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Quantitative Research Article

Comparative Analysis of Blood Glucose Levels Based on Variations in Blood Sample Types Among Patients with Diabetes Mellitus

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Abstract

Background/ problem: Excess carbohydrate intake in the body is stored as glycogen and, over time, can be converted into triglycerides. This condition contributes to increased blood glucose levels, which may lead to hyperglycemia and eventually develop into Diabetes Mellitus (DM)

Objective/ purpose: This study aimed to analyze the comparative results of blood glucose measurements using whole blood, EDTA plasma (Ethylenediaminetetraacetic Acid), and serum samples in patients with DM at BLUD Kendari Hospital

Design and Methodology: This research employed an analytical observational design with a cross-sectional approach. The study population consisted of 150 hospitalized DM patients, with a sample size of 59 respondents selected using simple random sampling.

Results: The results showed significant differences in blood glucose levels between EDTA plasma and serum samples (p=0.000), as well as between EDTA plasma and whole blood samples (p=0.000). In addition, a significant difference was also found between serum and whole blood samples (p=0.001). However, based on the ANOVA test, no statistically significant difference was observed among the three sample types overall (p=0.731).

Conclusion and Implications: All three sample types can generally be used for blood glucose measurement. Healthcare facilities consider the use of different types of blood samples and ensure the availability of appropriate laboratory instruments to improve the accuracy and quality of blood glucose testing

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Introduction

Glucose is the primary source of energy for the human body, derived from carbohydrate metabolism and stored as glycogen in the liver and muscles. Blood glucose levels are influenced by endogenous factors such as insulin, glucagon, and cortisol hormones, as well as exogenous factors including dietary patterns and physical activity(Antar et al., 2023). Carbohydrates play a major role as the main energy source; however, excessive carbohydrate intake is stored as glycogen and, over time, converted into triglycerides (TG), which can affect both blood glucose and triglyceride levels. Elevated blood glucose levels can lead to hyperglycemia, which is a hallmark of Diabetes Mellitus(Wang, 2025).

Diabetes Mellitus is a metabolic disorder characterized by hyperglycemia due to impaired insulin secretion, insulin action, or both. It is often referred to as a "silent killer" because many individuals remain undiagnosed until serious complications arise, with genetic factors being one of the key contributors. Blood glucose testing is the primary method for early detection of DM to prevent chronic complications. Normal fasting blood glucose levels range from 75–115 mg/dL, while postprandial levels are considered normal if below 140 mg/dL, with intermediate values indicating borderline conditions or impaired glucose tolerance.(Liarakos et al., 2025)

The diagnosis of DM is established based on blood glucose examination rather than glucosuria. Enzymatic methods using venous plasma or serum samples are recommended, although capillary blood can also be utilized with appropriate standardization(Fiedorova et al., 2022). For monitoring purposes, glucometers are commonly used in clinical practice. Blood samples used for testing include whole blood, serum, and plasma, each having different stability characteristics. The use of different sample types may influence test results due to factors such as anticoagulants and storage conditions, potentially leading to variations in measured glucose levels (Muliana, Irmayanti Haidir Bima, Eny Arlini Wello, Irna Diyana Kartika, 2024).

Based on these considerations, this study aims to compare blood glucose measurement results using whole blood, EDTA plasma, and serum samples in patients with Diabetes Mellitus. This research is expected to contribute to improving diagnostic accuracy and serve as a reference for laboratory personnel as well as for the advancement of clinical chemistry in enhancing public health outcomes.

Methods

This study employed an analytical observational design with a laboratory-based cross-sectional approach to determine differences in blood glucose levels among whole blood, EDTA plasma, and serum samples measured simultaneously. The study population consisted of all patients with Diabetes Mellitus admitted to BLUD Kendari Hospital, totaling 150 individuals. A sample of 59 participants was selected using simple random sampling to ensure statistical significance.

This study utilized blood specimens in the form of EDTA plasma, serum, and whole blood for glucose measurement. The instruments used included test tubes, EDTA tubes, lancets, micropipettes with tips, a Point of Care Testing (POCT) device, a photometer, and a centrifuge. The materials consisted of 70% alcohol for sterilization, glucose reagents, and the three types of blood samples. EDTA plasma and serum samples were obtained from venous blood and processed by centrifugation, whereas whole blood samples were obtained from venous or capillary blood and analyzed directly using a POCT device.

Glucose levels in EDTA plasma and serum samples were measured using an enzymatic method with a photometer, beginning with the mixing of reagents, samples, and standards, followed by incubation at 37°C for 10 minutes prior to measurement. In contrast, whole blood samples were analyzed directly using a glucometer by applying blood onto a test strip. All procedures were conducted in accordance with standard operating procedures to ensure accuracy.

The collected data were processed through editing, coding, and tabulation before analysis. Data analysis was performed descriptively to present respondent characteristics based on age and sex, and inferentially using the Kolmogorov–Smirnov test for normality. Hypothesis testing was conducted using paired sample t-tests and ANOVA with statistical software.

Ethical principles were strictly observed, including obtaining informed consent, ensuring participant anonymity, and maintaining data confidentiality. All research procedures were conducted following approval from the relevant authorities.

Results

This study involved 60 patients with Diabetes Mellitus. Based on sex distribution, the majority of respondents were female (36 individuals; 60%), while males accounted for 24 individuals (40%). This finding indicates that females were more represented as study subjects than males. Regarding age distribution, most respondents were in the older age group, particularly those aged 61–70 years (28 individuals; 46.67%), followed by the 51–60 age group (14 individuals; 23.33%). The youngest age group (31–40 years) comprised only 2 individuals (3.33%). This distribution suggests that Diabetes Mellitus is more prevalent among older individuals. The results of blood glucose measurements showed variations in mean values depending on the type of sample used. EDTA plasma samples had the highest mean glucose level (327 mg/dL), followed by serum (321 mg/dL) and whole blood (310 mg/dL). These differences indicate that the type of sample may influence the measurement of blood glucose levels.

Tabel 1 . Respondent characteristics

Variable	n	%	Mean Glucose (mg/dL)
Sex			
Male	24	40	
Female	36	60	
Ages (years)			
< 40	2	3,33	
40–50	6	10	
51–60	14	23,33	
61–70	28	46,67	
> 70	10	16,67	
Variation of Sample			
Whole Blood	60	100	310
Plasma EDTA	60	100	327
Serum	60	100	321

Normality testing using the Kolmogorov–Smirnov test demonstrated that all data were normally distributed ($p > 0.05$), allowing for the use of parametric tests. The paired sample t-test analysis revealed statistically significant differences in blood glucose levels across all sample type comparisons. The comparison between EDTA plasma and serum showed a significant difference ($t(59)=9.302$; $p<0.001$) with a mean difference of 6.13 mg/dL (95% CI: 4.81–7.45). Similarly, EDTA plasma compared to whole blood demonstrated a larger mean difference of 16.68 mg/dL (95% CI: 10.68–22.69; $p<0.001$), while serum versus whole blood also showed a significant difference (mean difference = 10.55 mg/dL; 95% CI: 4.65–16.45; $p=0.001$).

The effect sizes ranged from moderate to large, indicating that these differences are not only statistically significant but also practically meaningful, particularly between EDTA plasma and whole blood. These findings suggest the presence of systematic variation in glucose measurements across sample types, likely influenced by pre-analytical factors such as specimen composition and anticoagulant effects. However, the clinical relevance of these differences should be interpreted cautiously..

Tabel 2 comparation of sampel variation of Blood Glucose

Comparation	n	Mean ± SD (mg/dL)	Mean Difference (95% CI)	t (df)	p-value	Effect Size (Cohen's d)
Plasma EDTA vs Serum	60	326.82 ± 118.00 vs 320.68 ± 116.95	6.13 (4.81 – 7.45)	9.302 (59)	<0.001	1.20
Plasma EDTA vs Whole Blood	60	326.82 ± 118.00 vs 310.13 ± 114.97	16.68 (10.68 – 22.69)	5.563 (59)	<0.001	0.72
Serum vs Whole Blood	60	320.68 ± 116.95 vs 310.13 ± 114.97	10.55 (4.65 – 16.45)	3.580 (59)	0.001	0.46

The one-way ANOVA results indicated no statistically significant difference in blood glucose levels among EDTA plasma, serum, and whole blood samples ($F(2,177)=0.314$; $p=0.731$). This finding suggests that, at the group level, the variation in glucose measurements across the three sample types is not substantial enough to be considered significantly different.

Furthermore, the effect size was negligible ($\eta^2 = 0.0035$), indicating that the type of sample contributes minimally to the overall variability in glucose levels. This apparent discrepancy between significant paired comparisons and non-significant overall differences may be attributed to high within-group variability and relatively small between-group differences. Overall, these results imply that the three sample types can be used interchangeably in clinical practice, provided that pre-analytical procedures are properly controlled.

Table 3. Analysis of Blood Glucose Levels Across Sample Types

Source of Variation	Sum of Squares	df	Mean Square	F-value	p-value
Between Groups	8,545.08	2	4,272.54	0.314	0.731
Within Groups	2,408,278.90	177	5.563 (59)	13,606.10	-
Total	2,416,823.98	179	3.580 (59)	-	-

Discussion

Blood glucose measurement is a key parameter in the diagnosis and monitoring of Diabetes Mellitus (DM). Therefore, the accuracy of test results is crucial in clinical practice. The findings of this study demonstrate variations in blood glucose levels based on the type of sample used, namely whole blood, EDTA plasma, and serum. These results reinforce the importance of pre-analytical factors, particularly specimen type, in influencing the validity of laboratory test outcomes.

The characteristics of respondents in this study showed a predominance of female patients and older age groups, particularly those aged 61–70 years. Epidemiologically, the increased prevalence of DM among older individuals is associated with reduced insulin sensitivity, alterations in glucose metabolism, and increased insulin resistance due to the aging process(Abel et al., 2024). In addition, lifestyle factors and dietary patterns, such as high intake of simple sugars and low levels of physical activity, also contribute to the risk of DM. These findings are consistent with previous literature identifying age and behavior as major determinants of DM incidence(Fitria et al., 2025).

The higher mean glucose levels observed in EDTA plasma compared to serum and whole blood indicate that sample composition influences measurement outcomes. EDTA plasma contains anticoagulants that prevent clotting, thereby preserving the liquid component of blood and potentially improving analyte stability(Bowen & Dasgupta, 2025). However, the presence of additives such as EDTA may also interfere with enzymatic reactions, resulting in variations in measured glucose levels compared to serum or whole blood(Evriarti et al., 2024).

Inferential analysis revealed significant differences between each pair of sample types using the paired sample t-test, indicating systematic variations in measurements across specimen types. However, the ANOVA results showed no statistically significant difference overall among the three sample types. This suggests that although pairwise differences exist, they are not substantial enough to produce clinically meaningful differences in overall interpretation.

One important factor affecting glucose measurement is glycolysis occurring after sample collection. Blood cells, particularly erythrocytes and leukocytes, continue metabolic activity that consumes glucose if samples are not processed promptly (Grzych et al., 2025). Glucose levels may decrease by approximately 5–7% per hour at room temperature, and delays in analysis can lead to underestimation of true values(Sacks et al., 2023). This phenomenon helps explain variations observed among serum, plasma, and whole blood, each having different stability characteristics (Thachil et al., 2024).

In addition to pre-analytical factors, physiological mechanisms also contribute to variations in blood glucose levels. Glucose regulation is controlled by hormones such as insulin and glucagon, and disruptions

in this system, particularly insulin resistance, lead to elevated glucose levels(Galicia-garcia et al., 2020). In patients with DM, this imbalance results in glucose accumulation in the bloodstream, which is detected through laboratory testing. Therefore, interpretation of results should always consider the patient's clinical condition(Weronika et al., 2025).

These findings are consistent with previous studies reporting differences in glucose levels based on sample type and timing of analysis. Such differences become more pronounced when there are delays in processing or variations in sample handling. Therefore, standardization of laboratory procedures including sample selection, timing of analysis, and analytical methods is essential to ensure accuracy and reliability. Practically, this study highlights the need for greater attention to pre-analytical factors in glucose testing to support appropriate clinical decision-making.

Conclusion

This study demonstrates that variations exist in blood glucose measurement results depending on the type of sample used, namely whole blood, EDTA plasma, and serum, among patients with Diabetes Mellitus. Descriptively, the highest mean glucose levels were observed in EDTA plasma samples, followed by serum, and the lowest in whole blood. These findings indicate that the characteristics of each specimen may influence blood glucose measurement outcomes.

It can be concluded that although differences in glucose levels are observed among the different sample types, whole blood, EDTA plasma, and serum can all be used for blood glucose testing when standard operating procedures and pre-analytical factors are carefully considered. Therefore, appropriate selection of sample type and proper handling of the analytical process are essential to ensure the accuracy and reliability of laboratory results.

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