**Tropical Health and Medical Research**
Vol. 7, No. 2, August 2025, pp. 125-132
ISSN (Online): 2684-740X
*Journal homepage: https://tropicalhealthandmedicalresearch.com*

# Oral *Candida spp.* Density as a Blood Glucose Marker in Diabetes Mellitus Patients

***Aima Insana, Nurlailah, Rabiatul Adawiyah**

Medical Laboratory Technology Poltekkes Kemenkes Banjarmasin, Mistar Cokrokusumo Street 4A Banjarbaru Indonesia.
*Email: aimainsana21@gmail.com

**Abstract:** *Candida spp.* is a commensal fungus in the oral cavity that can become an opportunistic pathogen when there is a decrease in the immune system or metabolic disorders such as diabetes mellitus. Hyperglycemia in people with diabetes increases salivary glucose levels, which can be a nutrient source for Candida, thus triggering increased density, biofilm formation, and antifungal resistance. This study aims to analyse the relationship between blood glucose levels and oral *Candida spp.* density in patients with diabetes mellitus. The study used a cross-sectional design in 29 Guntung Manggis Banjarbaru Community Health Centre patients. Saliva samples were collected by mouthwash and planted on Hichrome Candida Differential Agar (HCDA) media to calculate colony density. At the same time, blood glucose levels were measured spectrophotometrically using the GOD-PAP method. The results showed abnormal blood glucose levels (≥200 mg/dL) were found in 16 respondents (55.2%), and abnormal *Candida spp.* density (>500 CFU/mL) was also found in 16 respondents (55.2%). The growth of *Candida spp.* detected in 24 samples (82.8%). The Chi-square test showed a significant association between hyperglycemia and increased oral *Candida spp.* density ($p = 0.017$). These findings suggest that hyperglycemia plays a role in increased Candida density in the oral cavity. Hence, monitoring blood glucose levels and oral Candida density is important for preventing fungal infection complications in patients with diabetes mellitus.

**Keywords:** Blood glucose; *Candida spp.*; colony density; diabetes mellitus; oral candidiasis; salivary.

## INTRODUCTION

Fungal infections caused by *Candida albicans* are a global health problem, especially in individuals with compromised immune systems or certain metabolic conditions, such as diabetes mellitus[1]. *Candida albicans* is a normal commensal of the skin, gastrointestinal tract, and genital mucosa but may become an opportunistic pathogen when there is an imbalance in the microbial environment or decreased immunity[2]. One significant risk factor for these infections is increased blood glucose levels, which create an environment that supports the growth and virulence of *Candida spp.*[3].

Recent studies have shown that hyperglycemia affects microbiological infections, especially *Candida albicans* adhesion, biofilm formation, and resistance to antifungals[4]. High glucose levels increase the expression of enzymes such as proteinases and

**Corresponding Author**: Aima Insana
Medical Laboratory Technology Poltekkes Kemenkes Banjarmasin,
Mistar Cokrokusumo Street 4A Banjarbaru Indonesia.
Email: Insana21@gmail.com

phospholipases, which enhance the fungus's invasive ability[5]. In addition, hyperglycemia also interferes with neutrophil function and innate immune responses, facilitating colonization and infection[6].

A clinical study by Mishra et al. found that diabetic patients with uncontrolled blood glucose levels had a higher prevalence of mucocutaneous candidiasis compared to normoglycemic patients. This finding is supported by an in vitro study showing that media with high glucose concentrations significantly increased the growth of *Candida albicans*[7,8].

This research approach differs from previous studies, which generally focused on isolating *Candida albicans* or clinical glycemic parameters alone. By correlating microbiological data (*Candida spp.* colony density) with blood glucose levels, this study offers the potential for an additional, non-invasive, and easily performed detection method in primary healthcare settings. These findings are expected to enrich early screening strategies for oral complications in diabetic patients and provide a basis for developing more practical monitoring protocols. This study analyzed the relationship between blood glucose levels and *Candida spp.* density in diabetic patients.

## MATERIALS AND METHODS

The materials used in this study are Aquadest, Hichrome Candida Differential Agar (HCDA), Tryptic Soy Broth (TSB), GOD-PAP Reagent, Syringe and samples which are used for oral-rinse saliva and blood serum. The tools used in this study are a sterile pot, ose, beaker, glass, Erlenmeyer flask, petri dish, micropipette, sterile test tube, ST-UV-1900PC spectrophotometer, analytical scale, hot plate, magnetic stirrer, Biosystem Tuttnauer-type autoclave, members IN-450 incubator, Memmert UN-110 oven, centrifuge and colony counter.

A cross-sectional design was used in this research, with a simple questionnaire for screening, sampling, and data collection at one time. The examination was conducted at the Mycology Laboratory of the Medical Laboratory Technology Department of the Ministry of Health Polytechnic of Banjarmasin. The sample examination was completed in May 2025. The population in this study was all diabetes mellitus patients treated at the Guntung Manggis Banjarbaru Health Centre from January to April 2025, and the sample was 29 respondents with a purposive sampling technique. The criteria in this research are Patients with a history of high blood glucose levels diagnosed with diabetes mellitus at the Guntung Manggis Banjarbaru Community Health Centre in February-March 2025, and pregnant women were excluded.

Saliva samples were collected from respondents by having them gargle with 10 ml of sterile distilled water for 30 seconds. They were then placed in a sterile container and stored in a cooler. The samples were then processed, and the saliva gargle was centrifuged at 3000 rpm. The supernatant was discarded, and the precipitate was mixed with 1 ml of sterile distilled water. A 25 µL sample of the processed sample was spread evenly on the surface of Hichrome Candida Differential Agar (HCDA). After incubation for 2 x 24 hours at 37°C, the colour indicated the growth of colonies, and the number was counted. The number of *Candida spp.* colonies on a plate was divided by 25, and multiplied by 1000; the colony density per mL of saliva was calculated[9].

Candida albicans grew bright green colonies with a greenish zone, Candida glabrata grew creamy to white colonies, Candida tropicalis grew purple colonies, and Candida krusei grew hairy purple colonies[10].

A certificated phlebotomist at Guntung Manggis Banjarbaru Community Health Centre collected a blood sample. First, the patient who relaxes is given an alcohol swab on the puncture area, a tourniquet is applied 1-2 cm above it, and then blood is taken from the cubital vein. After the syringe is full of blood samples, the syringe is removed, the tourniquet is released, and dry cotton is applied to the puncture wound.

Blood glucose level analysis in spectrophotometry using the GOD-PAP method. The blood sample taken is then centrifuged until 3 layers are formed, producing serum at the top of the liquid. 3 tubes are prepared, then the first tube is only filled with 1000 µL of GOD-PAP reagent, the second tube is filled with 1000 µL of GOD-PAP reagent and 10 µL of standard, the third tube is filled with 1000 µL of GOD-PAP reagent and 10 µL of sample. All tubes are homogenised and incubated first at room temperature for 15 minutes, then the absorbance is measured with the ST-UV-1900PC spectrophotometer at a wavelength of 546 nm. Calculate the absorbance result by dividing the sample absorbance by the standard absorbance, then multiplying by the standard concentration.

Data was collected and analysed periodically, with the Chi-square test as a correlation statistical test. The Health Ethics Research Commission of Poltekkes Kemenkes Banjarmasin No.430/KEPK-PKB/2025 approved this study.

## RESULTS AND DISCUSSION

Table 1 shows that the characteristics of the respondents were dominated by women, with 21 respondents (72.4%) and men. with 8 respondents (27.6%). Meanwhile. for the age group, there were more in the 46-55 years age range with 12 respondents (41.4%) and 56-65 years with 11 respondents (37.9%), followed by the age group >65 years with 4 respondents (13.8%), then 35-45 years with 2 respondents (6.9%).

Table 1. Respondent Characteristics

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| **Gender** | | |
| Female | 21 | 72.4 |
| Male | 8 | 27.6 |
| Total | 29 | 100 |
| **Age** | | |
| 35-45 yrs old | 2 | 6.9 |
| 46-55 yrs old | 12 | 41.4 |
| 56-65 yrs old | 11 | 37.9 |
| >65 yrs old | 4 | 13.8 |
| Total | 29 | 100 |

Table 2 shows that the respondents' data showed a range of blood glucose levels of 91-337 mg/dL. an average blood glucose level of 184.07 mg/dL and a median of 176 mg/dL. Meanwhile, the density of *Candida spp.* colonies ranged from 0-15.800 CFU/mL, an average of 1896.55 CFU/mL and a median of 640 CFU/mL.

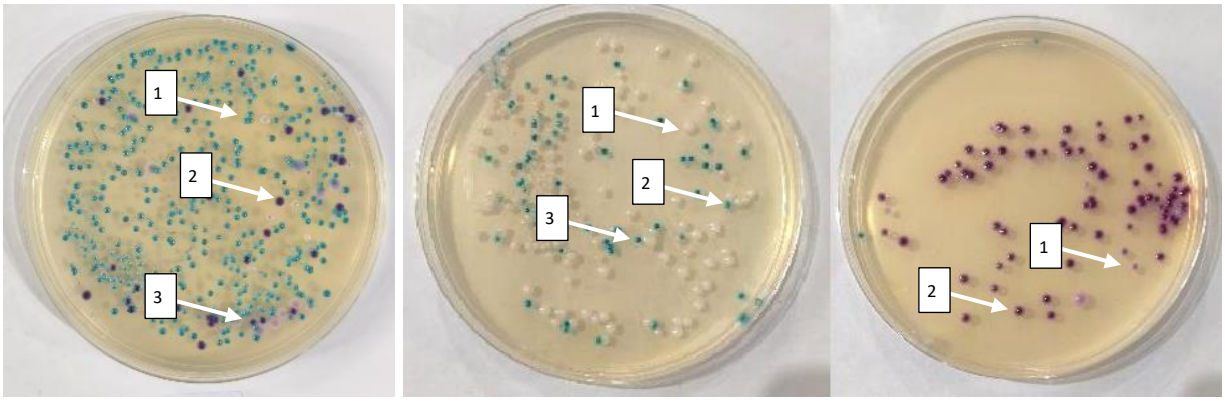
Table 2. Laboratory Analysis Test Results

| Value | Blood glucose levels mg/dL | Density of Candida spp (CFU/mL) |
|---|---|---|
| A range | 91-337 | 0-15.800 |
| Average | 184.07 | 1896.55 |
| Median | 176 | 640 |

Table 3. Categoric Laboratory Test Results

| Characteristics | Frequency | Percentage (%) |
|---|---|---|
| **Blood Glucose Levels** | | |
| Normal | 13 | 44.8 |
| Abnormal | 16 | 55.2 |
| **Density of *Candida spp.* (CFU/mL)** | | |
| Normal | 13 | 44.8 |
| Abnormal | 16 | 55.2 |
| **Growing Species** | | |
| *Candida spp.* | 24 | 82.8 |
| Non-Candida / Negative | 5 | 17.2 |

Based on the laboratory test results in Table 3. abnormal blood glucose levels were found in 16 samples (55.2%) and normal levels in 13 samples (44.8%). The standard and abnormal categories in this study, with a random blood glucose limit of ≥ 200 mg/dl. were based on the American Diabetes Association Professional Practice Committee[11]. For the Candida sp density category, 16 samples (55.2%) had abnormal levels, and 13 (44.8%) had normal levels. The standard normal category for oral Candida is 300-500 organisms per millilitre of saliva[12]. The species that grew on HCDA media were mostly Candida species, namely 24 samples (82.8%). followed by non-Candida/negative samples with 5 samples (17.2%).




a) b) c)

Figure 1. Candida sp Colonies from Research Results on HCDA Media

Based on the Himedia Laboratories guide[10], in sample a); the colonies that (1) grew were turquoise (*Candida albicans*), (2) dark bluish purple (*Candida tropicalis*), and (3) purple with a white border (*Candida krusei*). In sample b); the colonies that (1) grew were white (*Candida glabrata*), (2) light green (*Candida dubliniensis*), and (3) turquoise

(*Candida albicans*). Then, in sample c); the colonies that formed were (1) purple with a white border (*Candida krusei*), and (2) dominated by dark purple (Coccus Bacteria).

Table 3. Chi-Square Test Results

| Blood Glucose Levels | Density of *Candida spp* (CFU/mL) | | | | Total | % | p-value |
|---|---|---|---|---|---|---|---|
| | Normal | | Abnormal | | | | |
| | Frequency | % | Frequency | % | | | |
| Normal | 9 | 31.0 | 4 | 13.8 | 13 | 44.8 | |
| Abnormal | 4 | 13.8 | 12 | 41.4 | 16 | 55.2 | 0.017 |
| Total | 13 | 44.8 | 16 | 55.2 | 39 | 100 | |

From the chi-square test results in Table 3. it is known that 12 samples (41.4%) had abnormal blood glucose levels accompanied by an abnormal number of colonies. while 9 samples (31%) had normal blood glucose levels with a normal number of colonies. The p-value was 0.017, below the significance limit of 0.05. indicating a significant relationship between blood glucose levels and the density of *Candida spp* in saliva.

The blood sample is the most common biological fluid for diagnosing and monitoring diseases. However, whole saliva has increasingly been studied as a practical alternative to blood for diagnostic purposes. Whole saliva contains locally produced substances and serum components that can be used to diagnose various systemic diseases and understand their oral manifestation[13]. In addition saliva plays an important role in maintaining oral cavity homeostasis by preserving the oral ecosystem and serving as one of the biomarkers for successful treatment and disease risk estimation[14]. As an ultrafiltrate of blood. glucose can easily pass through the salivary gland epithelium in proportion to its concentration in the blood. making saliva the easiest human body fluid to collect[15].

Building on this understanding, the present study found a significant relationship between blood glucose levels and the density of *Candida spp.* in the saliva of diabetic patients (Table 3). This finding is consistent with research by Mishra et al. (2019). which reported that oral *Candida* carriers, as measured by the number of *Candida* colonies in saliva. positively correlate with blood glucose levels[7]. Elevated glucose levels in saliva may be a nutrient source for normal flora and pathogenic microorganisms. Among these. *Candida* species—regular inhabitants of the buccal cavity—can proliferate when salivary glucose levels are high, leading to oral candidiasis and dental plaques[16].

The increased risk of infection in hyperglycemic patients can be explained by its impact on the immune system. Hyperglycemia can impair several host humoral defence mechanisms including neutrophil functions such as adhesion chemotaxis and phagocytosis regardless of whether it is due to diabetes mellitus glucocorticoid therapy or hyperalimentation fluid infusion. Furthermore opsonisation may be inhibited when glucose binds to the biochemically active complement C3 site preventing attachment to microbial surfaces. Chronic hyperglycemia reduces neutrophil functions—such as adhesion. chemotaxis. phagocytosis. and respiratory burst—thereby impairing *Candida* clearance. Recent immunological reviews confirm that hyperglycemia is a key mediator of neutrophil dysfunction in T1D and T2D. which increases susceptibility to *Candida albicans*[17].

These physiological changes are further supported by biochemical evidence. Several studies have shown that salivary amylase concentration is higher in diabetic patients. and salivary glucose concentration is elevated in fasting and non-fasting (post-prandial) states[18]. Given that diabetes mellitus is a growing public health crisis—particularly in high- and middle-income countries—its complications, including oral manifestations, require serious attention. For example, the eastern Mediterranean region currently has the highest prevalence of diabetes mellitus in the world. Alongside millions of diagnosed cases. a significant portion of the population remains undiagnosed. contributing to a substantial economic burden on healthcare systems and increasing morbidity and mortality. Oral complications of diabetes mellitus include periodontal disease, hyposalivation, dental caries, halitosis, delayed wound healing, taste and salivary dysfunctions, candidiasis, and burning mouth syndrome[19].

From a clinical standpoint, the findings of this study are important because high *Candida* density in the oral cavity can progress to oral candidiasis, presenting with symptoms such as a burning sensation in the mouth, pain when swallowing, and white mucosal lesions. These conditions reduce the patient's quality of life and can act as a gateway for systemic infections in immunocompromised individuals. Therefore, blood glucose control and proper oral hygiene remain crucial preventive measures. Interventions such as dietary regulation, prophylactic antifungal therapy in high-risk patients, and oral hygiene education could reduce the risk of fungal infection-related complications.

Nevertheless, this study has limitations. The focus was solely on *Candida* species. without assessing the presence of other microorganisms, such as bacteria that may also contribute to oral infections. Moreover, the relatively small sample size and cross-sectional design limit causal inference. Additional factors. such as oral hygiene status. antibiotic use, and nutritional status, were not considered and may influence the observed outcomes. Furthermore, the study did not account for potential confounding factors—such as oral hygiene practices, use of antifungal medications, and wearing dentures—which could affect *Candida* colony counts in saliva.

## CONCLUSION

This study showed a significant correlation between blood glucose levels and oral *Candida* density in patients with diabetes mellitus. Subjects with abnormal blood glucose levels were accompanied by abnormal *Candida spp.* density, which was observed in 12 samples (41.4%). Of the 29 patient saliva samples, *Candida spp.* was found in 24 samples (82.8%). The Chi-square test confirmed a statistically significant relationship (p-value = 0.017) between blood glucose levels and oral *Candida spp.* density. Further research is recommended using samples stratified by type of diabetes mellitus to provide more specific clinical insights. The results of this study are expected to be a reference for healthcare professionals in developing methods for detecting and monitoring diabetes and *Candida spp.* density.

## CONFLICT OF INTEREST

In this study there is no conflict of interest

## REFERENCES


1. Rodrigues CF, Henriques M. *Candida spp.* infections in patients with diabetes mellitus. J Clin Med. 2019;8(1):76.
2. Lopes JP, Lionakis MS. Pathogenesis and virulence of Candida albicans. Virulence. 2022;13(1):89-121.
3. Gomes CC, Guimaraes LS, Pinto LCC, Camargo GADCG, Valente MIB, Sarquis MIDM. Investigations of the prevalence and virulence of Candida albicans in periodontal and endodontic lesions in diabetic and normoglycemic patients. J Appl Oral Sci. 2017;25(3):274-81.
4. Mandal SM, Mahata D, Migliolo L, Parekh A, Addy PS, Mandal M, et al. Glucose directly promotes antifungal resistance in the fungal pathogen *Candida spp.* J Biol Chem. 2014;289(37):25469-73.
5. Moharram AM, Abdel-Galil FA, Hafez WMM. On the enzymes' actions of entomopathogenic fungi against certain indigenous and invasive insect pests. Egypt J Biol Pest Control. 2021;31:1-9.
6. Mohammed L, Jha G, Malasevskaia I, Goud HK, Hassan A. The interplay between glucose and yeast infections: Do diabetics have a greater predisposition to develop oral and vulvovaginal candidiasis? Cureus. 2021;13(2):e13443.
7. Mishra N, Trivedi A, Gajdhar SK, Bhagwat H, Khutwad GK, Mall PE, et al. Correlation of blood glucose levels, salivary glucose levels and oral colony forming units of Candida albicans in type 2 diabetes mellitus patients. J Contemp Dent Pract. 2019;20(4):494-8.
8. Hosida TY, Cavazana TP, Henriques M, Pessan JP, Delbem ACB, Monteiro DR. Interactions between Candida albicans and Candida glabrata in biofilms: influence of the strain type, culture medium and glucose supplementation. Mycoses. 2018;61(4):270-8.
9. Wijerathna AAWM, Weerasekera WBMCRD, Jayawardene KLTD, Ratnapreya S, Bandara HMHN. Oral prevalence of Candida in adolescents on removable orthodontic appliance therapy at Dental Teaching Hospital, Peradeniya, Sri Lanka – a pilot study. Ceylon J Sci. 2024;53(4):201-8.
10. HiMedia Laboratories. HiCrome™ Candida Differential Agar [Internet]. 2023 [cited 2025 May 7]. Available from: https://www.himedialabs.com/us/m1297a-hicrome-candida-differential-agar.html
11. American Diabetes Association Professional Practice Committee. 2. Diagnosis and classification of diabetes: Standards of care in diabetes—2025. Diabetes Care. 2025;48(Suppl 1):S27-49.
12. Hamrun N, Mahardhika A. Jumlah koloni Candida albicans pada pemakai gigitiruan penuh berdasarkan lama pemakaian. Makassar Dent J. 2014;3(3):112-7.
13. Vaziri PB, Vahedi M, Mortazavi H, Abdollahzadeh SH, Hajilooi M. Evaluating salivary glucose, IgA and flow rate in diabetic patients: a case-control study. J Dent (Tehran). 2010;7(1):13-8.
14. Elkafri H, Mashlah A, Shaqifa A. Relationship between blood glucose levels and salivary pH and buffering capacity in type II diabetes patients. East Mediterr Health J. 2014;20(2):121-6.
15. Okuyama K, Yanamoto S. Saliva in balancing oral and systemic health, oral cancer, and beyond: a narrative review. Cancers (Basel). 2024;16(24):4276.

16. Chojnowska S, Baran T, Wilińska I, Sienicka P, Cabaj-Wiater I, Knaś M. Human saliva as a diagnostic material. Adv Med Sci. 2018;63(1):185-91.
17. Hostetter MK. Handicaps to host defense: effects of hyperglycemia on C3 and Candida albicans. Diabetes. 1990;39(3):271-5.
18. Gupta S, Nayak MT, Sunitha JD, Dawar G, Sinha N, Rallan NS. Correlation of salivary glucose level with blood glucose level in diabetes mellitus. J Oral Maxillofac Pathol. 2017;21(3):334-9.
19. Pérez-Ros P, Navarro-Flores E, Julián-Rochina I, Martínez-Arnau FM, Cauli O. Changes in salivary amylase and glucose in diabetes: a scoping review. Diagnostics (Basel). 2021;11(3):453.