Evaluation of Formulated Herbal Toothpaste Containing Aloe Vera Gel and Extracted Calcium Carbonate from The Shell of *Buccinum Undatum* (Whelk Snail)

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ABSTRACT

Prevalence of tooth decay in individuals attributes to bacterial buildup in the mouth and inconsistent effectiveness of certain commercial toothpastes and this has prompted the formulation of herbal toothpaste. The formulation is crafted with diverse bases to address gingivitis, dental caries and plaque, hence the toothpaste consist of intricate blends of abrasives, surfactants, anticaries agents, tartar control elements, pH buffers, humectants and binders ensuring consistency, shape and product stability. The herbal toothpaste formulation was prepared, incorporating aloe vera and calcium carbonate extract from the shell of *Buccinum undatum*. The focus of the composition aims to investigate the antimicrobial potential of the actives (aloe vera and calcium carbonate) in the toothpaste using cultures of *S. aureus*, *P. aeruginosa* and *K.pneumoniae* (prevalent micro organisms in the oral cavity) and comparing with a reference standard (Colgate toothpaste). Utilizing the hot liquid phase technology, the toothpaste was formulated, and then evaluated. The Physicochemical evaluation studies reveals the formulation to have such characteristics as pH-10, good foamability and abrasiveness, spreadability of 5.5 $gcms^{-1}$, viscosity-4600 cP and appreciable stability. Anti microbial studies indicated notable zone of inhibition for the selected organisms as: *K.pneumoniae* – 5.5 mm and *P. aeruginosa* – 5.0 mm with no effect on *S.aureus*. The formulated herbal toothpaste consisting of aloe vera and extracted calcium carbonate was observed to display appreciable antimicrobial and abrasive properties hence further study is required to enhance its acceptable application for potential oral effects, and consideration for long term public dental health use.

Keywords: Herbal Toothpaste, Aloe vera, whelk snail, Zone of inhibition (ZOI), Dental caries

BACKGROUND OF THE STUDY

Pharmaceutical pastes are semi-solid dosage forms that contain one or more drug substances intended for application topically or orally. They are generally thicker and stiffer than solid dosage forms as they are made up of firm formulations that consist of a substantial amount of finely powdered material.

A pharmaceutical paste accommodates the following ingredient;

Abrasive: which include calcium carbonate or calcium phosphate. They remove anything sticking to the surface of the teeth without scratching them.

Binders: such as sodium alginate or xantan gum provide elasticity and form to the toothpaste, and help

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prevent toothpaste from drying out by binding to water.

Humectants: such as, glycerol or propylene glycol helps, retain water to prevent hardening of the toothpaste.

Foaming agents: which include sodium lauryl sulfate or sodium alkylsulfo succinate, acting as surfactants and helps in dispersion of the paste in the oral cavity and enhancing cleaning

Preservatives: to prevent the growth of microorganisms and include, sodium benzoate, methyl and propyl paraben.

Other ingredients include;

Flavouring agents like peppermint, menthol, or spearmint. They get rid of the unpleasant smell and taste of the other raw materials and give a refreshing taste.

Sweetening agents like sorbitol, glycerol, and xylitol. They improve the taste of toothpastes and mouthwashes and give them a mild and sweet taste.

Anti-sensitive agents which include, strontium chloride or potassium nitrate

Fluoride which helps in strengthening enamel and also prevent cavities

Colouring agents to give attractive appearance

Aloe vera herbal remedy applications in dental conditions are on the rise and gaining significant scientific attention. It is a perennial succulent xerophyte thriving in dry areas with its water-storage leaves and the gray-green lance-shaped leaves hold a clear gel, with benefits linked to polysaccharides in the gel. This cactus-like plant, flourishes in hot, arid climates and numerous studies has showcased its antiviral, antibacterial, analgesic, anti-inflammatory, and wound healing properties (Tanwar et al; 2011). It finds extensive applications in dentistry due to its myriad benefits.

With notable antiseptic and anti-inflammatory properties, aloe vera is employed in treating conditions like gingivitis and peri odontitis as it efficiently diminishes gingival inflammation and associated pain. Aloe gels prove effective in addressing sore areas of the oral mucosa covered by dentures, acting as potent antifungal agents. They alleviate pain associated with mouth commissural ulcers and has been reported to hinder the growth of Candida albicans, the most prevalent candida species in the oral cavity as Aloe vera tooth gel shows great efficacy in controlling oral cavity microorganisms (Dilip George et al., 2009).

Calcium carbonate serves as an effective polishing agent in toothpaste formulations. Its abrasive nature helps in removing dental plaque and surface stains from teeth, contributing to the overall cleaning and smoothing of tooth surfaces.

Toothpaste containing calcium carbonate may impact cavities by raising plaque calcium levels (Lynch & Cate, 2005). The established inverse correlation between plaque calcium and cavities suggests a potential benefit. Additionally, the use of such toothpaste can lead to increased plaque fluoride, linked to reduced cavity risk. The retention of calcium carbonate particles in plaque may neutralize harmful acids and release calcium, further influencing cavity prevention

STATEMENT OF PROBLEMS

Persistent oral infections remain a significant global public health concern. The oral cavity represents a noteworthy potential origin of infection and inflammation, adding to the overall disease load and influencing

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general health; therefore, it merits systematic consideration by clinicians (Rautemaa et al., 2007). Inadequate oral hygiene may lead to the accumulation of plaque on the teeth especially when bacteria mix with saliva, they create an adhesive layer called plaque, which accumulates on the teeth. Consuming high-carbohydrate foods or drinks prompts the bacteria in plaque to convert carbohydrates into the energy they require and this metabolic process concurrently generates acid (Atkinson et al., 2021) and with time the acid within plaque initiates the breakdown of the tooth's surface, leading to tooth decay. Furthermore, other bacteria present in plaque may provoke irritation in the gums, causing inflammation and discomfort. Maintaining good oral hygiene is crucial for overall oral health, emphasizing the importance of regular dental plaque control. Strategies to enhance population oral hygiene have involved incorporating antibacterial agents like extracts from plants containing antibacterial properties into oral care products (Budală et al., 2023)

Aim of the study

To Formulate Herbal Toothpastes containing bioactive ingredient derived from the gel extract of Aloe vera stalk and calcium carbonate derived from the shell of *Buccinum Undatum*

Objectives of the study

To extract the calcium carbonate contained in the shell of *B.Undatum*

To formulate stable and effective toothpaste using aloe vera gel from Aloe vera plant and calcium carbonate extracted from the shell of *B.undatum*

To determine *in vitro* antimicrobial activities of herbal toothpaste on organisms prevalent in the oral cavity.

To evaluate the physico chemical properties and efficacy of the herbal toothpaste then compare to the commercial toothpaste (Colgate).

Justification of the Study

The oral cavity infections are the most common types of infections which results in gum inflammation and damage of enamel and dentine. If left untreated, the infection continues and could lead to tooth loss. The mouth normal flora consists of opportunistic bacteria which are normally non-pathogenic but an imbalance of the situation creates infection and tooth decay.

The high rate of tooth caries among individuals due to accumulation of bacteria in the mouth, and the discordant activity of some commercial toothpaste has led to the formulation of tooth paste of herbal origin, which could serve as an alternative in the treatment and prevention of oral infections. Herbal remedies still remain a source of novel principle for toothpaste formulation hence treating tooth infection and inflammation with bioactive ingredient derived from Aloe vera gel and calcium carbonate could be of immense benefit from the medical and economic perspective.

INTRODUCTION

Dental Caries

This is a gradual and chronic ailment characterized by the localized deterioration of dental hard tissues due to acidic by-products from bacterial fermentation of dietary carbo hydrates, The progression results from an ecological imbalance in the interaction between tooth minerals and oral biofilms (plaque) (Meena et al., 2013; Nyvad & Takahashi, 2008). Dynamic equilibrium between the tooth surface and its surrounding environment is influenced by microbial activity in the plaque, causing fluctuations in biofilm, pH, bacterial,

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acid production and buffering action from saliva and the tooth structure. When the pH drops below a critical level, demineralization of enamel, dentin, or cementum occurs, while mineral gain (remineralization) takes place as the pH increases (Jo E, 2012)

Dental caries is a prevalent and preventable condition and stands as a primary contributor to oral pains and tooth loss. It is recognized as a significant public health concern across all age groups where it impedes the attainment and preservation of oral well-being (Thean et al., 2007). The World Health Organization (WHO) therefore, highlights the persistent global challenge of oral diseases, emphasizing the profound impact of poor oral health on overall well-being and its association with chronic diseases (Reutemaa et al., 2005).

Aloe Vera Plant

Figure 1 Picture of Aloe vera plant

Botanical plant description

Aloe vera, scientifically known as Aloe barbadensis miller, is a member of the Asphodelaceae (Liliaceae) family. This perennial, xerophytic succulent plant displays a shrubby or arborescent growth, characterized by its pea-green color. Aloe vera is a plant without a stem or with a very short stem, reaching a height of 60–100 cm (24–39 inches) and spreading through offsets. The plant features triangular, succulent leaves with serrated edges.

Each leaf comprises of three layers such as:

An inner clear gel rich in water, glucose amines, amino acids, lipids, sterols, and vitamins;

A middle layer of bitter yellow latex containing anthraquinones and glycosides

An outer protective rind comprising of about 15–20 cells, which synthesizes carbohydrates and proteins and houses vascular bundles responsible for substance transportation, including water (xylem) and starch (phloem) (Pandey et al 2016).

Plant Habitat

The Aloe genus, a monoecious and perennial species with shallow roots, thrives predominantly in arid climates, spanning Africa, India, and other such regions. With approximately 140 species, most concentrated in South Africa, they exhibit adaptability to subtropical summer rainfall and winter rainfall areas. Aloe species showcase versatility in soil adaptation, favoring a loamy texture with a pH of 7.0 to 8.5, though some thrive in acidic soils with temperature preferences range from 4 °C to 21 °C. Aloe species can

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reach heights of 61–99 cm, flowering typically in May to June and some species exhibit sensitivity to soil mineral composition, leading to diverse flower colors. The ideal post-nursing soil is well-drained sandy or rocky sites.

Active constituents and their properties:

Aloe vera's active components include a gel with 98% water, 0.66% total solid content, and 0.56% soluble solids, exhibiting seasonal variations. The dry matter of aloe gel comprises polysaccharides (53%), sugars (17%), minerals (16%), proteins (7%), lipids (5%), and phenolic compounds (2%). Additionally, Aloe vera contains 75 potentially active constituents, such as vitamins, enzymes, minerals, sugars, lignin, saponins, salicylic acids, and amino acids, contributing to its multi functional properties.

Healing properties

Aloe gel not only increases wound collagen content but also alters collagen composition, favoring more type III collagen. The gel accelerates wound contraction and augments the breaking strength of resulting scar tissue. Increased synthesis of hyaluronic acid and dermatan sulfate in granulation tissue during wound healing has also been observed after oral or topical treatment (Chithra et al., 1998).

Anti-inflammatory action

Aloe vera gel extracts exhibit anti-inflammatory activity by inhibiting the arachidonic acid pathway via cyclooxygenase. They reduce prostaglandin E2 production and feature maloyl glucans, such as veracylglucan B and veracylglucan C, with potent anti-inflammatory effects. Additionally, a novel anti-inflammatory compound called C-glucosyl chromone is isolated from gel extracts (Atam et al, 2013).

Antimicrobial Activity

Devi D L et al. (2016) highlighted the potent antimicrobial properties of A. vera gel and leaf against a broad spectrum of bacteria and fungi. Anthraquinone aloin in A. vera was found to inactivate various enveloped viruses, including Herpes Simplex, Varicella zoster, and Influenza. A. vera contains six antiseptic agents—Lupeol, salicylic acid, urea nitrogen, cinnamonic acid, phenols, and sulfur—all exhibiting inhibitory action on fungi, bacteria, and viruses, showcasing strong antiseptic, antibacterial, fungicidal, and virucidal properties. Additionally, A. vera promotes cell growth, acts as a neurologically calming agent, and functions as a detoxifying agent (Subhash et al., 2014).

Drug/vitamin bioavailability

A.vera gel enhances the bioavailability of vitamins C and E, as demonstrated in a double-blind, randomized, controlled trial (Joseph B et al., 2010). The gel protects against the degradation of vitamins in the intestinal tract, and its polysaccharides may bind to vitamins, slowing their absorption.

Moisturizing and anti-aging effect

Aloe vera exhibits remarkable moisturizing activity, aided by the presence of muco polysaccharides that help bind moisture into the skin. Aloe stimulates fibroblasts, promoting the production of collagen and elastin fibers thereby making the skin more elastic and less wrinkled.

Antidiabetic and hypolipidemic Activity

Aloe vera is a traditional remedy for diabetes mellitus in various parts of the world and humans and animal evidence suggests that Aloe vera can alleviate chronic hyperglycemia and perturbed lipid profiles, major

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risk factors for cardiovascular complications in diabetes. Phytosterols in A. vera, though not extensively absorbed from the intestine, can bind cholesterol and prevent its absorption, thereby lowering plasma cholesterol concentrations, including the atherogenic low-density lipoprotein (LDL) fraction.

Cosmetic and therapeutic effectiveness

The cosmetic and alternative medicine industries regularly assert claims regarding the soothing, moisturizing, and healing properties of Aloe vera. Currently, A. vera gel serves as an active ingredient in numerous skin lotions, sun blocks, cosmetics, as well as commercially available yogurt, beverages, and certain desserts (Subhash et al, 2014). It is crucial to note its potential toxic properties at certain doses, whether used for ingestion or topical applications.

Whelk snail (*Buccinum undatum)*

Figure 2: Picture of Shell of Whelk Snail

Description of *Buccinum Undatum*

This belong to the Domain: Eukaryota, Kingdom: Animalia, Phylum: Mollusca, Class:Gastropoda,Family: Buccinidae, Genus: Buccinum and Species: B. undatum.

Whelk Snail possesses a solid, ovate-conical, ventricose shell that exhibits various shades such as very pale, white, yellowish, or reddish. During its life, a bright, yellowish-brown periostracum covers the shell. The spire consists of seven or eight convex whorls marked by oblique, thick, and waved folds. The shell's surface is sculpted with vertical, wavy folds, earning it the name "undatum," signifying wavy. The large, white aperture is broadly oval, tapering to a deeply notched siphonal canal, while the outer lip is arched. The shell's maximum height is 10 cm, and its maximum width is 6 cm. The animal secretes a thin and copious slime and this species displays considerable variability in size and form, with instances of less apparent oblique folds and occasionally disappearing transverse striae. The deep brown epidermis varies, and some specimens showcase bright yellow or violet hues, often surrounded by one or more reddish bands.

Habitat

This species primarily inhabits soft substrates in the sub littoral zone and occasionally the littoral fringe, where it may be encountered alive during low tide. It does not thrive in the intertidal zone, as it is sensitive to low salinities and may crawl out of its shell, risking desiccation when exposed to air.

Composition

The shell of *B. Undatum* is a remarkable structure composed predominantly of calcium carbonate, with the crystalline form being aragonite. Aragonite is a polymorph of calcium carbonate, meaning it has a distinct

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crystal structure compared to the more common form, calcite. This composition gives the shell its characteristic strength and hardness.

Calcium carbonate is derived from the environment by the whelk and is deposited in layers within the shell. The process involves the extraction of dissolved calcium and carbonate ions from the surrounding water. These ions then combine within the shell, forming crystals of aragonite that arrange themselves in a specific pattern, contributing to the overall structural integrity of the shell. The aragonite crystals are organized in a matrix, creating a tough and durable material. This composition serves a crucial role in the whelk's survival, providing protection from predators and environmental factors. The intricate design and robustness of the shell highlight the organism's adaptation to its habitat, emphasizing the significance of its structural composition in the broader context of its biological function (Anderson W D, 1985).

Effect of calcium carbonate in the teeth

Calcium carbonate has abrasive property hence useful in toothpaste to maintain clean and stain-free teeth through regular brushing. Toothpaste with calcium carbonate can impact the occurrence of cavities by raising plaque calcium levels, and there is a well-established inverse correlation between plaque calcium and cavities. Research indicates that plaque retains calcium carbonate particles, potentially impacting cavities by neutralizing harmful plaque acids and simultaneously releasing calcium (Lynch & Cate, 2005). Calcium carbonate can act as a pH buffer, helping to neutralize acids produced by bacteria in dental plaque. This buffering effect is important for preventing enamel erosion caused by acidic conditions. Calcium is an essential mineral for tooth enamel remineralization and the calcium carbonate contributes to maintaining a balance of calcium ions in the oral environment and promoting enamel health. Calcium carbonate has been shown to have very good antibacterial effect. Some studies suggest that calcium carbonate have antimicrobial properties, which can help inhibit the growth of certain bacteria in the oral cavity, contributing to better oral hygiene (Attae et al, 2011) (Ordu et al; 2023).

MATERIALS AND METHOD

Apparatus and Material

Materials: Whelk Snail (Choba market, Nigeria), Aloe vera plant (Choba market, Nigeria)

Apparatus: Brookfield Viscometer (LV DV–II Ultras programmable Remoter, USA), Thermostat hot water bath (HH-S, India), What mann's Filter paper, Stirring rod, Beaker, Macerating glass guard, Glass mortar and pestle, Weighing scale, Muslin cloth, Funnel, Glass slide, pH meter (H20 Remediation Eng. Kolkata, West Bengal India), Drying equipment (oven) (MRC Lab. China), Milling machine, Thermostat incubator (DNP -9022-1A) (Dongguan Hongjin Hj-2251, China), Portable pressure steam sterilizer (Wincom company, China)

Culture Media

The culture media used in the study include;

MacConkey agar (Tm media, India), Nutrient agar (Tm media India), Sabouraud dextrose agar (Thermo Fischer scientific inc., Nigeria), Muller-Hinton agar (FC-Bios, Malaysia), EMB agar, cetrimide agar (FC-Bios, SDN BHD, Malaysia)

Extraction of Aloe vera gel

Healthy and mature aloe vera leaves (80g), were collected and rinsed thoroughly to remove any dirt or

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debris. A sharp knife was used to carefully cut off the serrated edges of the leaf and trim away the base. Then, the leaf was cut into smaller sections for easier handling. The leaf sections were laid flat on a cutting board and a spoon was used to gently scoop out the clear gel from the inside of the leaf. For a smoother consistency, the extracted gel was blended using a blender. The blended gel was strained through a fine mesh strainer to remove any remaining debris.

Extracted weight of gel was 38g hence percentage yield is calculated as:

Weight of gel extracted/Weight of aloe vera leaves × 100/1

Collection of Whelk snail shells

Whelk snail shells were washed with aquad to remove dirts from the outer surface and the inside of the shells cleaned thoroughly to remove any organic material or impurities. The shells were then dried properly.

Extraction of calcium carbonate from the shell of *B. undatum*

The cleaned shells were grinded using an industrial grinder and sieved to get fine powder About 400g of the crushed snail shell powder was weighed into a container. Dilute hydrochloric acid (HCl) solution of 10%v/v was prepared and slowly added to the snail shell powder while stirring. The acid reacted with the calcium carbonate in the shells to form calcium chloride, carbon dioxide, and water. The acid solution was added until the effervescence (bubbling) stops, indicating a complete reaction. The calcium chloride solution formed was filtered to remove impurities. A solution of sodium carbonate was prepared by dissolving in the aquade and this solution was used to neutralize the acid by adding it to the container containing the calcium chloride solution and this resulted to the formation of a white precipitate. The mixture was stirred to ensure complete neutralization then passed through Whatman's 4 filter paper in a filtration apparatus to separate the solid calcium carbonate (which remains on the filter paper). The residue (calcium carbonate) was washed with aquade to remove any residual sodium chloride then dried in an oven at a temperature between 60-80ºC to obtain a dry powder which was stored in a dry, airtight container until ready for use.

Extracted weight of calcium carbonate was 200g hence percentage yield is calculated as:

Weight of calcium carbonate extracted/Weight of *B.undatum* shells × 100/1

Table1: Formulation contents

Ingredients	Quantity (W/W) %.
Aloe vera gel	15
Calcium carbonate	35
Sodium Lauryl sulfate	2.5
Menthol	1.0
Carboxymethyl cellulose	4.0
Methyl paraben	0.1
Propyl paraben	0.02
Ascorbic acid	2.0
Sorbitol	2.0
Glycerin	6.0
Propylene glycol	4.0
Colour	1.0

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Demineralized water(aquade) to	100

Formulation

Using the hot liquid phase technology, the toothpaste formulation was made by heating liquid ingredients to certain temperature to aid solubilization and overall mixing process. Three phases of mixture are involved in the formulation technique as described below.

A 35g quantity of calcium carbonate, 4g of carboxy methyl cellulose (CMC), 0.1g of methyl paraben, 0.02g of propyl paraben (dry ingredients) were weighed and transferred into a glass mortar and pestle and triturated using doubling up technique.

Using a water bath, 6g of glycerol, 4g of propylene glycol and 1.0g of menthol was weighed and transferred into a beaker with a little quantity of aquade for preparation. This was heated in the water bath while maintaining a controlled temperature of 70-80°C with continuous stirring using to avoid localized heating. The liquid mixture in the beaker was then transferred in aliquot into the dry powder mixture and homogenized properly under vacuum for about 30 minutes with addition of sufficient aquade to obtain a smooth paste.

A 15g of aloe vera gel, 2.5g of sodium lauryl Sulfate, 2.0g of ascorbic acid, 2.0g of sorbitol and 1.0g of color were weighed and transferred into a beaker and mixed properly without heating. This mixture was then transferred into the formed paste and homogenized under vacuum for 10mimutes to form smooth toothpaste. After the formation, 50g of the preparation was transferred into each dispensing tube and the tubes were appropriately capped, polished and labeled.

Evaluation of the Herbal Toothpaste

Drying Tendency: All the batches were evaluated for their drying tendency at room temperature for a week

Organoleptic The formulated herbal toothpaste was observed for its appearance, color, odour, taste and texture.

Determination of pH: A 0.5g amount of the formulated herbal toothpaste was weighed and transferred into a 150ml beaker. 50ml of aquade was added into the beaker then stirred well to form a solution. Then the digital pH meter was placed on the solution triplicate determination of the pH was recorded (Asha et al 2018).

Figure 3: pH evaluation of the toothpaste

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Determination of Formability

The foam ability of the product was evaluated by taking small amount of the paste into measured quantity of water in a measuring cylinder and noting the initial volume and final volume of foam formation after agitation for 10 minutes (Asha et al 2018).

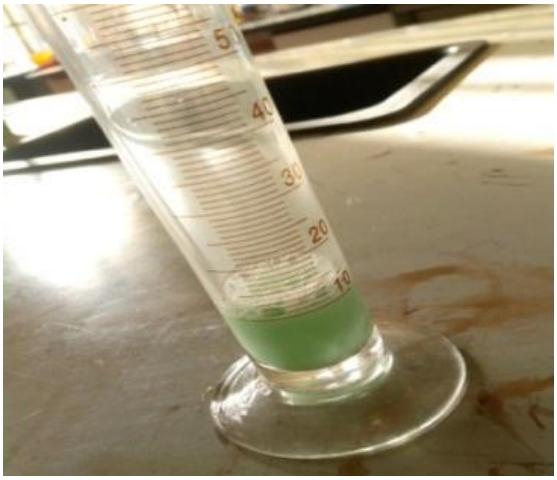

Figure 4: Evaluation of the tooth paste formability

Determination of Spreadability

A 0.5 g of the paste was weighed and placed at the center of the glass slide (10 x10 cm) and, another glass slide was placed over it carefully. 10g weight was placed at the center of the plate (avoid sliding of the plate), and the diameter of the paste in centimetre, after 15 min. was measured (Asha et al 2018)

The Spreadability (S) can be calculated using the formula;

S= M x LT

S = spreadability, L= length moved on the lower glass slide, T = time taken, M = weight applied to the upper plate

Determination of Viscosity:

Paste viscosity measurements were evaluated using a Brook field digital visco meter (LV DV–II Ultras programmable Remoter, USA) using spindle no.3 by applying increasing values of the shear rate, in order to reveal possible flow behavior of the pastes. All viscosities measurements were performed at controlled temperature of $30^{O}C$.

Anti microbial evaluation of the Toothpaste.

Agar well diffusion method: A 0.1 ml of standardized inoculums (0.5 McFarland standards) of the various organisms were introduced into 20 ml of Muller-Hinton agar and poured aseptically into a sterile petri dish. A sterile cork borer, of 6mm was used aseptically to bore wells on the solidified agar and the herbal toothpaste was transferred using sterile syringes into the bored wells. This was carried out in duplicates. The petri dishes were set on the work bench aseptically for few minutes to allow for the settling of the introduced extracts. The plates were then incubated at 37°C for 24 hours after which they were observed for zone of inhibition. The above procedure was repeated for the formulated toothpaste which was labeled A and the positive control (Colgate gel) labeled B.

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RESULTS

Percentage yield: Calcium carbonate (50%) and aloe vera gel (47.5%)

Table 2: Physico chemical evaluation of Formulated herbal tooth paste (A) and Colgate gel (B)

Parameters.	Observation A	B
Appearance	Paste-like	Paste-like
Colour.	Mint-green	Mint-green
Odour.	Minty	Minty
Taste.	Slightly salty	Slightly sweet
Texture.	Smooth	Smooth
Stability.	Stable	Stable
Drying tendency	Not dried	Not dried
Abrasiveness.	Good abrasiveness	Good abrasiveness
Viscosity	4600 cP	4000 cP
pH	10	8.6
Spreadability	5.5g cms-^{1}(good)	7.3 gcms-^{1}(good)
Foamability	Good	Good

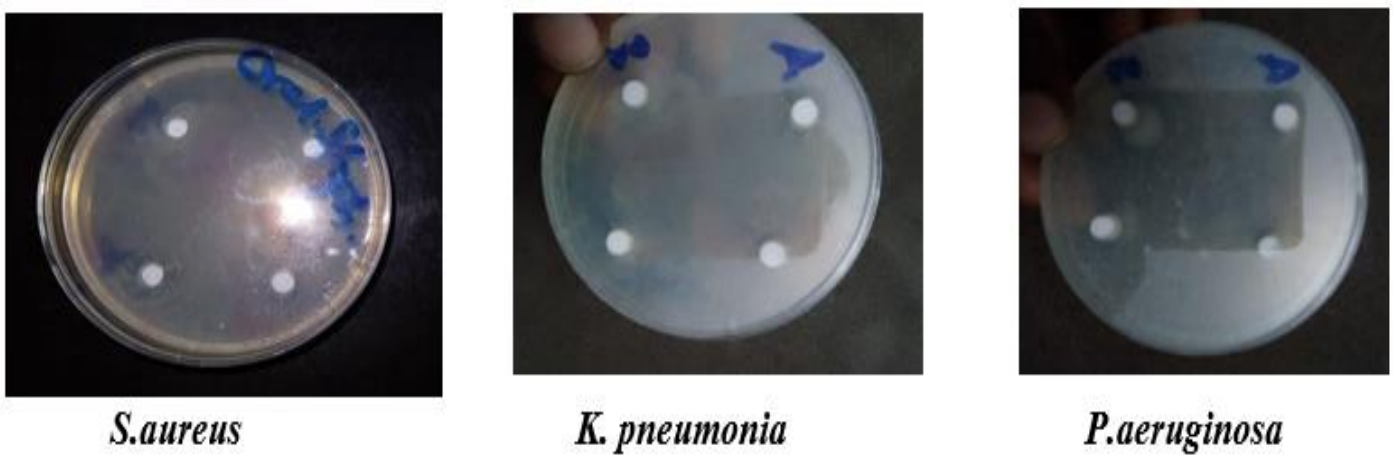

Fig 5: Antimicrobial effects of colgate and the formulated herbal toothpaste on the Isolates (S. aureus, K. pneumoniae, P. aeruginosa

Table 3: Result for the Inhibitory Zone Diameter (IZD) observed from the antimicrobial studies

Test organism	Inhibitory Zone Diameter (IZD) for Colgate toothpaste (mm)	Inhibitory Zone Diameter for formulated herbal toothpaste (mm)
Staphylococcus aureus	–	–
Klebsiella pneumoniae	6.0	5.5
Pseudomonas aeruginosa	–	5.0

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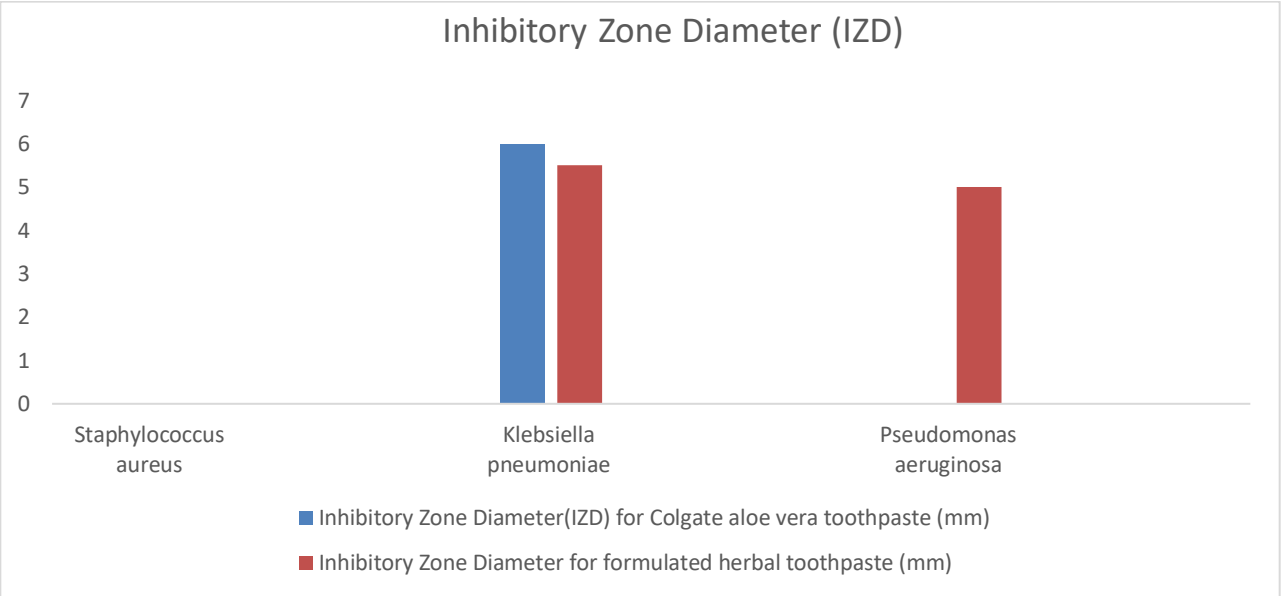

Figure 6: The Inhibitory Zone Diameter (IZD) observed from the antimicrobial effect studies

DISCUSSION

The prevalence of tooth decay in individuals attributes to a bacterial buildup in the mouth also as result of the inconsistent effectiveness of certain commercial toothpastes and this prompted the study on formulation of the herbal toothpaste. Herbal toothpaste formulations are crafted with diverse bases to address gingivitis, dental caries and plaque in dental paste preparations. Toothpastes consist of intricate blends of abrasives, surfactants, anticaries agents like fluoride, tartar control elements, pH buffers, humectants for moisture retention and a pleasing mouth feel, and binders ensuring consistency, stability and shape.

Characterization of the formulated herbal toothpaste in comparism to the marketed preparation (Colgate toothpaste) showed mint green coloration, minty smell, smooth consistency, and good homogeneity as shown in Table 2. The stability profile of the formulated toothpaste was acceptable and the pH of the Formulated toothpaste and Colgate aloe vera toothpaste were 10 and 8.6 respectively. The pH of toothpaste is usually alkaline, and therefore, the risk of erosion on teeth is eliminated as enamel erodes easily in acidic environments. Alkalinities of toothpaste also help normalize the pH of the mouth and prevent bacterial growth (Jostab A M et al, 2018). The spread ability for the formulated toothpaste and Colgate toothpaste was 5.5 gcms- ^{1}and 7.3 gcms- ^{1} respectively. Spread ability aid in ease of application as toothpaste with good spread ability is easier to apply evenly across the teeth and gums. This facilitates a smooth and comfortable brushing experience, promoting thorough coverage of all oral surfaces and improved cleaning. This aids in the efficient distribution of active ingredients, as it reduces wastage and contributes to better cleaning and protection against dental issues. Toothpaste with optimal spread ability allows users to apply an appropriate amount without excessive squeezing thus the low spead ability index of the formulated tooth pasted can be improved by reduction in the binder concentration.

The herbal formulated toothpaste as compared to standard toothpaste shows good foam ability and foam ability of toothpaste is of key importance since the foam created during tooth brushing aids in the dispersion of tooth paste the oral cavity, reaching areas that might be difficult to access. This ensures that active ingredients are distributed evenly across the teeth and gums, promoting better oral hygiene.

Additionally, the foam created by toothpaste assists in the removal of debris and plaque, contributing to a more thorough cleaning process. The physical action of brushing combined with the foam helps dislodge

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particles and bacteria from the tooth surfaces and gum line. Moreover, the sensation of foam can enhance the perception of cleanliness and freshness during and after brushing, contributing to a positive user experience. This sensory aspect may encourage individuals to maintain regular oral care routines, ultimately supporting their overall dental health.

The viscosity of the herbal toothpaste and Colgate toothpaste were 4600 cP and 4000cP respectively which was acceptable. Higher viscosity toothpaste tends to stay on the brush and tooth surfaces, preventing it from dripping off too quickly. This ensures better coverage during brushing. Viscosity influences how well the toothpaste adheres to tooth surfaces where optimal adhesion helps the active ingredients to maintain contact with the teeth for an extended period, enhancing their effectiveness. Viscosities of toothpaste also influence the dispensing control allowing users to apply an appropriate amount on their toothbrush.

Considering the antimicrobial evaluation of the toothpaste, no zone of inhibition was seen for S.aureus for both the standard (Colgate toothpaste) and the herbal formulation. For *K. pneumoniae*, both toothpaste were able to inhibit the growth of the organism with inhibitory zone diameter of 6.0 mm and 5.5 mm for Colgate and the formulated herbal toothpaste respectively, For *P. aeruginosa* the inhibitory zone diameter was 5.0 mm for the formulated herbal toothpaste while there was no zone of inhibition for Colgate aloe vera toothpaste. The formulated herbal toothpaste therefore show superiority over the colgate since evidence of inhibition was shown on two micro organisms (*K. pneumoniae* and *P. aeruginosa*) rather than one (*K. pneumonia*) as observed in the use of reference product (Colgate).

CONCLUSION

The formulated herbal toothpaste derived from the gel of the leaves of *Aloe vera* and calcium carbonate from the shell of *B. undatum* showed good stability profile with pH of 10 with smooth consistency and minty odor. Results for the anti microbial assay indicates that the active components (aloe vera and calcium carbonate), contains bioactive principles useful for the prevention and treatment of dental caries as it showed growth inhibition for *P. aeruginosa* and *K. pneumoniae* and proved superior as compared to the reference sample (Colgate) which showed inhibition of only one organism (*K.pneumonia*).

This study offers insights for those favoring herbal paste formulations as it has been proved to have good scope therefore, further studies on its implication on public dental health is recommended.

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