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The Effect of Red Dragon Fruit Juice on Blood Glucose Levels and Salivary pH in Type 2 Diabetes Mellitus Patients: A Quasi-Experimental Study

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Abstract

Type 2 diabetes mellitus (T2DM) is characterized by chronic hyperglycemia, leading to microvascular complications including xerostomia and altered salivary pH, which increase caries risk. While pharmacological management remains primary, side effects drive interest in complementary alternatives. Red dragon fruit (Hylocereus polyrhizus), rich in flavonoids and antioxidants, presents a potential adjunct therapy. This study evaluated the effect of red dragon fruit juice on random blood glucose levels and salivary pH in T2DM patients at a primary health center in Banjar, South Kalimantan. A quasi-experimental pre-test post-test control group design involved 30 participants (15 intervention, 15 control). Intervention group received 150 mL red dragon fruit juice daily for 7 days. Blood glucose and salivary pH were measured pre- and post-intervention. Wilcoxon signed-rank and Mann-Whitney tests were used for analysis. Intervention group showed significant reductions in blood glucose (p=0.003) and increases in salivary pH (p=0.000). Control group changes were non-significant (p=0.520, p=0.317). Red dragon fruit juice significantly lowered blood glucose and normalized salivary pH in T2DM patients. The effect is attributed to flavonoid-mediated improved insulin sensitivity and antioxidant reduction of oxidative stress on pancreatic beta-cells. This intervention offers a low-cost, accessible non-pharmacological strategy for T2DM self-management.

Background

Diabetes mellitus is not a single disease but a cluster of metabolic disorders whose common denominator is chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both (American Diabetes Association, 2024). Type 2 diabetes (T2DM) accounts for 90–95% of all cases globally. The International Diabetes Federation (IDF, 2021) estimated that 537 million adults (20–79 years) were living with diabetes in 2021, a number projected to rise to 783 million by 2045. In Indonesia, the prevalence increased from 6.9% in 2013 to 10.9% in 2018 according to Basic Health Research data, with South Kalimantan showing above-average rates of oral health problems (Pratiwi et al., 2022).

Systemic complications of T2DM—cardiovascular disease, nephropathy, retinopathy, and neuropathy—are well-documented (Handari et al., 2023). Less emphasized, however, is the oral cavity as a primary site of diabetes-related pathology. Hyperglycemia induces non-enzymatic glycation of proteins, leading to advanced glycation end-products (AGEs) that impair collagen turnover and delay wound healing in periodontal tissues (Ludiana et al., 2022). More relevant to the current study, chronic hyperglycemia alters salivary composition and flow rate. Xerostomia (subjective dry mouth) and hyposalivation (objective reduction in saliva) are common but underdiagnosed complications. Saliva's buffering capacity, primarily via bicarbonate and phosphate systems, maintains oral pH near neutral (6.8–7.2). Persistent hyperglycemia reduces salivary flow, decreases pH, and promotes an acidic environment conducive to Streptococcus mutans and Lactobacillus proliferation, thereby increasing dental caries and enamel demineralization risk (Chumroenvidhayakul et al., 2023).

Standard T2DM management includes metformin or sulfonylureas (e.g., glibenclamide). While effective, these agents carry side effects: gastrointestinal disturbances (nausea, diarrhea, abdominal distension), weight gain, and in some cases, hypoglycemia (Pratiwi et al., 2022). This pharmacological burden drives patient interest in complementary non-pharmacological approaches, particularly traditional fruits with purported antihyperglycemic properties. Red dragon fruit (Hylocereus polyrhizus), indigenous to Central and South America but widely cultivated in Indonesia, has attracted attention. Unlike white-fleshed dragon fruit (H. undatus), the red variety contains betacyanins (a red-violet pigment), flavonoids, phenolic compounds, vitamin C, and dietary fiber (pectin). Mechanistically, flavonoids increase peripheral glucose uptake by enhancing insulin signaling and upregulating GLUT-4 translocation. Additionally, betacyanins and vitamin C reduce reactive oxygen species (ROS), protecting pancreatic beta-cells from oxidative stress-induced apoptosis (Nur et al., 2023).

Previous studies, though limited, support the hypoglycemic effect of dragon fruit. Lanongbuka et al. (2022) reported significant fasting blood glucose reduction in T2DM patients after 14 days of red dragon fruit juice. Auliah (2024) similarly found dose-dependent reductions in blood glucose. However, critical gaps remain. First, most studies measured only blood glucose, ignoring oral health parameters directly relevant to diabetic patients. Second, salivary pH—a modifiable risk factor for caries—has been examined in diabetes but rarely as an outcome of fruit-based interventions. Third, existing studies often lacked control groups or used pre-experimental designs, limiting causal inference. Fourth, the population of Banjar Regency, South Kalimantan—a region with high periodontal disease prevalence—has not been systematically studied.

Therefore, this study aimed to determine the effect of red dragon fruit juice on two outcomes simultaneously: random blood glucose levels and salivary pH in T2DM patients. The central hypothesis was that daily consumption of red dragon fruit juice over 7 days would lower blood glucose and raise salivary pH compared to a control group receiving standard care only.

Methods

A quasi-experimental study with a non-equivalent control group pre-test/post-test design was conducted in Mei 2026. The study took place at West Martapura Primary Health Center (Puskesmas), Banjar Regency, South Kalimantan. This facility was selected because it houses the Prolanis (chronic disease management program) for T2DM patients, ensuring a stable population of eligible participants. This study received ethical approval from the Health Research Ethics Committee of Poltekkes Kemenkes Banjarmasin, under Ethical Clearance Certificate Number: 046/KEPK-PKB/2026. All research procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki, including obtaining informed consent, ensuring data confidentiality, and providing appropriate protection for elderly participants with Diabetes Mellitus

Participants were recruited using accidental sampling from the Prolanis registry. Inclusion criteria: (1) confirmed T2DM diagnosis by physician for ≥1 year; (2) age 38–65 years; (3) random blood glucose at screening between 160–250 mg/dL; (4) not currently using insulin therapy; (5) willing to provide written informed consent. Exclusion criteria: (1) known allergy to dragon fruit; (2) severe diabetic complications (e.g., diabetic foot ulcer, end-stage renal disease); (3) pregnancy or lactation; (4) acute infection or fever during study period; (5) use of oral corticosteroids or other drugs affecting glucose metabolism. A total of 30 participants were assigned non-randomly to either intervention group (n=15) or control group (n=15). Group assignment was based on participant availability and willingness to attend daily juice provision sessions.

Intervention group: Received 150 mL of pure red dragon fruit juice daily for 7 consecutive days. Juice was prepared fresh each morning at the health center’s nutrition unit. Red dragon fruits (Hylocereus polyrhizus) were obtained from a single local supplier to ensure consistency. Fruits were washed, peeled, blended without added sugar or water, and strained. Participants consumed the juice under researcher observation breakfast. No other dietary or medication changes were instructed (patients continued their usual oral antidiabetic drugs). Control group: Received standard care from the Puskesmas, consisting of monthly blood glucose monitoring and medication dispensation. No placebo juice was given.

Data were analyzed using SPSS version 26. Normality was assessed using Shapiro-Wilk test ($p<0.05$ indicating non-normal distribution). Within-group pre-post differences were analyzed using Wilcoxon signed-rank test (non-parametric paired data). Between-group differences in change scores (post-pre) were analyzed using Mann-Whitney U test. Significance was set at $\alpha=0.05$ (two-tailed). The study complied with the Declaration of Helsinki. All participants signed informed consent forms after receiving detailed study information. No financial compensation was provided, but participants received their routine health check-ups free of charge.

Result and Discussion

1. Blood Glucose Level

Table 1 present blood glucose changes. In intervention group, median blood glucose decreased from 215 mg/dL to 162 mg/dL post-intervention. This 53 mg/dL median reduction was statistically significant ($p = 0.003$). In contrast, control group showed minimal change: 208 mg/dL to 201 mg/dL ($p = 0.520$). Between-group comparison of change scores (post-pre difference) revealed a significantly greater reduction in intervention group (median $\Delta = -52$ mg/dL) compared to control group (median $\Delta = -6$ mg/dL; Mann-Whitney $p = 0.001$).

Table 1. Comparison of Blood Glucose Levels Pre and Post Intervention

Group	Pre (mg/dL), median	Post (mg/dL), median	Δ median	Z	p-value*
Intervention (n=15)	215	162	-53	-2.959	0.003
Control (n=15)	208	201	-6	-0.645	0.520

*Wilcoxon signed-rank test within groups

This study demonstrated that 150 mL of red dragon fruit juice consumed daily for one weeks significantly lowered random blood glucose in T2DM patients by a median of 53 mg/dL—a clinically meaningful reduction. For context, a reduction of ≥30 mg/dL in random glucose is associated with lower risk of microvascular complications in observational studies (Liang et al., 2024). The magnitude of effect is comparable to low-dose metformin (500 mg/day) in newly diagnosed patients, though the mechanism differs. Flavonoids, specifically quercetin and kaempferol present in H. polyrhizus, activate AMP-activated protein kinase (AMPK) in peripheral tissues (muscle, liver, adipose). AMPK phosphorylation enhances GLUT-4 translocation to the cell membrane, increasing glucose uptake independent of insulin signaling (Nur et al., 2023). This explains why the intervention reduced glucose even though participants continued their oral medications—the effect is additive, not substitutive.

Additionally, the antioxidant content (betacyanins, vitamin C at ~75.4 mg/100g fruit) reduces oxidative stress in pancreatic beta-cells. Chronic hyperglycemia generates ROS via the polyol pathway and mitochondrial electron transport chain. ROS activate stresssensitive signaling pathways (NF-κB, JNK, p38 MAPK) that impair insulin gene expression and promote beta-cell apoptosis (Lin et al., 2023). By scavenging ROS, dragon fruit preserves residual beta-cell function. The 7-day timeframe is sufficient to observe these cellular effects, as shown in animal models where H. undatus extract reduced streptozotocin-induced hyperglycemia within 7–10 days (Chumroenvidhayakul et al., 2023). The non-significant change in control group rules out regression to the mean or natural disease fluctuation as explanations. If spontaneous improvement had occurred, controls would also show reductions. Their stability (only -6 mg/dL) confirms that observed changes in intervention group are attributable to the juice.

Our blood glucose findings align with (Lanongbuka et al., 2022) who reported a 49 mg/dL reduction after similar protocol in Manado, Indonesia. However, that study used a pre-experimental one-group design lacking a control, limiting causal inference. Our controlled design strengthens evidence. Auliah found dose-response: 100 mL, 150 mL, and 200 mL produced 31, 47, and 58 mg/dL reductions respectively (Auliah, 2024). The current study's 53 mg/dL reduction matches the 150 mL dose effect, suggesting no additional benefit beyond this volume. Discrepancies exist. Priyanti reported smaller reductions (32 mg/dL) in elderly patients (mean age 68 years). Older age correlates with longer disease duration and more compromised beta-cell reserve, potentially reducing responsiveness to flavonoid-based interventions. Our participants' mean age (56.7 years) is younger, possibly explaining stronger effect (Priyanti et al., 2022).

The reduction in blood glucose levels among elderly patients with Diabetes Mellitus following the administration of red dragon fruit (Hylocereus polyrhizus) juice also corelated to its bioactive compounds, particularly flavonoids, antioxidants, and soluble dietary fiber. Flavonoids are known to inhibit α-glucosidase and α-amylase enzymes, thereby slowing intestinal glucose absorption and reducing postprandial blood glucose levels. In addition, antioxidants such as betacyanins and vitamin C may help alleviate oxidative stress, which is closely associated with insulin resistance. The soluble fiber content of red dragon fruit can also delay gastric emptying and slow the release of glucose into the bloodstream. Nevertheless, several factors may have influenced the observed outcomes, including fasting duration, the use of antidiabetic medications, physical activity levels, and adherence to dietary recommendations (Lestari, L.A., et al., 2023).

2. Salivary pH

Table 2 present Salivary pH increased significantly only in the intervention group. Median pH rose from 6.2 to 6.8, representing a +0.6 unit increase (p = 0.000). Control group pH remained essentially unchanged: 6.3 to 6.4 (p = 0.317).

Between-group differences were highly significant. Intervention group median ΔpH was +0.6 versus control ΔpH of +0.1 (Mann-Whitney p = 0.000).

Table 2. Comparison of salivary pH Pre and Post Intervention

Group	Pre-pH, median	Post-pH, median	Δ median	Z	p-value*
Intervention (n=15)	6.2	6.8	+0.6	-3.519	0.000
Control (n=15)	6.3	6.4	+0.1	-1.003	0.317

*Wilcoxon signed-rank test within groups

The increase in salivary pH from 6.2 (acidic) to 6.8 (near-neutral) is arguably as important as glycemic improvement. A pH of 5.5 is the critical threshold for enamel demineralization; pH below 5.5 promotes net calcium and phosphate loss from teeth (Susanti et al., 2022).

Diabetic patients with poor glycemic control often have salivary pH between 5.5–6.2 due to: (1) reduced flow rate (xerostomia) concentrating hydrogen ions; (2) altered buffer capacity; (3) increased glucose in saliva serving as substrate for acidogenic bacteria.

Two mechanisms explain pH improvement. First, reduced blood glucose directly reduces salivary glucose concentration. Salivary glucose in diabetics can reach 0.5–1.0 mg/dL compared to <0.1 mg/dL in non-diabetics. When salivary glucose decreases, fermentation by S. mutans produces less lactic acid, preventing pH drop (Urianti et al., 2025). Second, dragon fruit contains soluble fiber (pectin) that stimulates saliva secretion through mastication and taste stimulation. Increased flow rate dilutes hydrogen ions and replenishes bicarbonate buffers.

The clinical implication is substantial. Chronic acidic oral environment in diabetics accelerates root caries, especially in older adults with gingival recession. By raising pH above 6.5, the intervention shifts the oral environment from cariogenic to non-cariogenic. Patients with pH ≥6.5 have 60% lower caries incidence over 12 months compared to those with pH <6.0 (Cahyani et al., 2021). For salivary pH, no prior dragon fruit study has examined this outcome, making direct comparison impossible. However, studies of other polyphenol-rich foods (green tea, cranberry) show similar pH-neutralizing effects. Susanti reported that 14 days of green tea extract raised salivary pH from 6.0 to 6.7 in T2DM patients, attributing it to tannins and catechins. Our results extend this class effect to dragon fruit (Susanti et al., 2022).

The increase in salivary pH following the consumption of red dragon fruit juice may be explained by enhanced salivary secretion and changes in salivary buffering capacity. The high water content and the presence of minerals such as magnesium and potassium, along with vitamin C, may stimulate the salivary glands and promote salivary flow. An increased salivary flow rate is associated with a higher concentration of bicarbonate ions (HCO_3^-), which serve as the primary buffering system in saliva, thereby elevating salivary pH toward a more alkaline state. This effect is particularly relevant for elderly individuals with Diabetes Mellitus, who are often predisposed to xerostomia and reduced salivary pH as a consequence of chronic hyperglycemia. Furthermore, the improvement in salivary pH may contribute to the maintenance of oral health by reducing the risk of dental caries, enamel demineralization, and oral infections (Sinha, S., & Sharma, R, 2022).

The simultaneous improvement in blood glucose and salivary pH is not coincidental but mechanistically linked. Hyperglycemia induces polyuria and dehydration, reducing whole-body fluid volume including saliva (xerostomia). Lower salivary flow concentrates glucose and hydrogen ions. When blood glucose drops, osmotic diuresis decreases, hydration improves, salivary flow normalizes, and pH rises. Thus, the intervention addresses the root cause (hyperglycemia) rather than merely palliating oral symptoms. This dual benefit makes dragon fruit particularly attractive for diabetic patients with xerostomia or recurrent caries.

Conclusion

Fourteen-day consumption of 150 mL red dragon fruit juice significantly lowered random blood glucose and increased salivary pH in T2DM patients compared to standard care alone. The magnitude of glucose reduction (53 mg/dL median) is clinically relevant, while the pH increase (0.6 units) shifts the oral environment from cariogenic to neutral. These effects are attributed to flavonoid-mediated AMPK activation, reduction of oxidative stress, and improved hydration/salivary flow. Dragon fruit juice represents a low-cost, accessible, non-pharmacological adjunct for T2DM self-management, particularly in resource-limited settings like Banjarbaru where fresh fruit is available year-round.

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