Measurement of glycated haemoglobin through photoacoustic spectroscopy, a non-destructive assessment

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Global diabetes prevalence has reached epidemic proportions. It was estimated that diabetes prevalence in adults was 10.1% in 2021 (536.6 million people), with a projected rise to 12.2% in 2045 (783.2 million people) [1]. Chronic complications are the main cause of morbidity and mortality in diabetes. According to the American Diabetes Association diabetes diagnosis criteria include fasting plasma glucose (PG, 100-125 mg/dL), 2 h PG during a 75 g oral glucose-tolerance test (140-199 mg/dL), random PG (200 mg/dL) and 5.7-6.4% glycated haemoglobin (HbA1c) [2]. HbA1c is the most accurate variable for metabolic monitoring of diabetes. Variability of HbA1c is associated with chronic complications and predicts outcome of cardiovascular events [3]. There are several techniques to measure Hb1Ac [2]. However, samples >200 μL, are required, they are manipulated, destroyed, and only used for the measurement of HbA1c. In previous work we used photoacoustic spectroscopy (PAS) to correlate glycemia with haemoglobin and p450 cytochrome [4,5]. PAS, a non-destructive technology used to measure different substances in body fluids [6], is based on the following phenomena: A sample is confined into a close chamber where it is illuminated with a modulated light beam. The sample absorbs the incident light and heat is produced. [7] The release of heat to the environment is periodic, generating a pressure wave or an acoustic wave (signal) that is detected by a microphone. [7].

The goal of the present study was to measure HbA1c through PAS. Photoacoustic (PA) absorption spectra were obtained according to previous work [4,5]. In short, 60 μL of six Bio-Rad Lyphochek HbA1c standards were used instead of blood. Concentrations of HbA1c were from 3.1 to 19.8 %. Five measurements were performed for each standard. Absorption spectra were detected from 250 to750 nm. Spearman correlation was calculated. Significance level was $p<0.05$. Data are shown as mean ± standard error of the mean (SEM). Figure 1 shows concentration dependent spectra. Figure 2 shows a significant correlation of the area under the curve (AUC, 250-750 nm) and the percentage of HbA1c. As far as we know, it is the first time that PAS is used to measure and standardize HbA1c concentrations. The advantages of PAS over the other techniques used to measure HbA1c include using small volume (less than 100 μL) and a non-destructive technique that allow the measurement of HbA1c and other substances at the same time, *ie* albumin, creatinine, p450 cytochrome, which are important for the evaluation of patients with diabetes. It is concluded that PAS a non-destructive technique that could be used to measure HbAlc, which opens a new horizon in the evaluation of patients with diabetes.

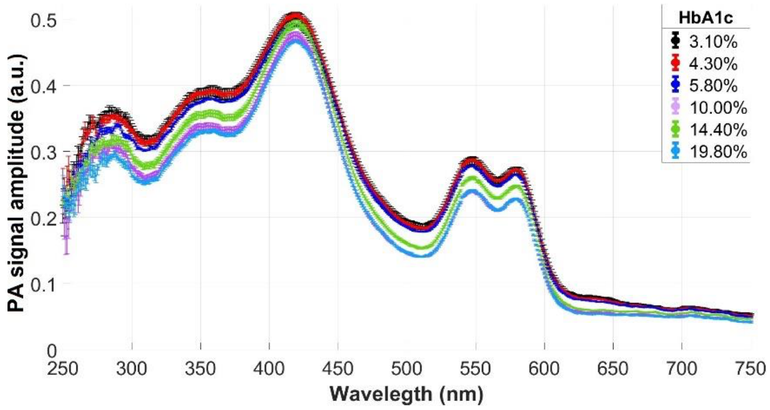

Fig. 1. Photoacoustic absorption spectra from 250 to 750 nm of HbA1c standards. The figures shows the mean ± standard error of the mean (SEM) of five measurements. Concentrations of the standards are from 3.1 to 19.8%.

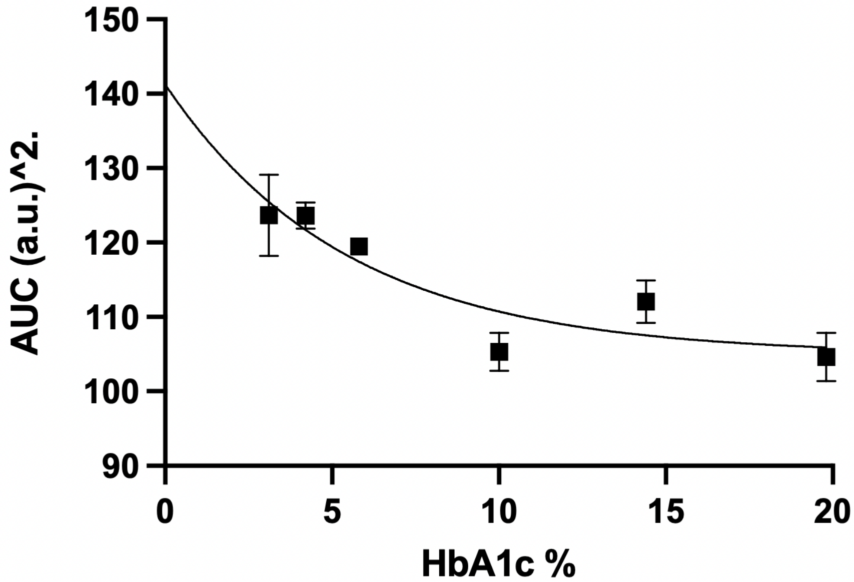

Fig. 2. Area under the curve (AUC) obtained from photoacoustic spectra (figure 1). It is shown the mean ± SEM. R= - 0.94, p = 0.01. Spearman correlation. a.u. = arbitrary units.

Acknowledgements – The authors thank E. Ayala, R. Fragoso, M. Guerrero, A. B. Soto for their technical support at the Physics Department, CINVESTAV-IPN. The study was supported by grants SECTEI No. 282-2019 and SIP20212108. In addition, the study was supported by Technological Development Projects or Innovation for IPN students.

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