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Immediate reduction in debris index after chewing red guava versus watermelon albedo among elementary school students

Penurunan segera indeks debris setelah mengunyah jambu biji merah dibandingkan albedo semangka pada murid sekolah dasar

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Abstract

Background: Food debris retained on tooth surfaces could support plaque accumulation. Mechanical chewing and saliva-mediated clearance could reduce debris, but direct evidence comparing red guava with watermelon albedo in schoolchildren was limited. Chewing may facilitate oral debris clearance, but comparisons of red guava with watermelon albedo in schoolchildren remain limited.
Objectives: This study aimed to compare the immediate reduction in debris index after chewing red guava and watermelon albedo among elementary school students.
Methods: A non-equivalent pretest-posttest study involved 38 students at Pilubang Elementary School No. 21, Agam Regency, Indonesia. Sixteen fifth-grade students received 25 g of red guava and 22 fourth-grade students received 25 g of watermelon albedo. Participants chewed for approximately 32 cycles over 1 minute. Debris index was assessed immediately before and after chewing. Paired t tests assessed within-group changes; an independent-samples t test compared change scores.
Results: Mean reductions were 1.21 ± 0.27 points for guava and 0.76 ± 0.30 for albedo. The unadjusted between-group difference was 0.45 points (95% CI: 0.26–0.64; $p < 0.001$; Hedges' $g = 1.53$).
Conclusion: Red guava was associated with a larger immediate reduction in debris index than watermelon albedo. Complete confounding with grade prevents attributing this difference independently to fruit type. The findings concern immediate debris clearance and do not establish sustained oral-health benefits.

Keywords:
Child, citrullus, mastication, oral hygiene index, psidium

Abstrak

Latar belakang: Debris makanan yang tertahan pada permukaan gigi dapat mendukung akumulasi plak. Pengunyahan mekanis dan pembersihan melalui saliva dapat mengurangi debris, tetapi bukti yang membandingkan langsung jambu biji getas merah dengan albedo semangka pada anak sekolah masih terbatas.
Tujuan: Penelitian ini bertujuan membandingkan penurunan segera indeks debris setelah mengunyah jambu biji getas merah dan albedo semangka pada murid sekolah dasar.
Metode: Studi pretest-posttest non-ekuivalen melibatkan 38 murid SDN 21 Pilubang, Kabupaten Agam, Indonesia. Sebanyak 16 murid kelas V menerima 25 g jambu biji merah dan 22 murid kelas IV menerima 25 g albedo semangka. Peserta mengunyah sekitar 32 siklus selama 1 menit. Indeks debris dinilai segera sebelum dan sesudah pengunyahan. Uji t berpasangan menilai perubahan dalam kelompok; uji t independen membandingkan skor perubahan.

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Hasil: Rerata penurunan sebesar 1,21 ± 0,27 poin pada kelompok jambu dan 0,76 ± 0,30 pada kelompok albedo. Perbedaan antarkelompok tanpa penyesuaian sebesar 0,45 poin (IK 95%: 0,26–0,64; p < 0,001; Hedges' g = 1,53).
Kesimpulan: Kelompok jambu menunjukkan penurunan segera indeks debris yang lebih besar. Perancuan lengkap dengan kelas membatasi atribusi perbedaan tersebut secara independen pada jenis buah. Temuan hanya mencakup pembersihan debris segera dan tidak membuktikan manfaat kesehatan mulut berkelanjutan.

Kata Kunci:
Anak, citrullus, mastikasi, indeks kebersihan mulut, psidium

Introduction

Oral health is integral to general health, nutrition, communication, and social participation. Nevertheless, oral diseases remain among the most prevalent noncommunicable conditions worldwide and disproportionately affect children and socioeconomically disadvantaged populations (GBD 2017 Oral Disorders Collaborators, 2020; Peres et al., 2019; WHO, 2022). In Indonesia, the 2023 Indonesian Health Survey identified persistent problems involving dental caries, limited use of oral health services, and low oral health literacy, indicating that practical preventive strategies remain relevant for school-age children (BKPK, 2024; Warman et al., 2025).

Debris refers to soft food remnants and loosely adherent material present on tooth surfaces. Although debris is not identical to mature dental plaque, persistent retention can create a favorable environment for plaque accumulation and acid production (Chenicheri et al., 2017; Ifitri et al., 2024). Routine toothbrushing remains the central method for oral hygiene; however, oral clearance is also influenced by salivary flow, movements of the tongue and cheeks, and mastication. Mechanical and gustatory stimulation during chewing can increase salivary flow and improve oral clearance, particularly in children (Vantipalli et al., 2017). Food texture also modifies chewing time, the number of masticatory cycles, and oral processing behavior, and children adapt their chewing patterns to the physical properties of different foods (Frank et al., 2019; Linas et al., 2019).

Fibrous fruits have therefore been studied as supportive self-cleansing foods. Indonesian quasi-experimental studies have reported short-term reductions in debris after chewing red guava, apple, watermelon, papaya, pineapple, and jicama (Diyatama et al., 2020; Fadjeri et al., 2023; Hartari et al., 2021; Hidayati & Suyatmi, 2016; Meilani et al., 2024; Novriani & Zainur, 2021). These effects are commonly attributed to the interaction between fruit texture, chewing-related friction, and stimulated saliva. However, findings vary by fruit, comparator, sample, and study procedure, suggesting that the physical form of the food may be as important as its water or fiber content (Appleton et al., 2021; Khorasaniha et al., 2023).

Fruit structure and texture may influence oral processing. Evidence on guava structure and the composition of watermelon flesh provides a rationale for examining fruit-based oral clearance, but does not directly establish the relative hardness of guava and watermelon albedo (Baião et al., 2025; da Silva et al., 2023; Janani et al., 2022; Wang et al., 2024). The present study used watermelon albedo, the white tissue between the outer rind and red flesh. Specifying this tissue is important because evidence on red watermelon flesh cannot automatically be generalized to albedo.

Comparing guava with albedo addresses whether immediate debris-index changes differ between groups receiving these distinct fruit portions under the same prescribed portion size and chewing duration. Direct comparisons in elementary school students remain limited. This study therefore aimed to compare the immediate reduction in debris index in two non-equivalent class groups after standardized chewing at Pilubang Elementary School No. 21, Agam Regency. We hypothesized that the mean reduction in debris index would differ between the two fruit groups.

Methods

Study Design and Setting

This study used a quasi-experimental, non-equivalent two-group pretest-posttest design at Pilubang Elementary School No. 21, Ampek Angkek District, Agam Regency, West Sumatra, Indonesia.

Allocation followed existing classes rather than random assignment. The study compared immediate debris-index changes after one standardized chewing episode; the between-group contrast does not identify a fruit effect independent of grade.

Participants and Sampling

The source population comprised 48 fourth- and fifth-grade students, and total population sampling was planned. Eligibility required attendance during data collection, willingness to participate, parent or guardian permission, and at least two index teeth available for examination. Thirty-eight students met the eligibility criteria and completed the protocol.

All 16 fifth-grade participants received red guava, and all 22 fourth-grade participants received watermelon albedo. The sample comprised 23 boys and 15 girls. Fruit assignment was therefore completely confounded with grade, and the groups were non-equivalent.

Interventions

Each participant received 25 g of fruit. The red-guava portion consisted of ripe fruit with the seed-containing central portion removed. The watermelon portion consisted of the white albedo between the outer rind and red flesh, rather than the red flesh. Participants were instructed to chew bilaterally for approximately 32 cycles over 1 minute and then swallow the portion. Portion weight, prescribed chewing instructions, and the immediate observation period were standardized. Fruit hardness and actual chewing cycles were not objectively measured.

Outcome Measurement

The primary outcome was the Greene and Vermillion debris index. Before the intervention, disclosing solution was applied to designated index teeth, and participants rinsed to remove excess solution. Examiners assessed the buccal surfaces of teeth 16 and 26, the labial surfaces of teeth 11 and 31, and the lingual surfaces of teeth 36 and 46. Scores were categorized as good (0.0–0.6), fair (0.7–1.8), or poor (1.9–3.0). The same teeth and examination sequence were used immediately after chewing.

Five dental health students assisted after a 3-day calibration and procedural standardization session. A numerical inter- or intra-examiner reliability coefficient was not available in the reported study information, and examiner blinding was not documented.

Data Analysis

Continuous variables were summarized as means and standard deviations; categorical variables as frequencies and percentages. Change scores were calculated as pre-intervention minus post-intervention debris index, with larger positive values indicating greater reduction. Change scores were approximately normally distributed in both groups (Shapiro–Wilk $p > 0.05$), and Levene's test supported homogeneity of variance ($p = 0.539$). Paired t tests assessed within-group changes; an independent-samples t test compared mean change scores between groups. The unadjusted mean difference, 95% confidence interval, and Hedges' g were reported, with significance set at $p < 0.05$.

These analyses describe changes within groups and an unadjusted contrast between non-equivalent classes. Because fruit assignment and grade were perfectly aligned, the contrast cannot separate fruit-related differences from grade-related differences.

Ethical Considerations

The study was conducted with school permission, written parent or guardian informed consent, and age-appropriate assent from participating children. Before data collection, the children received an explanation of the study purpose, the chewing and examination procedures, the expected activities, and their right to decline or withdraw without penalty. Participant identities were coded in the analysis dataset.

Results

All 38 eligible students completed the pre- and post-intervention assessments. The guava group comprised fifth-grade students and was older on average than the fourth-grade albedo group. Although baseline mean debris indices were similar, allocation by class precluded equivalent groups and confounded fruit assignment with grade.

Table 1 presents the available group characteristics; Table 2 presents the unadjusted changes.

Table 1. Participant and baseline characteristics

Intervention Group	n	Grade	Age (years), mean ± SD (range)	Baseline debris index, mean ± SD
Guava	16	V	11.13 ± 0.50 (10–12)	1.78 ± 0.49
Watermelon Albedo	22	IV	10.36 ± 0.49 (10–11)	1.74 ± 0.48

Note: The total sample included 23 boys (60.5%) and 15 girls (39.5%); sex distribution by intervention group was not available.

Table 2. Immediate changes in debris index according to intervention group

Intervention group	Mean ± SD	Mean change, mean ± SD	Within-group p-value	Between-group p-value*
Guava, n= 16				
Pre-intervention	1.78 ± 0.49	1.21 ± 0.27	<0.001	<0.001
Post-intervention	0.58 ± 0.25			
Watermelon Albedo, n= 22				
Pre-intervention	1.74 ± 0.48	0.76 ± 0.30	<0.001	
Post-intervention	0.98 ± 0.48			

Note: Within-group comparisons were analyzed using paired-samples t-tests. *The between-group comparison was performed on the change scores using an independent-samples t-test: mean difference = 0.45; 95% confidence interval, 0.26–0.64; $t(36) = 4.74$; $p < 0.001$; Hedges' $g = 1.53$.

Both groups showed immediate decreases in debris index. Mean reductions were 1.21 ± 0.27 points in the guava group and 0.76 ± 0.30 in the albedo group. The unadjusted difference in mean change was 0.45 points (95% CI: 0.26–0.64; $p < 0.001$), with Hedges' $g = 1.53$. This contrast describes the two non-equivalent class groups and should not be interpreted as an independent causal effect of fruit type.

Discussion

A single standardized chewing episode was followed by an immediate debris-index reduction in both groups, with a larger observed reduction in the guava group. However, every guava participant was in fifth grade and every albedo participant was in fourth grade. Thus, the observed 0.45-point difference cannot be attributed independently to fruit type. Similar baseline debris-index means do not resolve this structural confounding. The findings concern immediate debris clearance, rather than sustained plaque control or caries prevention.

The observed decrease is biologically plausible because mastication produces a combination of mechanical friction, movement of oral soft tissues, bolus formation, and salivary stimulation. Saliva contributes to lubrication, dilution, buffering, and physical clearance within the mouth. Experimental research in children has shown that chewing stimulation increases salivary flow and alters oral pH, demonstrating that mechanical oral activity can rapidly modify the oral environment (Fitri et al., 2025; Vantipalli et al., 2017). Food oral processing is also strongly affected by texture. The number of cycles, chewing time, and swallowing behavior vary according to food properties and age, and children can adjust their masticatory behavior to the material being consumed (Frank et al., 2019; Linas et al., 2019). Thus, the effect observed in this study is likely to reflect the combined action of the fruit surface against the teeth and the saliva generated while the food was being comminuted.

Differences in fruit structure could plausibly contribute to oral clearance through tooth–food contact during chewing. However, the relative hardness and breakdown of the actual guava and albedo portions were not measured, and the between-group difference may also reflect grade-related characteristics. The present study did not directly measure hardness, chew work, salivary flow, or the number of effective tooth contacts, so this explanation remains mechanistic rather than proven. Nevertheless, international oral-processing studies show that solid-food properties influence chewing frequency, cycle number, and oral behavior, while salivary incorporation changes as the bolus is formed (Carvalho et al., 2016; Linas et al., 2019; Wang et al., 2024). The standardized 25-g portions and one-minute chewing instruction reduced procedural variation but could not eliminate individual differences in bite force, dental status, or chewing efficiency.

The results for red guava are consistent with earlier Indonesian evidence. Hidayati & Suyatmi (2016) reported significant debris-index reductions after chewing both apple and red guava among children aged 8-10 years. Their finding supports the potential of red guava as a mechanically active fruit, although apple produced a greater decrease in that comparison. The present study adds an unadjusted comparison involving watermelon albedo, with a confidence interval and standardized effect-size estimate; its non-equivalent allocation limits comparison with earlier studies. The immediate improvement from a mean score in the fair category to a mean score in the good category after guava chewing is clinically understandable as a short-term reduction in loose debris (Nasir & Garg, 2025). It should not be interpreted as complete plaque control, because the debris index captures visible soft deposits and does not directly measure bacterial plaque maturation or caries activity (La Rosa et al., 2023).

The decrease after watermelon albedo is also consistent with studies of watermelon-based interventions. Hartari et al. (2021) found that both apple and watermelon reduced debris index among junior high school students, although apple was more effective. Diyatama et al. (2020) similarly reported a difference between apple and watermelon, while Novriani & Zainur (2021) observed a decrease after watermelon and papaya consumption. In children with visual impairment, Nurjannah et al. (2023) also reported changes after chewing watermelon and papaya. Together, these studies indicate that watermelon can contribute to immediate oral clearance, but its magnitude may depend on the comparator, fruit portion, texture, chewing duration, and characteristics of the participants. The current use of albedo rather than red watermelon flesh is particularly important because these tissues differ physically. Future articles and interventions should specify the exact edible portion to ensure reproducibility.

Evidence from other fibrous fruits reinforces the broader concept without establishing equivalence among foods. Fadjeri et al. (2023) reported improved debris-index categories after elementary school children chewed jicama, and Meilani et al. (2024) found a reduction after pineapple chewing. These findings suggest that the oral effect is not unique to a single fruit but arises from a class of foods that stimulate mastication and saliva. However, calling these foods natural toothbrushes would overstate the evidence. Fruit chewing is unlikely to reach all proximal surfaces, gingival margins, pits, and fissures, and some fruits contain fermentable sugars or acids. These short-term findings should not be translated into a claim that fruit chewing prevents caries. Routine toothbrushing with fluoride toothpaste remains essential.

The between-group contrast remains inseparable from grade-related differences because allocation followed intact classes. The guava group was composed of fifth-grade students with a mean age of 11.13 years, while the watermelon group was composed of fourth-grade students with a mean age of 10.36 years. Age and oral development influence the efficiency of chewing solid foods. Frank et al. (2019) demonstrated age-related differences in standardized solid-food mastication among children and adolescents, and Linas et al. (2019) showed that oral condition and food type affect children's chewing behavior. Older students may have stronger bite forces, more mature coordination, or a different pattern of erupted permanent teeth, potentially increasing the apparent effectiveness of the guava intervention. Similar baseline debris means do not demonstrate comparable groups on age, dental development, or other characteristics. The reported age ranges overlap, so age adjustment may be computationally possible if individual data are available. Such an analysis would assess sensitivity to measured age and model assumptions; it would not separate fruit assignment from grade. The large effect size therefore cannot establish the independent superiority of guava.

The clinical meaning of a debris-index change should also be considered separately from statistical significance. The debris index is an ordinally derived surface score summarized as a mean, and no universally accepted minimal clinically important difference has been established for a single chewing episode. In this study, the guava group's mean moved from the fair range to the good range, whereas the watermelon-albedo group's mean remained within the fair range. This shift describes group mean scores, not the proportion of individual children whose categories improved. The confidence interval and design limitations are more informative than a group mean category label alone. Reporting the large Hedges g improves transparency, yet the

effect size may be inflated by the small sample and class-based allocation. Replication is therefore necessary before recommending one fruit as consistently superior across school populations.

The use of whole fruit is also relevant from a nutrition perspective. Whole fibrous fruit requires oral processing, whereas fruit juice largely removes the mechanical component and may deliver free sugars and acids more rapidly to tooth surfaces. A school recommendation should therefore favor appropriate portions of whole fruit without added sugar rather than sweetened juice or fruit-flavored beverages. The oral-health benefit also depends on the overall dietary pattern, frequency of sugar exposure, fluoride use, and toothbrushing behavior. Integrating nutrition education with dental-health messages may prevent the misleading idea that a single food can neutralize an otherwise cariogenic diet. Such integration is consistent with the broader call to address common risk factors linking oral diseases with other noncommunicable conditions (Peres et al., 2019; World Health Organization, 2022).

School-based oral-health education provides a context in which dietary and oral-hygiene messages can be discussed (Das et al., 2025). The present study did not evaluate educational effectiveness, implementation feasibility, or sustained behavior change. Any educational use of fruit chewing would require separate evaluation and should not imply substitution for mechanical plaque control (Rubido et al., 2018). The message should emphasize complementary behavior: children should continue brushing twice daily with fluoride toothpaste, limit frequent exposure to free sugars, and obtain regular preventive dental care. This distinction is important because global and national reports identify oral diseases as persistent, largely preventable public-health problems requiring coordinated action beyond isolated food-based interventions (Kemenkes RI, 2024; WHO, 2025). Participant engagement was not measured in this study. The observed immediate debris response should not be used to claim educational or preventive effectiveness.

This study has several strengths. The fruit amount and chewing period were standardized, the same debris-index procedure was used before and after the intervention, and two active food interventions were directly compared. Participant-level change scores were analyzed, and the effect was reported with a confidence interval and standardized effect size. The study also focused on a practical outcome relevant to school dental-health programs. These features improve the clarity and usefulness of the findings despite the modest sample size.

Several limitations constrain interpretation. First, fruit assignment was completely confounded with grade, and the groups differed in mean age; the independent effect of fruit type could not be identified. Second, there was neither a no-chewing nor a neutral-chewing control, so changes cannot be separated from spontaneous salivary clearance, elapsed time, or mastication itself. Third, examiner blinding was not documented, and a numerical inter- or intra-examiner reliability coefficient was unavailable despite calibration training. Fourth, only an immediate response was assessed; durability, plaque accumulation, gingival outcomes, and caries incidence were not measured. Fifth, saliva, fruit hardness, moisture, and actual chewing cycles were not objectively recorded. Sixth, the small sample from one school limits generalizability. Finally, recent food intake, toothbrushing, and other oral-hygiene behaviors were not fully controlled. Future studies could use randomized or counterbalanced crossover allocation, appropriate control conditions, blinded assessment, documented reliability, and standardized pre-assessment procedures.

Conclusion

Under the conditions of this nonrandomized study, chewing 25 g of red guava was associated with a greater immediate reduction in debris index than chewing 25 g of watermelon albedo among two non-equivalent groups of elementary school students. Fruit assignment was completely confounded with grade, so the observed difference cannot establish an independent fruit effect. Fibrous fruit may be considered as a potential adjunct after meals, but it should not replace twice-daily toothbrushing with fluoride toothpaste or professional preventive care.

The present findings do not establish sustained benefits or educational effectiveness. Further randomized or crossover studies with appropriate controls, blinded assessment, and objective measurements are required.

Conflict of Interest

The authors declare that they have no conflicts of interest related to this study.

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