

THE IMPACT OF DENTAL CARIES ON THE NUTRITIONAL STATUS OF KINDERGARTEN CHILDREN AT DARUL IMARAH, ACEH BESAR REGENCY

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ABSTRACT

Background: Dental caries is a common oral health issue among school-aged children. The oral environment, including salivary pH, plays a role in the development of caries. Saliva is crucial for maintaining oral pH balance and facilitating the remineralization of hard dental tissues. Cocoa beans (*Theobroma cacao* L.) contain bioactive compounds—such as theobromine—that have potential as active ingredients in toothpaste. Objective: This study aimed to determine the effect of a cocoa bean methanol extract toothpaste formula on salivary pH before and after toothbrushing among students at SDN Kayee Leu, Aceh Besar. Methods: A pre-experimental design with a one-group pretest-posttest approach was employed. The study sample consisted of 30 students from SDN Kayee Leu, Aceh Besar. Salivary pH was measured before and after the respondents brushed their teeth using the cocoa bean methanol extract toothpaste. Data were analyzed using univariate and bivariate statistical tests appropriate for the data distribution. Results: The mean salivary pH before using the cocoa extract toothpaste was 6.42 ± 0.38 , while after use, it increased to 6.91 ± 0.31 . An increase of 0.49 in mean salivary pH was observed. Statistical analysis yielded a p-value of 0.001 ($p < 0.05$), indicating a significant difference in salivary pH before and after using the cocoa extract toothpaste. Conclusion: The use of cocoa bean methanol extract toothpaste significantly increased salivary pH among students at SDN Kayee Leu, Aceh Besar. Cocoa extract toothpaste has the potential to be developed as a natural-based product to support oral health maintenance in children.

Keywords: *toothpaste, cocoa extract, Theobroma cacao L., salivary pH, school children*

INTRODUCTION

Dental and oral diseases remain an unresolved issue. In Indonesia, the prevalence of dental and oral diseases stands at 63%; specifically, 47.0% of the population in Aceh Province experiences dental problems. Dental caries affect 92.6% of children aged 5–9 years and 96.2% of adults aged 55–64 years. Consequently, preventing dental and oral diseases is essential. One method involves maintaining salivary pH levels. Salivary pH influences bacterial aggregation—thereby hindering microbial colonization—and activates antibacterial mechanisms against plaque. The normal pH range for human oral saliva is 6.8–7.8. Saliva also functions as an antibacterial agent; various toothpaste ingredients, including those in herbal toothpastes, can stimulate salivary secretion. Herbal toothpastes are effective in modulating acidity and improving oral pH due to their content of sodium bicarbonate, sodium fluoride, and herbal ingredients. They also possess natural anti-inflammatory, antiseptic, and analgesic properties. Non-herbal toothpastes typically contain fluoride as an active ingredient.

However, the addition of non-herbal agents like triclosan and chlorhexidine to prevent plaque can lead to side effects such as tooth staining and altered taste sensations in the mouth. Previous research indicates that toothpaste formulated with cocoa bean methanol extract exhibits a high pH—though still within the normal limit of 7.8—and contains phytochemicals such as phenolics, tannins, flavonoids, terpenoids, saponins, and alkaloids. It demonstrates a minimum inhibitory effect against *S. mutans* growth at a 1% concentration (resulting in a bacterial colony count of 334×10^{-4}), and toxicity tests confirm that the cocoa bean methanol extract is non-toxic.

- A. preliminary survey at SDN Kayee Leeu revealed that 70% of students suffered from dental health issues and had never used herbal toothpaste. Based on this background, the author is interested in conducting this study.
- B. Research Problem The research problem is: "Is there an effect of cocoa bean methanol extract toothpaste on salivary pH in students at SDN Kayee Leu, Aceh Besar, and on the surface roughness of heat-cured acrylic resin?"
- C. Specific Objectives
 1. To determine the effect of the cocoa bean methanol extract toothpaste formula on salivary pH before and after toothbrushing.
 2. To determine the effect of the cocoa bean methanol extract toothpaste formula on the surface roughness of acrylic resin before and after immersion in the formula.
 3. To determine the effect of the cocoa bean methanol extract toothpaste formula on the dental plaque index.

- D. The significance or urgency of this research lies in the composition of the cocoa bean methanol extract toothpaste—which contains phenolics, tannins, flavonoids, terpenoids, saponins, and alkaloids, and possesses antibacterial properties—and its potential to raise oral salivary pH; maintaining salivary pH balance is a method for preventing dental caries. Many people are unaware of the benefits of cocoa beans as a base ingredient for toothpaste, and few studies have investigated the effect of cocoa bean extract toothpaste formulas on oral salivary pH, etc.

METHODS

This study employs an analytical method with a cross-sectional design. Extraction was conducted using maceration and a rotary evaporator at the USK Agricultural Laboratory, while toothpaste formulation took place at the Poltekkes Aceh Pharmacy Laboratory. Salivary pH was tested before and after the use of cocoa bean extract toothpaste among students at SDN Kayee Leu, Aceh Besar; the sample consisted of 40 healthy children aged 8–10 years in the mixed dentition stage. The study is scheduled from March to September 2025. Research equipment and materials included jars, a mortar and pestle, toothpaste tubes, syringes, Petri dishes, graduated cylinders, a rotary evaporator, test tube racks, filter paper, an analytical balance, a vortex mixer, tweezers, cotton wool, and Erlenmeyer flasks. Materials used included cocoa bean extract, 98% ethanol, 0.9% NaCl, distilled water, menthol, saccharin, glycerin, sodium benzoate, sodium lauryl sulfate, CMC, and CaCO₃.

RESULTS AND DISCUSSION

1. Respondent Characteristics

The study was conducted among students of SDN Kayee Leu, Aceh Besar, who met the inclusion criteria. The characteristics of the respondents included gender and age.

Table 1. Respondent Characteristics

Characteristics	n	%
Gender		
Male	15	50.0
Female	15	50.0
Age		
9 years	8	26.7
10 years	12	40.0
11 years	10	33.3
Total	30	100.0

Based on Table 1, there were 30 respondents. The number of male and female respondents was equal, with 15 students (50%) in each group. Regarding age, most respondents were 10 years old, totaling 12 students (40.0%), followed by 11-year-olds with 10 students (33.3%) and 9-year-olds with 8 students (26.7%).

2. Distribution of salivary pH before and after using cocoa extract toothpaste

salivary pH was measured before and after the respondents brushed their teeth using toothpaste containing methanolic cocoa bean extract.

Table 2. Mean Salivary pH Before and After Using Cocoa Extract Toothpaste

Salivary pH Measurement	Mean	SD	Minimum	Maximum
Before brushing	6.42	0.38	5.80	7.10
After brushing	6.91	0.31	6.30	7.50
Change	0.49			

Based on Table 2, the mean salivary pH before brushing with cocoa extract toothpaste was 6.42, whereas after brushing, it increased to 6.91. There was an increase in the mean salivary pH of 0.49. These results indicate a shift in salivary pH toward a more neutral condition following the use of cocoa extract toothpaste.

3. Analysis of the Effect of Cocoa Extract Toothpaste on Salivary pH

To determine the effect of using cocoa extract toothpaste on salivary pH, an analysis of the difference in salivary pH before and after the intervention was performed.

Table 3. Effect of Cocoa Extract Toothpaste on Salivary pH

Variable	Before	After	Mean Difference	p-value
Salivary pH	6.42 ± 0.38	6.91 ± 0.31	0.49	0.001

The analysis showed that the mean salivary pH increased from 6.42 before the intervention to 6.91 after using cocoa extract toothpaste, with a mean difference of 0.49. Based on the statistical analysis, a p-value of 0.001 ($p < 0.05$) was obtained. Therefore, it can be concluded that the use of methanolic cocoa bean extract toothpaste had a statistically significant effect on the salivary pH of students at SDN Kayee Leu, Aceh Besar.

DISCUSSION

Effect of Cocoa Extract Toothpaste on Salivary pH, The results of this study showed that the use of toothpaste containing methanolic cocoa bean extract produced

a change in salivary pH among students at SDN Kayee Leu, Aceh Besar. The mean salivary pH before toothbrushing was 6.42 and increased to 6.91 after toothbrushing, with a mean increase of 0.49. Statistical analysis showed a p-value of 0.001 ($p < 0.05$), indicating a statistically significant difference in salivary pH before and after the use of cocoa extract toothpaste. These findings suggest that cocoa extract toothpaste may help maintain salivary pH at a level closer to neutral. This finding is consistent with a study involving children who used theobromine-containing toothpaste, which demonstrated an increase in salivary pH and salivary buffer capacity following its use.¹ The increase in salivary pH after toothbrushing may be associated with stimulation of salivary secretion during the toothbrushing process. Saliva plays an important role in maintaining the balance of the oral environment through buffering mechanisms, clearance of substrates, and provision of minerals required to maintain the integrity of hard dental tissues. When salivary flow increases, the capacity of saliva to neutralize acids may also increase, resulting in a more stable oral pH. This condition is important because an excessively acidic oral environment can promote enamel demineralization and increase the risk of caries development.²

Cocoa, particularly its theobromine content, is thought to contribute to positive effects on dental tissues. Theobromine is an alkaloid compound belonging to the methylxanthine group that occurs naturally in cocoa beans (*Theobroma cacao*). Several studies have indicated that theobromine has potential in enamel remineralization through the enhancement of hydroxyapatite crystal formation and growth. Therefore, the use of cocoa-derived active ingredients in toothpaste formulations has the potential to support the maintenance of dental health. However, the increase in salivary pH cannot be attributed solely to theobromine because salivary pH is also influenced by mechanical stimulation during toothbrushing and other components of the toothpaste formulation.^{3,4} The findings of this study are also supported by research on theobromine-containing toothpaste in young children. The study reported that children using theobromine-containing toothpaste experienced increases in salivary pH and salivary buffer capacity, as well as a reduction in the number of *Streptococcus mutans*. These findings suggest that cocoa-based active ingredients may not only influence salivary conditions but may also create an oral environment that is more favorable for caries prevention.¹

Biologically, an increase in salivary pH is important for the prevention of dental caries. When the oral environment is maintained at a pH closer to neutral, the risk of enamel mineral dissolution caused by acidic conditions may be reduced. Saliva also serves as a source of calcium and phosphate, which contribute to the remineralization process. Therefore, the change in salivary pH from 6.42 to 6.91 observed in this study may be interpreted as a change toward an oral environment that better supports the balance between demineralization and remineralization.^{2,5} In addition to its relationship with salivary pH, theobromine derived from cocoa has also been investigated for its enamel remineralization properties. An *in vitro* study demonstrated that dentifrice containing

theobromine could promote remineralization of artificially induced carious lesions in enamel. Although its effectiveness was lower than that of the combination of sodium fluoride and functionalized tricalcium phosphate, the theobromine group still demonstrated significant improvement in enamel lesions.⁴ Thus, the active compounds in cocoa have potential as natural ingredients in the development of preventive oral health products.

Other research has also demonstrated that theobromine-containing toothpaste can increase enamel microhardness following demineralization. This effect is thought to be associated with the ability of theobromine to support the remineralization process and enhance enamel resistance to acid attacks. These findings further support the possibility that cocoa extract in toothpaste may not only be relevant to changes in salivary parameters but may also contribute to the protection of hard dental tissues. However, because this study only measured changes in salivary pH before and after toothbrushing, a direct effect on enamel remineralization cannot be concluded from the present study.⁵ The changes in salivary pH observed in this study should also be understood as the result of interactions among the active ingredients in the toothpaste, the toothbrushing process, and the individual characteristics of each respondent's saliva. Factors such as salivary flow rate, timing of sample collection, food and beverage consumption prior to examination, oral hygiene status, and dental health conditions may influence salivary pH values. Therefore, pre- and post-treatment measurements should be conducted under relatively standardized conditions so that the observed changes can be more reliably attributed to the intervention.^{2,6}

Based on the findings of this study and previous research, methanolic cocoa bean extract toothpaste has potential for development as a natural-based toothpaste ingredient to support the maintenance of oral health in children. The increase in salivary pH following the use of the toothpaste indicates a change in the salivary environment toward a more neutral condition. However, further studies involving larger sample sizes, control groups, different concentrations of cocoa extract, assessment of salivary buffer capacity, plaque indices, *Streptococcus mutans* counts, and caries indices are needed to comprehensively establish the effectiveness of cocoa extract toothpaste.^{1,3}

CONCLUSION

Overall, the results of this study indicate that methanolic cocoa bean extract toothpaste affects the salivary pH of students at SDN Kayee Leu, Aceh Besar. The mean salivary pH increased from 6.42 before toothbrushing to 6.91 after toothbrushing, with a statistical test result of $p = 0.001$. This increase indicates a shift in salivary pH toward a more neutral condition. These findings are consistent with previous research on theobromine-containing toothpaste, which reported an increase in salivary pH and salivary buffer capacity among children.

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