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(RESEARCH ARTICLE)

Formulation and Evaluation of Natural Dental Herbal Prophylaxis Paste Using *Aloe barbadensis* Miller Extract for Oral Care in Enugu, Nigeria

Peter Chidiebere Okorie [1, 3, *], Maryann Chiamaka Onwuka [2], Kenneth Nkemdilim Okeke [3], John Emaimo [1], Maria Ezinne Okorie [4], Chibuzor Stellamaris Okonkwo-Ejete [5], Chidimma Sonia Obiekwe [3] and Odichinaka Michelle Okorie [3]

[1] *Department of Dental Technology, Faculty of Dental Health, Federal University of Allied Health Sciences, Enugu, Nigeria.*
[2] *Department of Dental Therapy, Faculty of Dental Health, Federal University of Allied Health Sciences, Enugu, Nigeria.*
[3] *Department of Dental Technology, School of Health Technology, Federal University of Technology, Owerri, Nigeria.*
[4] *Department of Biochemistry, Faculty of Basic Medical Sciences, Federal University of Allied Health Sciences, Enugu, Nigeria.*
[5] *Department of Dental Technology, School of Dental Health Sciences, Shehu Idris College of Health Sciences and Technology, Markfi, Nigeria.*

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Abstract

Aloe vera, specifically the *Aloe barbadensis* Miller variety, is widely recognized for its medicinal properties, particularly in oral care. This study aimed to formulate and evaluate a natural dental herbal prophylaxis paste using this plant, focusing on its effectiveness in controlling cavity-causing bacteria compared to conventional dental products. Conducted in Enugu, Nigeria, the research employed an experimental and descriptive cross-sectional design. The formulation for the natural dental paste included various ingredients: sorbitol, calcium carbonate, sweetener, herbal extract, coloring agent, sodium bicarbonate, menthol, sodium fluoride, binding agent, preservative, sodium lauryl sulfate, and distilled water. The final product was a smooth, free-flowing herbal paste. Data analysis was performed using descriptive and inferential statistics, revealing demographic details about respondents: 60% were male, with half of the participants aged between 31 and 40 years; 80% were married, and 40% held a Postgraduate Diploma, with some having less than five years of experience in dental therapy. When evaluating the product, 40% of respondents preferred its abrasive properties, while 80% favored its effectiveness for dry gums, and 70% appreciated its cold compression technique. The product showed promise in terms of efficacy, foaming ability, and cost-effectiveness. A significant correlation was found between the cost-effectiveness of the natural herbal prophylaxis paste and its efficacy, with a correlation coefficient of 0.463 at a 5% significance level. The study concludes that there is a need to promote research in herbal dental products, highlighting the potential antimicrobial benefits of such formulations. It also suggests that further efforts should focus on purifying raw materials to enhance the quality of herbal dental products and reduce reliance on imported alternatives.

Keywords: Aloe vera; Dental; Herbal; Toothpaste; Prophylaxis paste; Oral Care

1. Introduction

Oral health is defined as the condition of the mouth, teeth, and facial structures that allow individuals to perform essential functions such as eating, breathing, and speaking. It also encompasses psychosocial dimensions, including self-confidence, well-being, and the ability to socialize and work without experiencing pain, discomfort, or embarrassment [1]. Key preventive measures according to the World Health Organization (WHO) include proper tooth brushing techniques, flossing, routine dental checkups, and scaling and polishing of the teeth, often using prophylactic pastes, which can also be herbal and are known to be safe, effective, and less toxic [1]. The most effective way to prevent the development of dental diseases is by controlling the production of dental plaque. Plaque is a soft, thin layer that forms

* Corresponding author: Peter C. Okorie

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on teeth, gums, and any dental appliances in the mouth because of microbial action [2]. Dietary sugars, particularly sucrose, significantly contribute to plaque formation, accelerating both its development and thickness. Therefore, removing plague from the teeth and surrounding areas is essential for maintaining a healthy mouth [3].

The maintenance of a healthy mouth, alongside professional oral care, involves the removal of plaque, calculus, and stains using various dental instruments, such as hand scalers and ultrasonic scalers. This cleaning procedure is typically performed during 6-month recall appointments. The finishing process is a vital component of long-term oral hygiene and can be enhanced using oral hygiene products like prophylactic pastes. An ideal prophylactic paste should effectively clean while simultaneously polishing, which involves smoothing the morphological surfaces of both dentin and enamel [4]. Thorough cleaning with a prophylaxis instrument and paste is crucial for eliminating plaque and other surface debris [5]. Dental prophylaxis pastes, commonly referred to as prophy paste, are used for the complete removal of calculus, soft deposits like dental plaque, and stains on the supragingival and unattached subgingival surfaces after scaling. This process entails the careful removal of plaque and calculus from the tooth's surface, including the gumline, using dental instruments such as sickle scalers, jacquettes, hoe scalers, and excavators. Additionally, polishing is typically performed after scaling to eliminate stains and provide a smooth and shiny finish to the teeth. This is accomplished using a soft rubber cup that spins, along with a prophylaxis paste that is loaded into the cup and applied to the tooth for optimal oral health care [6].

Recently, medicinal plants, also known as medicinal herbs, have been identified and utilized in traditional medicine practices dating back to prehistoric times. These plants synthesize numerous active chemical compounds found in their roots, stems, leaves, flowers, or seeds, which can enhance health, prevent disease, and treat illnesses. The medicinal plant is an essential element of popular medical approaches worldwide in treating and preventing human/livestock disorders [7]. Over the past decade, herbal medications have gained popularity as a favored therapeutic option for both the prevention and treatment of various diseases worldwide. Many of the side effects associated with traditional medicines have been mitigated using herbal remedies, making them a safer alternative. These alternative products can include dental items with natural ingredients or various herbal formulations [8].

Previous research has demonstrated that dental plaque can be managed through both physical removal and the application of various pharmaceutical products, such as antimicrobial toothpaste and mouthwashes. Mechanical methods of plaque control encompass tooth brushing and the use of inter-dental cleaning aids, as well as professional prophylactic treatments [9]. Studies have indicated that incorporating *Aloe barbadensis* Miller, a recognized medicinal plant, into natural dental herbal prophylaxis paste significantly enhances oral health in dentistry. This improvement is primarily attributed to its anti-inflammatory and antimicrobial properties, which are beneficial for oral care. It is worth noting that herbal prophylaxis paste has been employed for centuries and is often regarded as a vital component of any dental hygiene routine. Recently, natural products have been more thoroughly explored as promising agents for the prevention of oral diseases, particularly plaque-related conditions such as dental caries, due to the potential side effects of certain harmful chemicals found in many commercially available prophylaxis pastes, which has raised considerable concern [10].

Herbal tooth gels that incorporate aloe vera, often referred to as a miracle plant, are acceptable in dental research and exhibit a safer profile with fewer side effects compared to synthetic formulations. These tooth gels enhance oral hygiene and combat microbial activity [11]. Moreover, many individuals utilize herbal medicines or products derived from *Aloe barbadensis* Miller within various national healthcare systems for health maintenance, specifically to prevent histamine release and serve as antiseptics, antioxidants, antimicrobials, antifungals, antibacterials, antivirals, and analgesics [12].

In dentistry, herbal extracts from *Aloe barbadensis* Miller have proven to be more effective in controlling bacteria responsible for cavities than many commercially available dental products. This effectiveness stems from compounds known as anthraquinones, which possess anti-inflammatory properties and are utilized in formulations for toothpaste, mouthwash, denture cleansers, and prophylactic pastes [10]. Beyond dental applications, aloe gel is also employed as a moisturizer in skincare, as well as in hair care products and cosmetics as a healing agent. Medicinally, it functions as an antiseptic, a natural antibiotic, a calming agent, a detoxifier, and a dilator that promotes circulation and blood flow to the skin. Additionally, it serves as an insect repellent and is used as a transparent pigment in miniature painting. The fibers from the leaves are utilized to create cords and nets [13].

2. Materials and Methods

2.1. Collection and Authentication of Aloe vera leaf extract.

Aloe barbadensis Miller, commonly known as aloe vera, was collected in August 2023 from the Abakpa Nike area, which is in Enugu State, Nigeria—a region known for its diverse botanical flora. The harvesting process involved selecting mature plants to ensure optimal quality and efficacy. Following its collection, the aloe vera was meticulously authenticated in the Microbiology Laboratory of the Federal College of Dental Technology and Therapy, which is now recognized as the Federal University of Allied Health Sciences in Enugu, Nigeria. This authentication process ensured that the species was accurately identified, confirming its characteristics and potential uses in various applications, including medicinal and therapeutic contexts.

Figure 1 Picture of an Aloe Vera leaf extracted in Enugu, Nigeria

2.2. Extraction Procedure for the *Aloe barbadensis* Miller gel

The leaves of *Aloe barbadensis* Miller were meticulously harvested in the early morning hours of August 2023 to ensure optimal freshness. Care was taken to carefully cut the leaves from the mother plant using a clean, sharp knife, which minimized any potential damage to the delicate rind and preserved the integrity of the plant. After cutting, the leaves were thoroughly washed under a gentle stream of fresh, clean water to remove any residual dirt or contaminants from the outer surface. This washing process ensured that the sap and exudates, which can sometimes affect the quality of the final product, were eliminated.

Once cleaned, the leaves were filleted to extract the inner gel-like substance. These fillets were then placed into a domestic blender, where they were initially processed at low speed for one minute. This careful blending helped to break down the cells without introducing excessive air, preserving the nutrients within the pulp. Following the initial blending, the crushed pulp underwent further homogenization at a higher speed, following the method outlined by Chandegara *et al.*, which involved blending until a smooth, consistent texture was achieved [13].

The resulting extract, characterized by its thick, jelly-like consistency, was then transferred into an airtight container, securely sealed to prevent any exposure to air and moisture. This precaution ensured that the quality of the aloe extract would be maintained for future use, preserving its beneficial properties.

Figure 2 Picture of a Fillet formed after manually removing the outer skin of the aloe vera leaves

2.3. Formulation of Prophylaxis Paste

The quantities of each ingredient in the herbal tooth/prophylaxis paste were established based on prior formulations. The combined weight of the ingredients totals 100%, resulting in a final product of 100 grams of prophylaxis paste. Table 1 outlines the ingredients used in the laboratory-produced prophylaxis paste, which are then compared with those found in commercially available alternatives. The herbal prophylaxis paste is formulated using *Aloe barbadensis* Miller leaf extract, calcium carbonate, and sodium lauryl sulfate, as detailed in Table 2. Each ingredient fulfills a specific role; for instance, *Aloe barbadensis* Miller extract offers relief from dental caries and contributes to plaque reduction due to its antibacterial properties, while calcium carbonate serves as an abrasive agent. Additionally, the paste incorporates sorbitol as a humectant, sodium lauryl sulfate as a foaming agent, methylcellulose as a binder, natural honey as a sweetener, ethanol for preservation, water as a solvent, sodium fluoride to reduce tooth and gum sensitivity as well as to prevent tooth decay, Cibanon Green Reactive agent for coloring, sodium bicarbonate as an anti-plaque agent, and menthol for flavor enhancement.

Table 1 Herbal Prophylaxis Paste Formulation Ingredients

Materials for Herbal Prophylaxis paste	Common name	Scientific name or Formula	Form	Uses
01	Aloe vera	*Aloe barbadensis* Miller	Leaf	relief from dental caries and reduction of plaque with its antibacterial activity
02	Limestone	Calcium carbonate ($CaCo_3$)	Calcite	Abrasive agent
03	Sorbitol	*D- Glucitor* ($C_6H_{14}O_6$)	Crystalline	Humectant to minimize water loss or drying out of the product
04	Sodium Lauryl Sulphate (SLS)	$C_{12}H_{25}SO_4Na$	Liquid	Detergent (foamy), reduces surface tension to help clean teeth
05	Methylcellulose	Methyl Esther	Powder	Binder
06	Pure honey	Hexose sugars ($C_6H_{12}O_6$)	Liquid	Sweetener, antioxidants, vitamins

07	Ethanol	C_2H_6O	Liquid	Preservative
08	Water	Distilled water (H_2O)	Liquid	Solvent
09	Sodium fluoride	Natrium Fluoride (NaF)	Powder	Reduce tooth and gum sensitivity / Prevent tooth decay
10	Green colour	Cibanon Green Reactive	Powder	colouring agent
11	Baking soda	Sodium bicarbonate ($NaHCO_3$)	Powder	Lowering salivary PH, remuneration of enamel, Anti-plaque
12	Menthol	$C_{10}H_{20}O$	Crystalline	Reduces sore mouth and pain/ serves as a flavour agent

2.4. Preparation of Base

According to a study conducted by Khandgoankar, Gayke, and Shinde, the production of toothpaste or prophylaxis paste involves three techniques: the cold compression technique, the multiple liquid phase technique, and the hot liquid phase technique. For this project, we employed Cold Compression Technique [14].

Initially, humectants such as sorbitol (70% w/v) were placed in the mixer bowl. The binding agent was then added to the humectant while agitating to ensure uniform dispersion. The liquid components, including water, sweetener, and preservatives, were mixed separately to create a liquid phase, and any necessary therapeutic additives were incorporated. This liquid phase was combined with the humectant-binder mixture in the bowl and mixing continued for 5 minutes to eliminate air from the thick gelatinous mixture.

After halting the vacuum, abrasive agents were introduced and mixed continuously until fully dissolved. The vacuum was reapplied and mixing continued for a minimum of 30 minutes. Surfactants and flavoring agents were dispersed separately in 5% humectant, and this mixture was added to the vacuum at the end, followed by an additional 5 minutes of mixing. This process ultimately resulted in a smooth, air-free paste.

Figure 3 Herbal Prophylaxis Paste Formulation Ingredients

Figure 4 Formulation Process in the Laboratory

Table 2 Composition of Natural Herbal Prophylaxis Paste Using *Aloe barbadensis* Miller

S/N	Ingredients	Quantity (g)
01	Calcium carbonate ($CaCo_3$)	50g
02	Sorbitol	20g
03	Sodium Lauryl Sulphate (SLS)	3g
04	Methylcellulose	2g
05	Pure honey	2g
06	Ethanol	0.50g
07	Distilled water	q.s
08	Sodium flouride (NaF)	0.10g
09	Cibanon	1g
10	Sodium Bicarbonate ($NaHCO_3$)	2g
11	Menthol	2g
12	*Aloe barbadensis* Miller	2g

2.5. Evaluation of Herbal Prophylaxis Paste

The evaluation process used by Krishananda *et al.*, Rathi *et al.*, Malgi *et al*., and Saloni & Shailedra was applied to assess the formulated herbal prophylaxis paste [15-18].

- **Physical examination (Colour, Odour, Smoothness, and Taste):** Formulated herbal prophylaxis paste was evaluated for its colour visually under the normal lamp. Odour was examined by smelling the product. The smoothness was tested by rubbing the paste formulation between the fingers. The taste was checked manually by tasting the formulation (Fig. 5) [16,19].

- **Fragrance test:** It was based on individual observation for its acceptability. 20 Dental Therapists who happened to be end users were asked about the acceptability of fragrance, and their opinions were taken. Fragrance was evaluated based on the following criteria.
  - The fragrance was good, as good as the fragrance of the reference herbal prophylaxis paste.
  - The fragrance was not so good compared to the reference herbal prophylaxis paste.
  - The fragrance of the herbal prophylaxis paste was poorer than the reference prophylaxis paste.

- **Abrasiveness**: A pea-sized amount of formulated prophylaxis paste was placed on a clean plastic microscope slide, and a drop of distilled water was added. A clean cotton swab was rubbed on the prophylaxis paste sample in a back-and-forth motion 30 times using short strokes. The slide was carefully rinsed and dried with soft tissue. The slide was examined under a dissecting microscope illuminated from above. The number of scratches on the surface of the slide was determined and rated on a scale of 0 (no scratch) to 5 (high degree of scratches) as illustrated by Malgi *et al.* [17].

- **Determination of spread-ability:** In this method, slip and drag characteristics of the paste were examined . 2g of the formulated paste was placed on the ground slide under study. The formulated paste was placed like a sandwich between this slide and another glass slide for 5 minutes to expel air and to provide a uniform film of the paste between the slides. An excess of the paste was scraped off the edges. The top plate was then subjected to a pull of 80g with the help of a string attached to the hook, and the time (sec) required by the top slide to cover 7.5cm was noted. A short interval indicated better spread ability. The formula was used to calculate spread ability: S=M× L /T Where,

  - S= Spread ability
  - M= Weight in the pan (tied to the upper slide)
  - L= Length moved by the glass slide
  - T=Time (sec) taken to separate the upper slide from the ground slide.
- **pH determination:** The pH of the formulated herbal prophylaxis paste was determined by using a pH meter. 10g of prophylaxis paste was placed in 150ml of the beaker. 10 ml of boiled and then cooled water was added to it, then stirred vigorously to make a suspension.

- **Homogeneity:** The herbal prophylaxis paste extruded a homogenous mass from the suitable collapsible container by applying normal force at 27±20C. In addition, the bulk of the contents extruded from the crimp of the container were rolled gradually.

- **Foam-ability:** The foam-ability of formulated herbal prophylaxis paste was evaluated by adding 2.0 g of the formulation in 50 ml water in a measuring cylinder, the initial volume was noted and then shaken for 10 minutes. The final volume of foam was noted.

- **Storage and Packaging**: The herbal prophylaxis paste was well stored in a cup that has a cork and was packaged in a paper box as can be observed in Fig 6.

- **Antimicrobial activity:** Antibacterial activity of formulated paste was performed by disc diffusion method in a triplicate manner by using Muller Hinton Agar media with *Staphyloccus aureus* strain. Then the formulated paste was placed over the bacterial plates and incubated at 37^{oC} for 24 hours, using ciprofloxacin HCl as the positive control. The diameter of the zone of inhibition was measured in millimeters, which is in line with the similar procedure conducted by Yadav & Prakash [20].

Figure 5 Formulated Prophylaxis paste

Figure 6 Packaged prophylaxis paste

3. Results

A comprehensive evaluation of the formulated product was conducted by twenty (20) registered and practicing dental therapists across various dental clinics in Enugu, Nigeria. This assessment utilized a questionnaire and focused on several key areas: the evaluators' sociodemographic profiles, the formulation process of the Natural Dental Herbal Prophylaxis Paste, the paste's efficacy, the knowledge of self-reliance and awareness regarding the medicinal benefits of local products, and the cost-effectiveness of the Natural Dental Herbal Prophylaxis Paste.

3.1. Socio-demographic characteristics

A total of 20 Dental Therapists participated in the study. Sixty percent of the respondents were male, while the majority (50%) were aged between 31 and 40 years. A significant portion of the respondents (60%) were single. Additionally, half of the participants (50%) held Higher National Diplomas (HND) or Bachelor of Science (BSc) degrees, with 40% having post-qualification experience ranging from one to five years (see Table 3).

3.2. Formulation of Natural Dental Herbal Prophylaxis Paste

Most of the respondents (70%) demonstrated a strong understanding of the steps involved in formulating Natural Herbal Prophylaxis paste. Approximately 80% exhibited a solid knowledge of the dry gum method, while 60% were familiar with the wet gum method. Additionally, 70% strongly acknowledged their knowledge of the cold compression technique, 40% understood the multiple liquid phases, and 50% were aware of the hot liquid phase (Table 4).

Table 3 Socio-demographic characteristics of the study respondents

Variable	Frequency	Percentage (%)
Gender		
Male	12	60
Female	08	40
Age Range		
21-30	02	10
31-40	10	50
41-50	04	20
51-60	02	10
61-70	02	10
71-Above	00	00
Marital status		
Single	08	40
Married	12	60
Divorced	00	00
Widow	00	00
Widower	00	00
Level of Education		
PhD	02	10
MSc	04	20
PGD	04	20
HND/BSc	10	50
Years of Experience		
1-5 yrs	04	40
6-10 yrs	04	0
11-15 yrs	05	20
16-20 yrs	03	20
21-25 yrs	02	0

25- Above	02	20

Table 4 Formulation of Natural Dental Herbal Prophylaxis Paste

Variables	**Frequency**	**Percentage (%)**
Knowledge of steps involved in the formulation of Natural Dental Herbal Prophylaxis paste		
Yes	14	70
No	06	30
Knowledge of methods in the formulation of Natural Dental Herbal Prophylaxis paste		
Dry Gum Method		
Yes	16	80
No	04	20
Wet Gum Method		
Yes	12	60
No	08	40
Awareness of techniques in the formulation of Natural Dental Herbal Prophylaxis paste		
Cold compression technique		
Yes	14	70
No	06	30
Multiple liquid phase technique		
Yes	08	40
No	12	60
Hot liquid phase technique		
Yes	10	50
No	10	50

Table 5 Efficacy of Natural Dental Herbal Prophylaxis paste

Variables	Frequency	Percentage (%)
Rate of efficacy of Natural Dental Herbal Prophylaxis paste during usage		
Excellent	06	30
Very good	08	40
Good	06	30
Average	00	00
Poor	00	00
Rate of Foaming ability of Natural Dental Herbal Prophylaxis paste during usage		
Excellent	04	20
Very good	14	70
Good	02	10
Average	00	00
Poor	00	00
Homogeneity of Natural Dental Herbal Prophylaxis paste		
Excellent	04	20
Very good	06	30
Good	10	50
Average	00	00
Poor	00	00
Rate of the smoothness of Natural Dental Herbal Prophylaxis paste		
Excellent	06	30
Very good	10	50
Good	02	20
Average	00	00
Poor	00	00

3.3. Efficacy of Natural Dental Herbal Prophylaxis Paste

Among the Dental Therapists who evaluated the efficacy of the dental herbal prophylaxis paste, 40% rated it as very good. A significant majority (70%) agreed that the foaming ability of the product is excellent. Half of the Dental Therapists deemed the product to be good, while 50% of the respondents rated its smoothness as very good (see Table 6).

3.4. Knowledge on self-reliance and awareness of the medicinal benefits of local products

All the respondents (100%) were aware that the knowledge acquired on product formulation will create an avenue for self-reliance, and conclusively, 100% of the dental therapists encouraged the creation of awareness on the medicinal benefits of Dental herbal prophylaxis paste (Table 6).

3.5. Cost-effectiveness of Natural Dental Herbal Prophylaxis paste

Summarily, 80% of the study group showed a positive response to the less cost-effective nature of natural dental herbal prophylaxis paste compared to the already existing commercial ones (Table 7).

Table 6 Knowledge on self-reliance and awareness of the medicinal benefits of local products

Variables	Frequency	Percentage (%)
Knowledge acquired on the formulation of Natural Dental Herbal Prophylaxis paste will create an avenue for self-reliance		
Yes	20	100
No	00	000
Creation of awareness on medicinal benefits should be encouraged		
Yes	20	100
No	00	000

Table 7 Cost effective of Natural Dental Herbal Prophylaxis paste

Variables	Frequency	Percentage (%)
Less cost effective of the Natural Dental Herbal Prophylaxis paste compared to the already existing commercial ones		
Yes	16	80
No	04	20

4. Discussion

4.1. Socio-demographic Characteristics of Subjects

In terms of the socio-demographic information of the respondents, 60% were male. This finding contrasts with a previous study conducted at Adiyaman University in Turkey in 2021, which assessed the use and awareness of herbal products among patients and showed that 51.5% of the participants were female [21]. In another study at the University of Benin in Edo State, Nigeria, which focused on the use of herbal and traditional medicine as well as self-medication among patients before seeking oral health care in a tertiary health facility, it was found that the majority of patients—64.7%—were female [22]. The disparity in gender distribution between the current study and previous research may be attributed to the challenges faced by female dental practitioners, including issues related to working hours and career breaks. Studies across various countries have indicated that female dentists tend to have shorter working hours compared to their male counterparts and take career breaks more frequently [23].

In terms of age distribution, 50% of the respondents in the current study fall within the 31–40-year age bracket. This contrasts with findings from a study on the use of herbal and traditional medicine in self-medication for oral health care at a tertiary health facility, where most respondents (32.8%) were aged 17-25 years [22]. The difference in age range can be attributed to the current study's focus on practicing dental therapists working in dental clinics in Enugu, Nigeria, while the previous study targeted a broader demographic, including professionals and managerial staff in tertiary healthcare settings. Consequently, it is more likely that a greater proportion of skilled, registered dental therapists in the current study will fall within the specified age range compared to those in the previous research.

In terms of marital status, the current study found that 60% of respondents were married. This result is consistent with previous research conducted in Malaysia regarding the knowledge and practice of herbal medicine related to oral health among dental personnel, where a notable 83% of respondents were also married [24]. Conversely, a similar study in

Edo State, Nigeria, by Mercy & Joan [22] identified that only 49.6% of participants were single. This discrepancy highlights an important trend: married individuals are approximately three times more likely to participate in dental services than their single counterparts. This insight could inform strategies to better engage single individuals in oral health initiatives, thereby enhancing overall community health outcomes.

Regarding educational attainment, 50% held either a HND or a BSc. This is consistent with findings from a prior study by Mercy & Joan [22], which indicated that 68% of participants possessed a BSc. This trend may be attributed to the high costs associated with education in various countries, prompting many individuals to halt their studies after completing Secondary School or obtaining National Diplomas.

4.2. Formulation of Natural Dental Herbal Prophylaxis Paste

Seventy percent of the respondents are knowledgeable about the steps involved in formulating Natural Dental Herbal Prophylaxis paste. This aligns with a similar study conducted in South Africa on the Formulation and Preparation of a Novel Toothpaste Using Essential Oils, where 80% of respondents knew this method [25]. Understanding the formulation step is crucial for achieving a smooth consistency in prophylaxis paste, and 80% of respondents are aware of the dry gum method to the wet gum method. After the primary emulsion is formed, the emulsion may be diluted with additional water or a water-miscible phase, as required in the dry gum method. Regarding the formulation technique, 70% of respondents are familiar with the cold compression technique, which is used to produce an air-free, smooth paste, as seen in a similar study on the Formulation and Evaluation of Polyherbal Toothpaste: To Overcome Oral Problems [14].

4.3. Efficacy of Natural Dental Herbal Prophylaxis Paste

The respondents found that the efficacy of natural dental herbal Prophylaxis paste was 40%, and they judged the efficacy to be very good. This is consistent with a previous study at Adiyaman University in Turkey, where 62.5% of the respondents found the herbal products to be effective [21]. The agreement with the previous study is that herbal products not only provide treatment but can also be used as a preventive method, which is beneficial in treating dental diseases. The results also show that dentists should be better equipped with phytotherapy practices and herbal products in the treatment of dental diseases, making it beneficial for dentists to integrate natural treatment methods and herbal products into treatment protocols. The difference is that the present study was carried out by registered practicing dental therapists in Enugu, Nigeria, while the previous study focused on patient attitudes during usage. The therapists involved in the usage have shown promising potential with the efficacy of a good number of herbal products [26].

The rate of foaming ability of natural dental herbal prophylaxis paste was found to be 70%, which is considered very good. A similar study carried out by Nuraskin *et al.* [27]. on the effectiveness of using Total Paste with Sodium Lauryl Content in Removing Dental Plaque in Indonesia found that 60% of students used a foaming agent (SLS). The similarity in the rate of foaming ability is an important quality of Prophylaxis paste, as it helps to distribute the cleansing ingredients throughout the mouth, including between teeth, and helps remove plaque and other debris from the mouth. Additionally, this volume of foam gives a feeling of thickness and satisfaction.

The homogeneity of natural dental herbal Prophylaxis paste was assessed to be 50% in the current study. The results obtained from a previous study in Bauchi State, Nigeria, on the formulation, physicochemical evaluation, and antimicrobial activity of green toothpaste presented the homogeneity as 50%, which agrees with the current study [28]. The accordance was examined at room temperature where normal force was applied to the container containing the herbal prophylaxis paste, and it was observed that paste extruded homogeneously from the container. This indicates that obtaining the formulation from the container poses no difficulty.

Lastly, the present study evaluated the herbal prophylaxis paste to be 50% in terms of smoothness. A similar study in Bauchi State, Nigeria also evaluated it, and the result was in line with 50% by sensory and visual inspection [28]. The similarity is as a result of the smoothness helping to prevent harmful effects on the teeth's outermost protective layer (enamel) rather than eroding it.

4.4. Knowledge of self-reliance and awareness of the medicinal benefits of local products

The study highlights the importance of self-reliance and the medicinal benefits of local products. All respondents (100%) agreed that the knowledge gained from this study will help raise awareness about the medicinal benefits, which is consistent with similar research by Ege *et al.* [21]. where 62.5% of respondents shared the same view. This similarity is attributed to the growing interest in herbal products across various medical fields. Notably, there is a lack of research

on herbal product usage in dentistry. Summarily, the formulation of Natural Dental Herbal Prophylaxis pastes using *Aloe barbadensis* Miller *not only* promotes self-reliance but also encourages the use of medicinal benefits in dentistry.

4.5. Cost-effectiveness of Natural Dental Herbal Prophylaxis paste

In a recent study, 80% of participants agreed that natural dental herbal Prophylaxis paste is less cost-effective compared to existing commercial options. This finding contrasts with a similar study on the evaluation and use of herbal products, where 73% of participants partially agreed that herbal products are less cost-effective [21]. This difference can be attributed to the significant increase in the use of herbal medicinal products, including dental products, with no less than 80% of people worldwide relying on them for some aspect of primary health care [26].

5. Conclusion

The study findings suggest that a Natural Dental Herbal Prophylaxis paste can be effectively developed using plant-based materials, particularly *Aloe barbadensis* Miller. This formulated product demonstrates promising cost-effectiveness and efficacy for oral health care in Enugu, Nigeria, when compared to existing commercial alternatives. However, the Natural Dental Herbal Prophylaxis paste exhibits lower levels of abrasiveness, sweetness, color, and surfactant properties. Overall, the research provides compelling evidence of the effective antimicrobial activity of herbal ingredients and emphasizes the potential for natural materials to replace synthetic components in cosmetic products, including dental items. Redirecting funds from the importation of commercial products to the sourcing of raw materials and equipment for the formulation of the Natural Dental Herbal Prophylaxis paste could enable Nigeria to become a leading producer and exporter of this natural dental care product in Africa and potentially worldwide, thereby benefiting the nation's financial sector.

Compliance with ethical standards

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Disclosure of conflict of interest

The authors declare that they have no competing interests

Statement of ethical approval

The experiment was carried out in accordance with the approval of the Ethics Committee of the department of Dental Therapy, Faculty of Dental Health, Federal College of Dental Technology and Therapy, Enugu, now Federal University of Allied Health Sciences, Enugu, Enugu State, Nigeria, and all in accordance with the ethical standards laid down in the 1964 as amended in 2000 Declaration of Helsinki..

Statement of informed consent

The informed concept was signed by all the evaluating participants (Dental Therapist) before they were allowed to evaluate the product

Availability of Data and Materials

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

Authors' Contributions

PCO conceived and designed the study, as well as contributed to the drafting of the manuscript. MCO played a role in both the study design and the harvesting of Aloe barbadensis Miller, in addition to drafting the manuscript. KNO supervised the experiment and also contributed to the manuscript drafting. JE was involved in the study design and provided oversight for the research. MEO supervised the procurement of raw materials and conducted

the statistical analysis. CSO participated in the experiments and data collection, while CSmO contributed to the experiments and supervised data collection. Lastly, OMO managed the acquisition of raw materials and assisted in drafting the manuscript. All authors read and approved the final version of the manuscript.

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