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FORMULATION AND EVALUATION OF ACTIVATED CHARCOAL TOOTHPASTE FOR TEETH WHITENING AND STAIN REMOVAL

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ABSTRACT

The present study aims to formulate and evaluate an activated charcoal toothpaste for enhanced oral hygiene and stain removal activated charcoal known for its high adsorptive capacity and natural origin we prepared trituration method and formulated four different formulations (F1-F4) by changing the ratios of calcium carbonate and activated charcoal. The developed charcoal toothpaste formulation was characterized by various parameter like ph, viscosity, foaming capacity, spread ability, physical appearance. Among the four formulations evaluated, the results obtained for each varied. However, formulation F4 demonstrated satisfactory outcomes, with all evaluation parameters falling within the desired range. Therefore, F4 is identified as the most promising formulation for ensuring oral hygiene.

KEYWORDS: Activated charcoal, Toothpaste formulation, Teeth whitening, Stain removal, Oral hygiene, Dental aesthetics, Physicochemical evaluation, Plaque removal, Natural oral care.

INTRODUCTION

According to WHO oral health is defined as "A healthy mouth allows individuals to perform essential functions such as eating, speaking, and expressing emotions without pain or discomfort."[1] Oral health plays a vital role in the physical, mental, social, and economic well-being of individuals and populations. The oral cavity and its surrounding structures are essential parts of the human body, integral to its daily functioning and contributing substantially to the overall health of individuals.[2] The mouth plays a vital role in how people express themselves, connect with others, and participate in daily activities. It's not just a tool for speaking or eating it's also a reflection of one's self-image. A healthy and attractive smile boosts personal confidence, influences how others perceive someone, and enhances their ability to communicate effectively. This, in turn, can shape opportunities for social interaction, professional success, and overall quality of life.[1]

A good oral hygiene is the state of being free from mild to chronic mouth ailments such as pain, sores, infections, tooth decay, tooth loss, periodontal (gum) disease, finally leading to oral cancers, and other diseases and disorders that limit an individual's capacity in biting, chewing, smiling, speaking, and psychosocial wellbeing. Which might contribute to a critical component of overall health and well-being, recognized by leading global health organizations like the World Health Organization (WHO) and the Centres for Disease Control and Prevention (CDC).[2]

KEY DETERMINANTS OF ORAL HEALTH MAINTENANCE

- Regular brushing
- Dental Floss
- Food Habits
- Regular Dental Check-ups
- Avoiding Tobacco and Limiting Alcohol

FACTORS EFFECTING POOR ORAL HYGIENE

Maintaining oral hygiene requires more than just routine practices; it demands an understanding of how individual habits (such as tobacco use, poor dietary choices, or

infrequent interdental cleaning), and medical factors (like diabetes, dry mouth, or medication side effects), contribute to oral disease risk. Effective prevention and intervention strategies should therefore be holistic (use of Charcoal) addressing.[3]

- Inadequate Oral Hygiene Practices
- Tobacco Use
- Excessive Alcohol Consumption
- High Sugar Diet
- Limited Access to Dental Care
- Low Oral Health Literacy
- Systemic Diseases and Medications
- Psychosocial Stress and Mental Health

MECHANISM OF CAVITY FORMATION: PROCESS OF DECAY

Oral cavity creates a dynamic environment, home to hundreds of different species of bacteria. Most of them are harmless, but certain types can be detrimental to our teeth. The process involves from plaque formation, acid attack, demineralization and cavity formation. The primary culprits are acid-producing bacteria, is most notably *Streptococcus mutans*.[4]

1. **Cardiovascular Disease** – Poor oral health is the gate way for bacteria to enter systemic circulation through **plaque buildup, gingivitis** i.e. redness and inflammation in the gums, **periodontitis** and entering the **systemic circulation**, leading to **increasing** blood pressure increasing stroke and heart attack risk [5].
2. **Alzheimer's Disease** – Oral pathogens may reach the brain, triggering **neuroinflammation** and decreased overall health.
3. **Diabetes** – Individuals neglecting oral hygiene encourages bacterial growth and intern leads to **periodontitis** which triggers a **low-grade infection** and inflammation, bacteria enter the circulation and makes insulin resistant [6].
4. **High-Risk Pregnancy** – Periodontal bacteria can be associate with preterm birth and low birth weight.
5. **Sleep Apnoea** – Teeth grinding and gum inflammation may signal airway disorders.
6. **Respiratory Issues** – Oral bacteria like *Staphylococcus aureus* and *Pseudomonas aeruginosa* can be inhaled directly into lungs forming colonization and leading to serious infections like pneumonia and COPD. Elderly patients are more prone to aspiration pneumonia.

MECHANISM OF TOOTH DISCOLOURATION

Tooth discolouration is not merely a cosmetic issue; it can profoundly impact an individual's confidence, social relationships, and general quality of life. Both internal and external factors can cause discolouration, which effects dental health and quality of life. Food and beverage stains adhere to the tooth's surface, while intrinsic stains may result from developmental difficulties, trauma, or by the use of medications. This discolouration can have a negative impact on self-esteem, social interactions, and even cause people to avoid specific meals or circumstances.[7]

- Intrinsic Discoloration
- Extrinsic Discoloration

APPROACHES FOR ORAL CLEANSERS

Oral cleansers are available in a number of forms, each designed to target specific areas of oral health from stain and plaque removal to breath refreshing and gum health [8].

- Toothpastes (Dentifrices)
- Mouthwashes
- Interdental Cleaners
- Tongue Cleaners
- Chewing Gums and Lozenges

TOOTHPASTE

Toothpaste is a semi-solid dosage form typically used as dentifrice, paste or gel scientifically engineered to clean teeth, remove plaque, and support both oral and systemic health. It plays a vital role in daily hygiene routines for billions of people worldwide, promoting oral cleanliness, aesthetics, and overall well-being.

Evolving from its ancient origins, modern toothpaste formulations integrate chemical and natural ingredients to deliver functional, therapeutic, and sensorial benefits.[9]

Functional Ingredients in Toothpastes

- **Abrasives**: Remove plaque and stains (e.g., calcium carbonate, silica)
- **Surfactants**: it helps to loosen and lift away debris and produce foaming (e.g., sodium lauryl sulphate)
- **Humectants**: Prevent drying and maintain texture (e.g., glycerine, sorbitol)
- **Viscosity modifiers:** To alter viscosity and spread ability (e.g. Xanthan gum)

- **Flavouring & Sweeteners**: Mask bitter taste and increase user compliance (e.g., peppermint oil, saccharin)
- **Preservatives**: prevent the growth of microorganisms(e.g., methyl paraben)

Activated Charcoal

Charcoal is produced by exposing organic materials to high temperatures, which removes water and other volatile constituents. The carbonization process releases gases and vapours such as water, carbon dioxide, methane, tar, phenols, aldehydes, or ammonia.

Types of Charcoal

1. **Activated Charcoal** – Activated charcoal is a fine powder black in colour, made from bone char, coconut shells, peat, petroleum coke, and coal. Charcoal gets activated when heated at a high temperature. The heating process for the formation of activated charcoal increases the surface area by reducing the pore size. In this form of charcoal, the number of pores is higher than the other forms of charcoal.

2. **Wood Charcoal** – Wood charcoal is a carbon compound made by strongly heating plant parts (plant wood). It is a lightweight compound. The colour of wood charcoal is black. It exists in a solid state.

3. **BBQ Charcoal** – BBQ charcoal is made by compressing sawdust without binders or additives under high temperature and pressure. This type of charcoal is preferred in Taiwan, Korea, Greece, and the Middle East countries. It has a hole through the centre, with a hexagonal intersection. The application of BBQ charcoal is primarily for barbecue as it does not produce any odour, smoke, little ash, high heat upon long burning (more than 4 hours).

4. **Coconut Shell Charcoal** – Coconut shell charcoal is the form of activated charcoal made up of coconut shells. Therefore, known as activated coconut charcoal. This type of charcoal is used for medicinal purposes. It is used for treating soft tissue and skin infections. It shows antibacterial properties. This form of charcoal is also known as coconut coal.

5. **Activated Bamboo Charcoal** – In this form, bamboo undergoes a pyrolysis reaction in the absence of oxygen and becomes activated. This form of charcoal is categorised into two types: Raw Bamboo Charcoal and Bamboo BBQ (Briquette) Charcoal.

Importance of Charcoal toothpaste:

- Surface Stain Removal
- Detoxification
- Natural Whitening Appeal
- Mild Abrasive Action. [10]

Applications of Activated Charcoal Toothpaste

- **Teeth Whitening via Adsorption**
  - Activated charcoal binds to surface stains caused by coffee, tea, wine, and tobacco. Its porous structure allows it to *adsorb pigments and plaque*, leading to visibly brighter teeth.[11]
  - Users often report a lightening effect of up to *three shades*, although this is anecdotal and varies by formulation.
- **Detoxification and Impurity Removal**
  - The high surface area of activated charcoal enables it to *trap toxins, bacteria, and food particles* in the oral cavity, contributing to a cleaner mouthfeel.
- **pH Regulation and Antibacterial Action**
  - Activated charcoal may help *neutralize oral pH*, creating an environment less conducive to bacterial growth. This can reduce bad breath and support gum health.[11]
- **Physicochemical Benefits**
  - Studies show that charcoal-based toothpaste can exhibit favorable *spreadability, foamability, abrasiveness*, and *stability*, making it a viable alternative to synthetic formulation.

MATERIALS AND METHODOLOGY

MATERIALS

1. Activated charcoal.
2. Calcium carbonate.
3. Xanthan gum.
4. Sodium lauryl sulphate.
5. Tween 80.
6. Glycerine.
7. Peppermint oil.
8. Methylparaben.
9. Distilled water.

THE FORMULATION FOR ACTIVATED CHARCOAL TOOTHPASTE

Table No 1: **Formula*tion* for Activated Charcoal Toothpaste.**

INGRIDENTS	FORMULATION			
	F1	F2	F3	F4
Activated charcoal	12g	14g	16g	20g
Calcium carbonate	20g	25g	30g	35g
Xanthan gum	0.5g	0.5g	0.5g	0.5g
Sodium lauryl sulphate	0.3g	0.3g	0.3g	0.3g
Tween 80	1.5g	1.5g	1.5g	1.5g
Glycerine	1ml	1ml	1ml	1ml
Peppermint oil	0.75ml	0.75ml	0.75ml	0.75ml
Methylparaben	1g	1g	1g	1g
Distilled water.	q.s	q.s	q.s	q.s

METHODOLOGY

Method of Preparation

- **Step 1: Sieving and Weighing**

All dry ingredients (calcium carbonate, Xanthan gum sodium lauryl sulphate, activated charcoal) are weighed accurately. Each dry ingredient is passed through sieve no.10 to achieve a uniform particle size.

- **Step 2: Preparation of Gum Mucilage**

The weighed gum Xanthan is dispersed slowly in a small quantity of purified water with continuous stirring to form a smooth mucilage base.

- **Step 3: Mixing of Powdered Ingredients**

All the sieved dry powders (including charcoal and alum) are transferred to a mortar and triturated well to ensure homogeneity.

- **Step 4: Incorporation into the Base**

The dry powder blend is gradually added to the prepared gum mucilage and starch paste with constant stirring to form a smooth paste.

- **Step 5: Addition of Flavouring Agents**

Peppermint oil added at this stage and mixed thoroughly to ensure uniform distribution throughout the batch.

- **Step 6: Adjustment of Consistency**

Add purified water gradually, if necessary, to adjust the final consistency of the toothpaste.

➢ **Step 7: Final Homogenization**

The final mixture is stirred or homogenized gently to eliminate any air bubbles and to achieve a smooth, uniform consistency.

EVALUATION STUDIES

1. Organoleptic evaluation

Color: The color of the formulation is checked by visual inspection.

Oduor: The odor of the formulation is determined by smell.

Texture: The texture of the formulation was checked by touch sensation.

2. Appearance, Homogeneity, and grittiness

The visual inspection should be done to assess homogeneity and appearance. Take 1ml formulation on the fingertips to check grittiness.

3. Determination of pH

Direct Method: 10 gm of the sample were placed in a glass vial and the pH meter electrode, previously rinsed with distilled water was immersed in the formulation to take three measurements for each sample and calculate the average.

4. Determination of spread ability

1 g of each sample was weighed and placed at the centre of the glass plate (10X10 cm) and another glass plate was placed over it carefully. Above the glass plates 2 kg weight was placed at the centre of the plate avoid sliding of the plate. The diameter of the paste in centimetres was measured, for all samples. The experiment was repeated three times and the averages were reported for all samples.

5. Determination of foaming ability

About 5 g of each sample was weighed and placed in a 100ml glass beaker. To this10ml of water was added and the beaker was covered with a watch glass and allowed to stand for 30 min, this operation was carried out to disperse the toothpaste in water. The contents of the beaker were stirred with a glass rod and the slurry was transferred to a 250ml graduated measuring cylinder, during this transfer ensure that no foam was produced and no lump paste went into the measuring cylinder. The residue left in the beaker was transferred with further portion of 5-6 ml of water to the cylinder. The content of cylinder was adjusted to 50ml by adding sufficient water. Stir the contents of the cylinder with a glass rod to ensure a uniform

suspension. The cylinder was stoppered and 12 complete shakes were given to it. The cylinder was allowed to stand for 5 minutes and the volume of foam with water and water only was noted for samples.

6. Determination of viscosity

The toothpaste formulation underwent rheological characterization using a Manual Brook field viscometer (Brookfield RV viscometer) to measure viscosity in centipoises at room temperature and the flow pattern was analyzed by constructing a graph. The graphs depicted apparent viscosity as a function of speed (RPM). The toothpaste was placed in the sample holder and the suitable spindle selected was lowered perpendicularly into the centre of toothpaste taking care that spindle does not touch bottom of the jar and rotated at a different speed. The viscometer measures the resistance to rotation and reports a viscosity value. The readings of viscosity of the formulation were measured after 5 minutes.

RESULT AND DISCUSSION

1. Physical Evaluation

- **Color:** The color of four formulations was checked by visual inspection. Black color was obtained.
- **Oduor:** The odor of all four formulations was determined by smell.
- **Texture:** The texture of all four formulations was checked by touch sensation respectively.

Table No 2: Physical Evaluation.

Parameter	Evaluation
Color	Black
Oduor	Characteristic
Texture	Fine and smooth

2. Measurement of pH

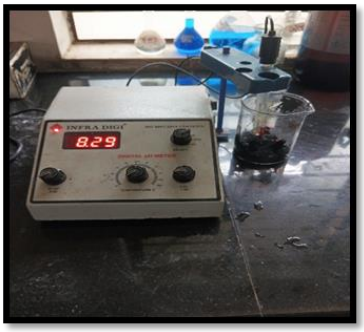

Figure No. 1

Table No. 3.

EVALUATION PARAMETER	Obtained pH			
	F1	F2	F3	F4
pH	7.78	8.04	8.08	8.29

The pH test of activated charcoal toothpaste was measured by using the calibrated pH meter and the pH of the formulations was found to be F1=7.78, F2= 8.04, F3=8.08and F4=8.29. all formulations are within the standard limit(pH6.5-8.5) we observed F4 shows maximum pH than other formulation values so F4 is selected.

3. Measurement of Foaming capacity

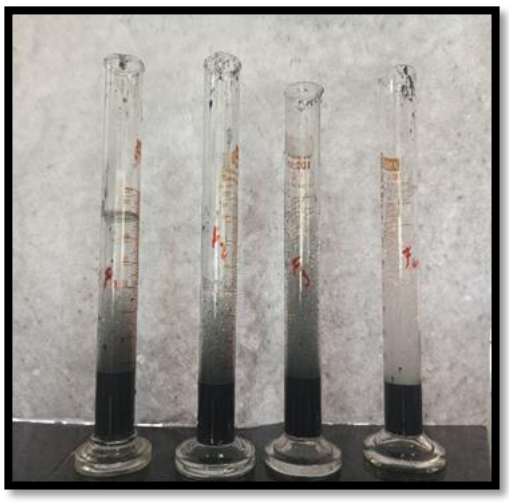

Figure No. 2

Table No. 4.

EVALUATION PARAMETER	F1	F2	F3	F4
Foaming capacity	45ml	42ml	35ml	30ml

4. Measurement of spread ability

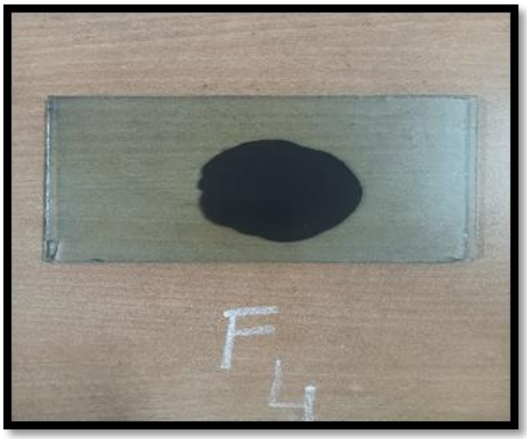

Figure No. 3.

Table No. 5

EVALUATION PARAMETER	F1	F2	F3	F4
Spread ability	7.0cm	6.6cm	5.9 cm	4.4cm

Spread ability of four formulations was measured in diameter by using spread ability plate. The F1 formulations produced Spread ability of 7.0cm and F2 has produced Spread ability of 6.6cm and F3 has produced Spread ability of 5.9cm and F4 has produced Spread ability of 4.4cm. F4 which produced maximum Spread ability is taken into consideration.

5. Measurement of Viscosity

Table No. 6.

EVALUATION PARAMETER	F1	F2	F3	F4
Viscosity	2354	3565	3962	4898

CONCLUSION

In conclusion, The research on toothpaste formulated with activated charcoal demonstrates significant potential as a natural and effective alternative to conventional toothpaste activated charcoal offers abrasives removal of surface stains, absorption of contaminants, promoting teeth whitening and detoxification.

In this study four formulations were prepared F1,F2,F3 and F4 respectively, Viscosity of four formulations was done by using brook field viscometer the viscosity of the product was noted. The F1 formulations shows viscosity of 2354cps, F2 formulations shows viscosity of 3565cps, F3 formulations shows viscosity of 3962cps and F4 formulations shows viscosity of 4898cps.F4 which produced good viscosity is taken into consideration.

In this study, four formulations—F1, F2, F3, and F4—were developed and evaluated. The pH values recorded were 7.78 for F1, 8.04 for F2, 8.08 for F3, and 8.29 for F4. All formulations exhibited acceptable pH levels, with F4 showing the highest value, making it the preferred choice.

Foaming capacity was measured as follows: F1 at 45 ml, F2 at 42 ml, F3 at 35 ml, and F4 at 30 ml. Although F4 had the lowest foaming volume, it was still within an acceptable range.

Spread ability was assessed with the following results: F1 at 7 cm, F2 at 6.6 cm, F3 at 5.9 cm, and F4 at 4.4 cm. F4's spread ability was closest to the standard range, suggesting optimal performance.

Based on the overall evaluation—pH, foaming capacity, viscosity, and spread ability of formulation F4 was selected as the most suitable formulation.

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