hardness	Frequency	Percentage (%)
Excellent (Mohs: 5.5-6)	10	40
Very good (Mohs: 4.5-5)	10	40
Good (Mohs: 3.5-4)	5	20
Average (Mohs: 2.5-3)	0	00
Poor (Mohs: 1.5-2)	0	00

Table 5: Texture Evaluation of the Product

Texture	Frequency	Percentage (%)
Excellent	15	60
Very good	5	20
Good	4	16
Average	1	04
Poor	0	00

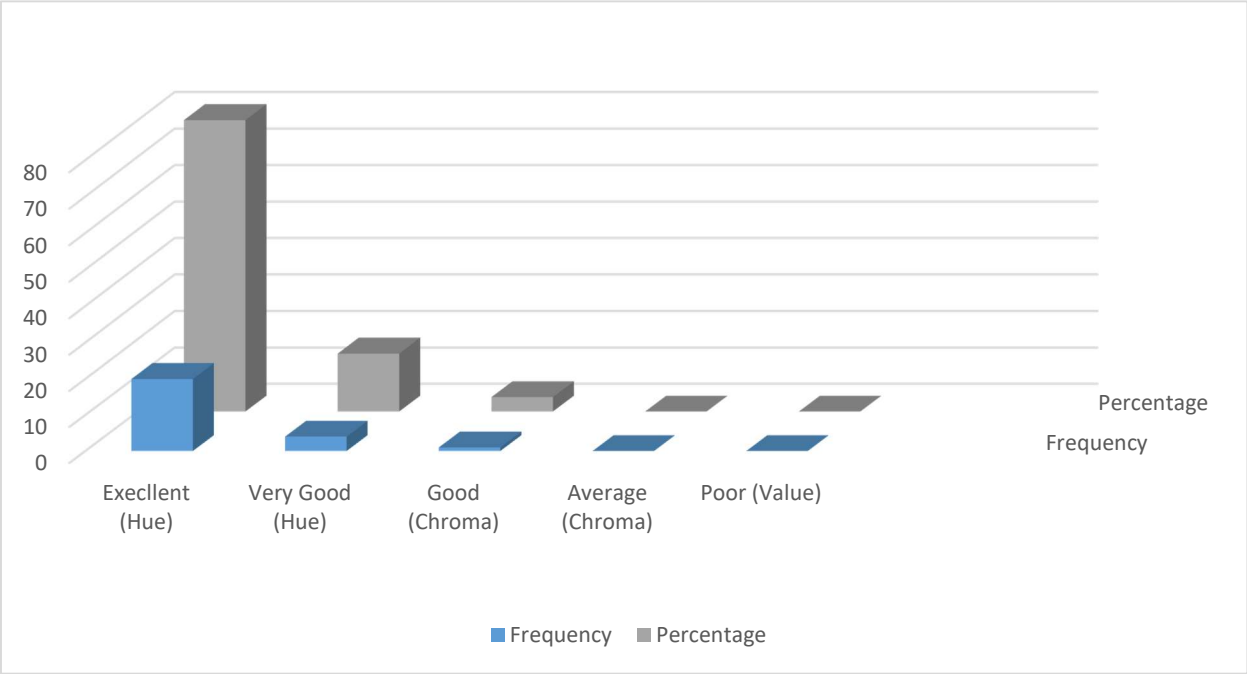

Figure 3: Colour Stability Evaluation of the Product

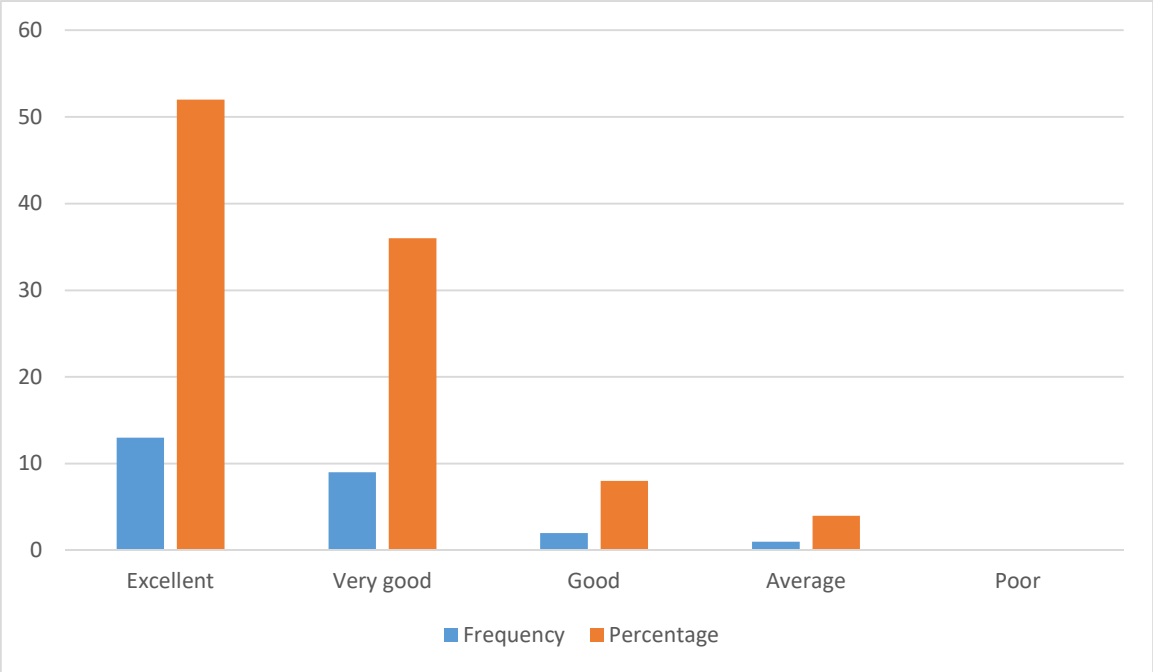

Figure 4: Effectiveness Evaluation of the Product

V. Discussion

This study carried out in Chemistry Laboratory of the Department of Applied Sciences, Federal College of Dental Technology and Therapy, Enugu provides information on production of Dental Polishing Rouge from Chromium (III) Oxide and *Cera alba* extracted from Beehives in Enugu, Nigeria. The findings are discussed below;

Hardness of the product: The results of the hardness of the product as shown in Table 4 indicate that the locally produced dental polishing rouge is excellent and can be easily used as a polishing material for acrylic and metallic dental prostheses. The rating is in agreement with the Mohs' rating scale. The rouge material is used in abrading the surface of a restoration with series of particles, causing scratches, coarse to fine, to produce a surface smooth enough to be aesthetically pleasing, well tolerated by soft tissue, and resistant to biofilm adhesion. This is in agreement with the work done by Kefi *et al.* (2008) [17].

Texture of the product: The appropriate procedures in extracting *Cera alba* were followed and the procedures in making dental polishing rouge was equally adhered as in agreement with FOA (1990) [15]. Since *Cera alba* was used as a binder, it is simply referred to as bonded abrasive and are in line with ([18], [19]) work on finishing and polishing procedures.

Colour Stability of the product: This is a factor for consideration in ensuring better rouge. The colour of the Chromium (III) oxide became dominant. The results of this study indicate that locally produced dental rouge is green in colour and has a colour indication as Hue, which is a dominant colour of an object and are considered in materials properties. This results effect is consistent with the work of ([17], [20])

Effectiveness of the product: This remains a vital aspect of the product evaluation. The result of this study shows chromium (III) Oxide and *Cera alba* (binder) produced dental polishing rouge is effective as (52)% and (36%) of the respondents who are the end users responded excellently and very good to the product. Which is in line with the study conducted by [17], where green rouge as a polishing abrasive are responsible to smooth the surfaces which roughened typically by finishing abrasive ([21], [22])

This study is a pilot study and it is believed that if the project is developed further, Chromium (III) oxide and *Cera alba* (binder) *Dental* polishing Rouge can be locally produced in large quantity in Nigeria. The resultant effect of this is availability of the product, affordability of the product, job opportunity and advancement of Dental Technology practice in Nigeria and West Africa as a whole since Federal College of Dental Technology and Therapy, Enugu have been the hub of Dental Technology training in Africa.

VI. Conclusion

The results of this study indicate high potential and possibility of producing *Cera alba* and Chromium (III) Oxide

based Dental Polishing Rouge. The quality of the produced Dental Polishing Rouge is of high quality, which produced a surface smooth enough to be aesthetically pleasing, well tolerated by soft tissues, and resistant to biofilm adhesion and comparable standard to the imported *commercial* ones. The ready availability of materials, instruments and equipment, knowledge, and application of the known principles and procedures will go a long way to make Nigeria independent and self-sufficient in dental polishing rouge. Results showed that the combination of the right principles and materials to locally produce dental polishing rouge aligns with Nigeria's sustainable development plan.

VII. Authors' Contributions

PCO conceived the study; designed the study and was involved in drafting of the manuscript; JE was involved in study design and supervision of the *study*; MOA and OM participated in the purchase of the raw materials, experiments and collection of data; SCO involved in the statistical analysis. KNO supervised the experiment, drafting of the manuscript and statistical analysis; CSmO was involved in the experiments and supervision of data collection; CSO participated in experiments and MEO was involved in the drafting of manuscript. All authors read and approved the final manuscript.

VIII. Acknowledgements

We thank the departments of Dental Technology and Applied Sciences, Federal College of Dental Technology and Therapy (FCDT&T), Enugu for giving us the *opportunity* to use their laboratory for the research and also the study participants who were involved in the evaluation of the product. We equally acknowledge the contributions of the staff of the Chemistry laboratory, FCDT&T who provided us with enabling environment and all the needed reagents. We are grateful to the Association of Dental Technologists of Nigeria (ADTN), Enugu State Chapter for being part of the evaluation process of the product.

IX. Competing Interest

The authors declare that they have no *competing* interests.

X. Availability of Data and Materials

The *datasets* used and /or analysed during the current study are available from the corresponding author on reasonable request.

XI. Ethics Approval and Consent to Participate

The experiment was carried out in accordance with the approval of the Ethics Committee of the department of Dental Technology, Faculty of Dental Health, Federal College of Dental *Technology* and Therapy, Enugu, Enugu State, Nigeria, and all in accordance with the ethical standards laid down in the 1964 as amended in 2000 Declaration of Helsinki. Informed concept was signed by all the evaluating participants (Dental Technologists) before they were allowed to evaluate the product.

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