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The Peadentoral: Where Waste and Nature Powers Up Your Smile

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ABSTRACT

PEADENTORAL is an innovative smart toothpaste that combines traditional Malaysian botanical knowledge with modern dental science to improve oral health monitoring. It provides real-time visual feedback through a color-changing mechanism that indicates oral pH levels, which enables users to detect early signs of plaque formation. The formulation uses natural ingredients such as *Clitoria ternatea* extract and upcycled eggshell calcium, offering a sustainable and fluoride-enriched alternative to conventional toothpaste. This product addresses the growing demand for eco-friendly and multifunctional personal care products while promoting better oral hygiene awareness. Its additional application as a household pH indicator further increases its practical value beyond oral care. With its unique features and sustainable design, Peadentoral shows strong potential for commercialization in both local and international markets.

Keywords: smart toothpaste, oral pH, sustainability, natural ingredients, plaque detection.

1. INTRODUCTION

Peadentoral is an innovative anhydrous toothpaste developed to improve dental hygiene and promote better oral care practices. This project focuses on creating a toothpaste that effectively cleans teeth, strengthens enamel, and reduces bacterial growth. By incorporating natural and sustainable materials, such as eggshell-derived calcium and *Clitoria ternatea* (butterfly pea flower), the formulation aims to provide a safer and more environmental friendly alternative to conventional toothpaste.

The main objective of this study is to develop a multifunctional oral care product that enhances daily brushing effectiveness while increasing user awareness of oral health conditions. Maintaining good oral hygiene is important to prevent problems such as plaque buildup, tooth decay, and gum issues. However, many individuals are unable to detect plaque easily, which often leads to ineffective brushing and poor oral health.

To overcome this issue, the toothpaste is later designed with a colour-changing feature that provides visual feedback during brushing. This allows users to clearly identify areas that require more attention, helping them to clean their teeth more thoroughly and effectively.

Overall, Peadentoral offers a practical, safe, and sustainable solution by combining effective dental cleaning with an easy-to-understand visual indicator, encouraging better oral care habits.

2. METHODOLOGY

Research on Peadentoral is based on the need to deal with dental healthcare in a sustainable manner without resorting to toxic elements. The central research question explores whether an anhydrous (water-free) toothpaste matrix, integrated with upcycled eggshell calcium and botanical anthocyanins, could offer a reliable oral care and real-time diagnostic tool for domestic safety. This is relevant to both theory and practice as it bridges the gap between agricultural waste management and preventive health. An anhydrous method is specifically chosen to maintain the stability of the natural pH sensor and to prevent premature reactions between the alkaline baking soda and the anthocyanin pigments

2.1 Preparation of Bio-Calcium from Agricultural Waste

In order to substitute calcium carbonate from the industry, the shells must go under a sterilization and micronization process which is very stringent. First, the raw materials have to undergo a cleaning procedure whereby they are soaked for half an hour in distilled water to eliminate any protein covering on them. The sterilization process is done thermally by subjecting the shells to boiling for 20 minutes in water at 100°C and dried in the oven at 150°C in the laboratory oven for 15 minutes. This process gets rid of all micro-organisms such as Salmonella and etc.

2.2 Lipid-Phase Extraction

The diagnosing ability depends upon the extraction of anthocyanin (Ternatins) from *Clitoria ternatea* in the lipid matrix. VCO is warmed under conditions that keep its temperature within the limit of 50°C to 55°C in order to avoid the decomposition of pigments. In addition to being an oral diagnosis tool, the product serves as a multiple-purpose acid-base indicator for home use. It can detect the presence of acids in drinks, in bacteria's metabolic products, and in any unknown liquid.

2.3 The Anhydrous Formulation

Finally, the synthesis of this formulation is achieved through an aseptic procedure in which all equipment used is confirmed to be fully dry, preventing early chemical reactions. The minerals are mixed in equal proportions in a homogenous form for about 8-10 minutes. Xanthan gum acts as a binder. In this formulation, the pre-emulsified liquid component is combined with the minerals in the presence of mechanical shear. Vigorous stirring was done for 3 minutes until a uniform emulsion in glossy indigo blue paste appears.

2.4 Synergistic Formulation for Holistic Oral Care

The ultimate blend focuses on achieving overall oral health via a mineral and herbal compound. Dicalcium phosphate and eggshell calcium are sources of vital minerals needed

for repairing tooth enamel. Xylitol starves acidogenic bacteria and prevents them from forming dental plaque. The incorporation of bamboo salt and an alkaline medium (pH 8.0) neutralizes mouth acids upon contact, thus preventing enamel demineralization immediately. Lastly, *Clitoria ternatea* works as a biologic antibiofilm compound that interferes with the glue (extracellular polymeric substances) formed by bacteria in order to attach themselves to the enamel surface.

3. RESULTS AND DISCUSSION

3.1 Physical and Chemical Properties of the Formulation

The Peadentoral exhibited a stable indigo-blue colour, smooth texture, that indicates the successful formulation of a homogeneous anhydrous system. The formulation maintains a stable alkaline pH (8.0-8.5), which plays a vital role in neutralizing oral acids that contribute to enamel demineralisation. This will create a protective environment that supports early-stage enamel repair and remineralisation, reducing the risk of acid-induced tooth erosion.

3.2 pH Sensitivity and Diagnostic Function

The toothpaste demonstrated a clear and rapid colour changing from blue to magenta when exposed to acidic conditions (pH < 5.5). This confirms the effectiveness of the *Clitoria ternatea* extract as a natural pH-sensitive indicator. The consistency of the colour change across different test materials demonstrates the reliability of the formulation in detecting low pH environments.

The pH sensitivity of the toothpaste was tested using various acidic and alkaline substances available in the environment. Upon contact with these acidic materials, the toothpaste showed a clear rapid colour change from blue to magenta.

Table 1. Colour Response of Peadentoral Under Different pH Conditions

pH Condition	Example Substance Used	Observed Colour Change	Interpretation
Acidic (pH < 5.5)	Vinegar	Magenta / Pink	Indicates presence of acid, simulates conditions similar to bacterial acid in the mouth
Neutral (pH = 7)	Distilled water	Blue (no change)	Indicates neutral environment, no harmful acid activity detected
Alkaline (pH > 7)	Baking soda solution	Deep Blue	Indicates alkaline condition, favourable for neutralising acids and protecting enamel

3.3 Relevance to Oral Health Application

Although the testing was conducted using external acidic substances, the findings strongly indicate potential application in oral care. In the oral cavity, bacterial activity produces acids that lower pH levels, similar to the acidic conditions created by vinegar.

Therefore, the observed colour changes suggest that the toothpaste has capability to indicate acidic zones in the mouth, which is associated with plaque formation and risk of enamel erosion. This provides users with visual guidance to improve brushing effectiveness and target high-risk areas.

In addition, the alkaline formulation helps to neutralize oral acids, while the presence of calcium-based compounds supports enamel remineralisation. The inclusion of xylitol may also contribute to reducing bacterial growth, enhancing overall oral hygiene.

3.4 Stability and Safety of the Product

The anhydrous formulation enhances product stability by preventing premature reactions and reducing moisture-related degradation. No separation or instability was observed during short-term evaluation.

Furthermore, the use of finely processed ingredients ensures low abrasivity, making the toothpaste safe for enamel and suitable for regular use. This ensures that the product is both effective and gentle for oral application.

4. CONCLUSION

Peadentoral successfully integrates traditional Malaysian botanical knowledge with modern dental science, offering a toothpaste that improves dental hygiene and promotes better oral care practices with real-time diagnostic tools for domestic safety. This natural formulation serves as a safer and more educational alternative to conventional toothpastes. The product demonstrates strong commercial potential within the expanding oral care and natural healthcare markets, where demand for eco-friendly, sustainable, and multifunctional products is rapidly increasing. By incorporating natural ingredients such as clitoria ternatea extract and upcycled eggshell calcium, peadentoral aligns with green consumerism trends while promoting waste-to-value innovation, reducing production costs and enhancing environmental appeal. Its unique color-changing diagnostic function enables early plaque detection, positioning it as a premium toothpaste distinct from existing brands. In addition, its dual functionality as a household pH indicator broadens its market reach beyond oral care into domestic safety applications. With strategic branding, proper packaging, and clinical validation, Peadentoral can be effectively marketed through pharmacies, supermarkets, dental clinics, and online platforms both locally and internationally. Therefore, Peadentoral holds strong potential for commercialization as an innovative, sustainable, and multifunctional healthcare product with promising market demand.

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