Open Access

Frontiers in Sustainable Science and Technology
E-ISSN: 3064-4720
DOI: https://doi.org/10.69930/fsst.v2i1.236
Research Article

ScienceTech. Group

Vol. 2 (1), 2025
Page: 21-31

Differences in Serum Blood Sugar Levels that were Directly Checked and Delayed for 1 Hour at Room Temperature using a Gel Separator Vacuum Tube

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Abstract. *Blood sugar testing is essential for diabetes management and should be fast, accurate, and affordable. This study aims to determine the difference in blood sugar levels between immediate and delayed (1-hour) serum examinations using vacuum gel separator tubes at Prof. Dr. H. M. Anwar Makkatutu Bantaeng Hospital. An observational laboratory research with a comparative quantitative design was conducted on 23 purposively selected patients undergoing routine check-ups, without a history of diabetes mellitus. Blood samples were analyzed immediately and after a 1-hour delay at room temperature. Results showed that in immediate examinations, blood sugar levels ranged from 79 to 161 mg/dL, with a mean of 109.26 mg/dL. In delayed examinations, levels ranged from 81 to 164 mg/dL, with a mean of 111.74 mg/dL. Statistical analysis revealed a significant difference between the two groups ($P < 0.05$). The findings suggest that delaying blood sugar testing by 1 hour can lead to measurable changes in serum glucose levels, emphasizing the importance of timely sample processing in clinical settings.*

Keywords: *Blood sugar levels, direct examination, postponed for 1 hour, serum glucose levels, statistical analysis*

1. Introduction

Blood sugar level examination is one of the most common examinations performed in clinical laboratories, especially for patients with diabetes mellitus. Diabetes is a chronic condition that requires regular monitoring of blood sugar levels to determine the appropriate treatment strategy. Fast, accurate, and inexpensive examinations are a top priority because they not only provide comfort for patients but also help doctors make accurate diagnoses and determine effective treatments. However, operational challenges are often faced by laboratories, especially when the number of patients examined is very large, which can cause delays in examinations (Fitriyani & Wibowo, 2022).

The blood sugar level examination procedure involves taking a blood sample which is then analyzed in the laboratory. The sample taken can be whole blood, serum, or plasma. Serum, which is a blood fluid without cells and fibrinogen, is often used in this examination because it has a higher sugar content than whole blood. This is due to the higher water content in serum, which allows for a higher concentration of glucose to be dissolved (Ramadhani et al., 2019). The selection of this type of sample is important to ensure the accuracy of the examination results.

Received: 26 November 2024 / Accepted: 12 April 2025 / Available online: 6 May 2025

Under normal circumstances, a person's blood sugar level ranges from 70-110 mg/dl. Meanwhile, the normal value of blood sugar in serum and plasma is 75-115 mg/dl, 2-hour postprandial blood sugar level ≤140 mg/dl, and random blood sugar level ≤140 mg/dl (Immigration, 2011). These parameters are important guidelines in determining whether a person is experiencing hyperglycemia, hypoglycemia, or normal conditions. Deviations from these values require prompt medical attention, so the speed of laboratory examination is very important. Delays in blood sugar testing of up to one hour are common in clinical laboratories. These delays can be caused by various factors, such as technical problems, overflowing patient numbers, or administrative errors. This situation not only impacts laboratory efficiency but can also cause anxiety for patients who need immediate results. Patients who have health conditions that depend on blood sugar information often feel anxious if test results are delayed, especially if the results are important for medical decision-making in a short time (Kutlu, 2023).

One method that is often used to measure blood sugar levels is enzymatic-based spectrophotometry. This method involves a series of chemical reactions in which blood sugar is converted into products that produce color changes. The intensity of the resulting color is then measured to determine blood sugar levels. This colorimetric method is very reliable because it is designed for high specificity to glucose, so the results given are more accurate (Rahmatunisa et al., 2021**).** Glucose stability in serum is influenced by the glycolysis process, where glucose is enzymatically degraded into pyruvate or lactate through the activity of enzymes such as hexokinase, phosphofructokinase, and glucose-6-phosphate dehydrogenase. This glycolysis process can continue in the blood sample after collection if the sample is not processed immediately or stored at low temperatures. The rate of glycolysis increases at room temperature, leading to potential decreases in glucose concentration over time.

However, another factor that also affects the results of the examination is how the blood sample is stored before being analyzed. Delaying the examination without proper preservation methods can cause glycolysis, where glucose in the blood is broken down by enzyme activity. Therefore, storage at low temperatures is recommended to slow down the glycolysis process. Laboratories that have adequate storage facilities, especially in large hospitals, can maintain the accuracy of the examination results (Butt, et al., 2016).

The use of vacuum gel separator tubes is also a solution to maintain the integrity of blood samples. These tubes are designed to efficiently separate serum from other blood components, so that blood sugar levels are more stable even though there is a time lag before analysis is performed. However, although this technology is helpful, challenges remain if the delay lasts more than an hour at room temperature. Therefore, further research is needed to understand the extent to which changes in blood sugar levels can occur due to the delay in examination time.

Research on the effect of time delay on blood sugar levels provides an important contribution to clinical laboratory practice. This research not only helps laboratories evaluate the reliability of their test methods but also provides guidance on how best to handle samples under less than ideal conditions**.** In addition, this study has practical implications for public health, particularly in the context of diagnosing diabetes or managing pre-diabetic patients, where even small changes in blood sugar levels due to delays in testing may affect clinical decisions, including the determination of treatment protocols or insulin dosage.

This is especially relevant for small laboratories that may face limited facilities. Delays in testing also have the potential to bias results if samples are not processed promptly. In the clinical setting, this can impact medical decision-making, especially in patients with diabetes who are at high risk of complications if their blood sugar levels are not well managed. Therefore, laboratories should consider methods that can minimize changes in blood sugar levels during storage.

This study was conducted to evaluate the difference in blood sugar levels in serum that was immediately examined compared to serum that was delayed for one hour at room temperature. By using a gel separator vacuum tube, this study is expected to provide insight into the effect of time and storage conditions on the accuracy of laboratory results. This study was conducted at Prof. Dr. HM Anwar Makkatutu Bantaeng Regional Hospital, a health facility that serves many patients with blood sugar examination needs. The main objective of this study is to provide empirical data that can be the basis for developing standard operating procedures (SOPs) in clinical laboratories. This data is important to ensure that the blood sugar examination results given to doctors are in accordance with the patient's clinical condition. Thus, this study has high practical relevance in improving the quality of health services. In a broader context, the findings of this study can support efforts to improve the efficiency and quality of laboratory examinations, and contribute to public health management, particularly in controlling diabetes cases in the community.

2. Methods

This study used an observational laboratory research design with a comparative analytical quantitative approach. This design aims to directly observe changes in blood sugar levels in serum after being delayed for one hour at room temperature. The study was conducted for two months, namely from August to September 2024, at Prof. Dr. HM Anwar Makkatutu Regional Hospital, Bantaeng Regency. The research sample was selected using a non-probability sampling method with a purposive sampling approach, namely a sampling technique based on certain criteria, so that 23 samples were selected that were suitable for analysis. However, the sample size of this study is relatively small, and this becomes one of the study's limitations. In addition, demographic data such as age, gender, and possible comorbidities of the participants were also identified because these factors may influence blood sugar levels. The demographic characteristics of the participants in this study consisted of 6 males (26.1%) and 17 females (73.9%), with an age range of 21-65 years old. No participants had a history of diabetes mellitus or other metabolic disorders, as these were exclusion criteria.

The research procedure began with the preparation of the necessary tools and materials. Some of the main tools used include a 3 cc syringe, 70% alcohol cotton, a gel separator vacuum tube, a handscoon, and a tourniquet. These tools are guaranteed to be sterile and ready to use for blood sampling. In addition, the main instrument for analysis, namely the Cobas C 111 automatic analyzer, was also calibrated and checked to ensure the accuracy of the results produced during the study. The Cobas C 111 analyzer is designed for reliable and accurate measurement of blood glucose levels. Regular calibration of the device was performed before and during the study to ensure measurement consistency. However, the device has limitations in pre-analytical factors, such as potential variability caused by

delayed sample processing or improper storage conditions, which can influence the measurement results.

Sampling is done carefully in the vein. This process begins by cleaning the vein area using cotton soaked in 70% alcohol and ensuring the area is dry before injection. 1.5 cc of blood is taken using a 3 cc syringe, then placed in a gel separator vacuum tube for further processing. After the blood sample is taken, the tube is immediately processed to separate the serum by centrifugation. Blood samples in a vacuum gel separator tube were centrifuged for three minutes at 3000 rpm to separate serum from other blood components. The resulting serum was then pipetted at 1500 µl/ml and placed into two different cups. One cup was used for direct blood sugar level examination, while the other cup was stored for examination to be carried out after one hour.

Environmental conditions in the laboratory during storage were also considered. While this study focused on room temperature storage (approximately 25-27°C), it is acknowledged that environmental factors such as humidity and room temperature fluctuations can potentially influence glucose stability. Therefore, storage was conducted in a controlled laboratory environment to minimize external variability. The blood sugar level analysis process was carried out using an automatic Cobas C 111 brand tool, and the results obtained from the direct examination were recorded immediately. Serum samples for the postponed examination were carefully stored according to established procedures. After one hour, these samples were then analyzed using the same tool, namely Cobas C 111.

To distinguish the results of the examination between the immediate and postponed samples, the patient's name was given a marker in the form of an additional number behind their name. This marking is important to ensure that the tool can read and record the results according to the processed sample. After the examination is complete, the results that come out of the automatic tool are immediately recorded. This step is carried out carefully to ensure that the data obtained does not experience recording errors. This process involves two stages, namely direct examination after the sample is taken and examination after a one-hour delay.

The results of these two stages of examination become the main data that will be analyzed further to determine the differences that occur. Data analysis was performed by comparing the results of direct examination with the results of examination after a one-hour delay. To verify the robustness of the findings, statistical analysis was conducted using paired t-test if the data were normally distributed, or Wilcoxon signed-rank test if the data were not normally distributed.

The first step in data analysis is to determine whether the distribution of the difference in examination results follows a normal distribution or not. If the data has a normal distribution, then a parametric statistical test will be used to determine whether there is a significant difference between the two data. However, if the distribution is not normal, then a non-parametric statistical test will be applied for a more appropriate analysis. This analysis method aims to quantitatively identify whether there is a change in blood sugar levels due to a one-hour delay in room temperature conditions. The results of this analysis are expected to provide empirical data that is useful in evaluating the effect of sample storage time on the accuracy of blood sugar examination results. The data can later be used as a reference in developing standard operating procedures (SOPs) in clinical laboratories to improve the quality of laboratory services.

In addition, data collection is carried out by ensuring that all procedures run according to standard laboratory protocols. Officers who carry out sampling and analysis have been given special training to maintain the quality and consistency of the data obtained. All steps from blood collection, serum processing, to blood sugar testing on automatic devices are carried out under controlled conditions. This aims to minimize the risk of technical errors that can affect research results, such as sample contamination or changes in glucose levels due to inappropriate procedures. To ensure the reliability of the results, this study also considered environmental factors and equipment used during the analysis process. The laboratory room was maintained at a stable temperature according to clinical laboratory standards, and the Cobas C 111 device was calibrated periodically during the study. This step ensures that the device provides consistent and accurate results, both in direct examination and examination after a delay. In this way, the study can isolate the delay time variable as the main factor analyzed without being influenced by other external variables.

The results of the study will be presented in tables and graphs to facilitate interpretation. Comparison of blood sugar levels between direct and delayed samples will be analyzed statistically to determine whether there is a significant difference. With this approach, the study not only provides quantitative results but also provides a deeper explanation of the effect of delay time on the stability of blood sugar levels in serum. These data are expected to be the basis for laboratories in designing better procedures for handling blood samples to improve the accuracy and reliability of blood sugar examination results.

3. Results and Discussion

This study was conducted for 3 days starting from August 30 to September 1 with a total of 23 patients who were examined for blood sugar levels in patients who were examined directly and postponed for 1 hour at room temperature using venous blood samples taken from 23 patients in a gel separator vacuum tube. The participants in this study had an age range of 21-65 years, with no history of diabetes mellitus or other metabolic diseases, as these conditions were part of the exclusion criteria. This demographic detail provides additional information about the general characteristics of the study population, which may influence blood sugar level variations. Before looking at the blood sugar levels of patients, the results of the distribution of patient characteristics that were measured for blood sugar levels can be seen in the following Table 1.

Table 1. Characteristics of patients whose blood sugar levels are measured

K	N	%
Valid Male	6	26.1
Woman	17	73.9

Source: Primary Data 2024

The observed increase in mean blood sugar level of 2.48 mg/dL after a 1-hour delay indicates a minor effect of storage time. However, in clinical practice, especially for patients with borderline glucose levels or pre-diabetic conditions, this small difference could influence diagnosis or management decisions, particularly if the glucose level approaches

diagnostic thresholds such as random blood glucose ≥200 mg/dL.

Based on Table 1 above shows the distribution of patient characteristics. Based on gender, there were 6 male patients (26.1%) and 17 female respondents (73.9%).

Table 2. Descriptive analysis of blood sugar levels in serum that are examined immediately and delayed for 1 hour

Treatment	Amount Patient	Minimum (mg/dL)	Maximum (mg/dL)	Mean (average)
Inspection direct	23	79	161	109.26
Inspection postponed 1 hour	23	81	164	111.74

Source: Primary Data 2024

Based on Table 2, the results of the descriptive analysis above can be seen that the blood sugar levels in the direct examination treatment were 23 people with a minimum serum blood sugar level of 79 mg/dl, and a maximum level of 161 mg/dl, with an average of 109.26 mg/dl, while the examination treatment was delayed for 1 hour as much as 81 mg/dl, and a maximum level of 164 mg/dl with an average of 111.74 mg/dl.

The observed increase in mean blood sugar level of 2.48 mg/dL after a 1-hour delay indicates a minor effect of storage time. However, in clinical practice, especially for patients with borderline glucose levels or pre-diabetic conditions, this small difference could influence diagnosis or management decisions, particularly if the glucose level approaches diagnostic thresholds such as random blood glucose ≥200 mg/dL.

Table 3. Test results for blood sugar levels in serum of RSUD patients. Prof. DR. HM Anwar Makkatutu Bantaeng

Treatment	Low	Percentage (%)	Norma	Percentage (%)	Tall	Percentage(%)	P
Checked Direct	1	4.3	20	86.9	2	8.6	0.00
Examination postponed for 1 hour	0	0	21	91.3	2	8.6	

Source: Primary Data 2024

Environmental conditions such as room temperature (25-27°C) and humidity were considered stable during the examination process. Nevertheless, fluctuations in environmental factors or sub-optimal storage could potentially accelerate glycolysis and influence blood sugar stability. Therefore, laboratories should minimize external variability by controlling temperature and humidity to maintain sample integrity. While the results of the treatment of patients with blood sugar levels in serum were examined directly, there were 1 person with low blood sugar levels (4.3%) and 20 people with normal blood sugar levels (86.9%), and 2 people with high blood sugar levels (8.6%). In this study, a significant difference was found in the results of direct blood sugar examination and 1 hour delay with a

value ($p>0.05$). This is in line with the existing theory that when blood is delayed for 1 hour, there will be an increase in blood sugar results (Bowen and Remaley, 2014).

In the treatment of examination delayed 1 hour, 21 people had normal blood sugar levels (91.3) and 2 people had high blood sugar levels (8.6%). Based on the data in Table 1, this study shows the distribution of patient characteristics based on gender. Of the 23 samples studied, the majority of respondents were women, 17 people (73.9%), while 6 were men (26.1%). The dominance of female respondents may reflect the pattern of patient visits to the hospital, where women tend to be more active in conducting health checks, including blood sugar checks. In addition, the higher prevalence of diabetes in women in some populations is also an important factor underlying this distribution. Previous research by Wild et al. (2004) showed that women, especially after menopause, have a higher risk of developing diabetes due to hormonal changes that affect insulin sensitivity and glucose metabolism.

In Table 2, descriptive analysis shows that the blood sugar levels of the samples examined directly had a minimum value of 79 mg/dL, a maximum of 161 mg/dL, and an average of 109.26 mg/dL. Meanwhile, samples that were delayed for one hour had a minimum value of 81 mg/dL, a maximum of 164 mg/dL, and an average of 111.74 mg/dL. These data indicate an increase in the average blood sugar level of 2.48 mg/dL after a one-hour delay. This change, although small, indicates the effect of time on the stability of blood sugar levels in serum. This is in accordance with the metabolic mechanism in serum which tends to be more stable than whole blood because cellular components such as erythrocytes have been separated, so that glycolysis activity is reduced. However, although enzymatic activity is minimal, small changes in blood sugar levels are still possible during serum storage for a certain time.

Environmental conditions such as room temperature (25-27°C) and humidity were considered stable during the examination process. Nevertheless, fluctuations in environmental factors or sub-optimal storage could potentially accelerate glycolysis and influence blood sugar stability. Therefore, laboratories should minimize external variability by controlling temperature and humidity to maintain sample integrity.

These results are consistent with previous research by Ramadhani et al. (2019) which stated that blood sugar levels in serum are more stable than whole blood due to minimal cellular activity that accelerates glycolysis. In addition, research by Butt et al. (2016) supports this finding, where the use of gel separator tubes can help maintain stable blood sugar levels. This study also confirms that although blood sugar test results in serum are more stable than whole blood, the delay time can still affect sugar levels, especially if serum storage is carried out at room temperature. Therefore, it is important for laboratories to pay attention to the time between sampling and analysis to ensure accurate test results.

This study emphasizes the importance of laboratory procedures to handle blood samples promptly or store them at low temperatures to prevent glucose degradation. Laboratories serving high patient volumes should implement strategies such as the use of gel separator tubes and standardized SOPs for delayed sample handling.

In the context of further research, it is recommended to investigate the effects of longer storage duration, variations in environmental conditions (temperature, humidity), and different glucose measurement methods (spectrophotometry, POCT) to enhance the accuracy of blood sugar examination results.

From a public health perspective, accurate and reliable blood sugar examinations are essential for the early diagnosis of diabetes and effective management of pre-diabetic patients. Misinterpretation due to sample handling errors can lead to inappropriate clinical decisions, potentially affecting treatment protocols, including insulin dosage adjustments.

Thus, this study provides valuable contributions to laboratory practices, supports the development of more accurate clinical laboratory systems, and improves the overall quality of healthcare services.

Clinically, changes in blood sugar levels, even small ones, have important implications, especially in patients with diabetes. For example, a random blood sugar result of ≥200 mg/dL can be used as one of the diagnostic criteria for diabetes mellitus. If the test results are affected by delays or instability in serum blood sugar levels, diagnostic or treatment decisions can be affected. Therefore, this study emphasizes the importance of maintaining consistent analysis times and using appropriate storage methods to maintain stable blood sugar levels, especially in patients with vulnerable metabolic conditions. This study also provides important implications for laboratory practice, especially in healthcare facilities with high patient volumes. In situations where delays in testing are unavoidable, laboratories are advised to use gel separator tubes and ensure that serum is stored at low temperatures. These steps aim to minimize changes in blood sugar levels during storage. In addition, laboratories must ensure that the SOPs implemented include procedures for handling samples that are not immediately examined, so that the results provided to doctors remain valid and support appropriate clinical decision-making.

In the context of further research, these data serve as an important basis for further exploring the influence of other variables, such as longer storage duration or different storage temperatures on blood sugar stability. Additional research can also be conducted by comparing analysis results using various measurement methods, such as spectrophotometry and point-of-care testing (POCT) devices. This research can help improve the reliability and validity of laboratory results in various healthcare facilities. This research also provides practical contributions to improving the efficiency and accuracy of clinical laboratory services. By understanding the extent to which delays affect test results, laboratories can create better policies for handling samples. This is especially important in hospitals with limited resources or laboratories that serve a large number of patients. These steps can help improve the overall quality of healthcare services.

In the future, the results of this study can be used as a basis for developing guidelines and policies in clinical laboratories, especially in blood sugar level examinations. In addition, this study also forms the basis for the development of new technologies that can maintain serum stability for a longer period, allowing for more reliable test results even if there is a delay. Thus, this study not only provides benefits for current laboratory practices but also contributes to innovation and improving the quality of clinical laboratory services in the future.

Conclusion

Based on the results of this study, it can be concluded that there is a difference in blood sugar levels in serum that is examined directly compared to serum that is delayed for one hour at room temperature. The results of the examination showed an average increase in blood sugar levels of 2.48 mg/dL after a one-hour delay. Although this difference is

relatively small, in a clinical context, this change may become significant, particularly in patients with sensitive metabolic conditions, pre-diabetic patients, or those with blood sugar levels close to the diagnostic threshold (≥200 mg/dL). Even minor changes could influence clinical interpretation, diagnosis, or treatment decisions such as insulin dosage or glycemic index determination. This study also emphasizes the importance of time in the laboratory examination process. Delaying the examination, even for only one hour, can affect the results of the analysis due to metabolic mechanisms that are still ongoing in the serum, especially glycolysis which reduces glucose concentration over time if not controlled.

Therefore, laboratories need to implement strict handling and storage protocols, including the use of vacuum gel separator tubes, immediate sample processing, or storage at low temperatures (2-8°C) to minimize glucose degradation and maintain the accuracy of blood sugar levels. This conclusion provides an important contribution to clinical laboratory practice, especially in improving the accuracy and validity of blood sugar examination results. In addition, this study has practical relevance for public health management, particularly in supporting early diagnosis of diabetes, proper management of pre-diabetic patients, and strengthening clinical decision-making processes based on valid laboratory data. This study also forms the basis for the development of better standard operating procedures (SOPs) in the laboratory, to support appropriate clinical decision-making, improve the quality of health services, and minimize potential errors in laboratory practice.

Funding

This research received no external funding.

Acknowledgments

The author would like to express his gratitude to Stikes Panrita Husada Bulukumba and friends and parties who have helped in this research.

Conflicts of Interest

The authors declare no conflict of interest.

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