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Original Research Article

ACCURACY OF SIX POINT–OF-CARE GLUCOMETERS AND LABORATORY METHOD FOR BLOOD GLUCOSE DETERMINATION IN SHEEP

[1]OKORIE-KANU, C.O., [2]ONOJA, R.I, [3]UGWUANYI, H.E., [4]OKORIE-KANU, O.J., [4]ABA, P. E., [5]IGBOKWE, I.O.

*[1]*Department of Veterinary Pathology, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. [2]Department of Veterinary Pathology, University of Nigeria, Nsukka, Enugu State, Nigeria. [3]Department of Veterinary Physiology and Biochemistry, University of Nigeria, Nsukka, Enugu State, Nigeria. [4]Department of Veterinary Public Health and Preventive Medicine, University of Nigeria, Nsukka, Enugu State, Nigeria. [5]Department of Veterinary Pathology, Ahmadu Bello University, Zaria, Kaduna State, Nigeria.*

**Correspondence:* okorie-kanu.christain@mouau.edu.ng; ; drcokoriekanu@yahoo.co.uk +238038993505

ABSTRACT

This study compared the accuracy and agreement of six point-of-care glucometers (PCGs) with a laboratory method for blood glucose determination in sheep. Thirty (30) healthy sheep were used for the study. Blood (2 ml) was collected from the jugular vein and the six glucometers were used to assay the blood glucose concentrations immediately. After then, the samples were placed into clean and plain test tubes, allowed to clot under room temperature, centrifuged and serum harvested. Blood glucose test kit was used to measure glucose concentrations in serum by the glucose oxidase method. Data generated were analysed using Correlation coefficient, Student's t-test and Bland Altman Plot. Results showed that the mean value generated by Accu-Answer® glucometer was comparable with the laboratory method, On Call® Plus II glucometer underestimated the glucose concentration while the values generated by Accu-chek® active, Finetest®, BG Check® and Tyson Bio® Evolve glucometers were significantly higher when compared with the laboratory method. Therefore, Accu-Answer® glucometer may be used to determine blood glucose concentration in sheep with reasonable accuracy while Accu-chek® active, On Call® Plus II, Fine test® and BG Check® glucometers may be used with caution and Tyson Bio® Evolve may not be appropriate in sheep.

Keywords: blood glucose determination, diagnosis, point of care glucometer, sheep

INTRODUCTION

Glycemic disorders in sheep, including pregnancy toxemia, peri-parturient ketosis, neonatal dysglycemia and diabetes mellitus are characterized by hypoglycemia or hyperglycemia early in the course of the diseases (Hochleithner, 1994; Fudge, 2000; Saun, 2000; Rolin, 2006; Liu *et al*., 2023). Severe symptoms, including, depression, staggering gait, blindness, muscle tremors, convulsions, abortion, still birth, coma and death (Saun, 2000; Kemp *et al*., 2013; Vasava *et al*., 2016) ensue if not detected and managed early (Bosos*et al*., 2011); and monitoring of glucose levels allows for early detection, treatment and management. Also, blood glucose determination under field conditions is necessary before intravenous injection of a glucose solution.

Conventional or laboratory method of blood glucose determination is not only expensive, but requires expertise, large sample quantity and takes much time for generation of results making it difficult for early detection of these disorders.

Point-of-care glucometers are vital in blood glucose monitoring and diagnosissince they are not only easy to operate, cheap with rapid generation of result but also require little quantity of blood (Lieske *et al*., 2002), but not without concerns about the accuracy and reliability of the

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results generated by them in various animal species. Although, many PCGs have been found valuable in several species (Wess & Reusch, 2000ab; Johnson *et al*., 2009; Hackett & McCue, 2010; Katsoulos, 2011; Horning *et al*., 2013;Petritz *et al*., 2013; Wittrock *et al*., 2013; Sellerie*t al*., 2014; Tauk*et al*., 2015;Mair *etal*., 2016; Morley *et al*., 2018; Okorie-Kanu *et al*., 2018ab, 2021, 2025a), many have underestimated or overestimated the blood glucose values in other species including Amazon parrots (Acierno *et al*., 2009) black-tailed Prairie dogs (Higbie *et al*., 2014), mice (Togashi *et al*., 2016), alpacas (Beemer *et al*., 2013), dogs (Suvarnavibhaja*et al*., 2014), ferrets (Petritz *et al*., 2013), pigeon (Mohsenzadeh*et al*., 2015), primates (Clemmons *et al*., 2016), layer chicken (Okorie-Kanu, *et al*., 2018a) and fish (Okorie-Kanu *et al*., 2018b).

These variations in the values generated by these glucometers have been attributed to species-specific matrix properties such as disparity in glucose concentration between red blood cells and plasma, packed cell volume, rheology and glucose concentration in different animal species (Tang *et al.*, 2000; Tonyushkina& Nichols, 2009; Rebel *et al*., 2012).

This study was therefore designed to compare the six PCGs with the laboratory method to identify the PCGs best suited for blood glucose determination for accuracy and agreement in this species.

MATERIALS & METHODS

Apparently healthy 30 adult sheep were used for the study. All protocols in the experiment were approved by the College of Veterinary Medicine Research Ethical Committee, Michael Okpara University of Agriculture, Umudike, with clearance number MOUAU/CVM/REC/202430.

One (1) ml of blood was collected from the jugular veins with a hypodermic syringe and blood glucose levels were assayed immediately with the PCGs. The blood samples were thereafter emptied into clean test tubes without anticoagulant and kept for 30 minutes at room temperature to clot and thereafter centrifugedwith an800DCentrifuge (Ty-PAC Inter-medical Ltd, China)at 3000g and serum harvested.

According to manufacturers' instructions for blood glucose determination, a test strip was inserted into the glucometer port for test strip and allowed for a flashing blood image to appear on the glucometer screen. Thereafter, a drop of blood was placed on the pad of the test strip using a capillary tube for Accu-chek® active glucometer while for Accu-Answer®, Fine test®, BG Check®, On Call® Plus II, and Tyson Bio® Evolve glucometers, the test strip was filled by capillary action by placing the strip pad on a drop of blood. Result in mg/dl was displayed on the screen after 5 seconds in all methods.

Accu-chek® active glucometer (Roche Diagnostics GmbH, Nannheim, Germany) was based on hexokinase reaction and the range of glucose concentration detectable was 10 - 600 mg/dl.

BG Check® glucometer (Hangzhou Health Shining Co. Ltd., Hangzhou, Zhejiang, China) was based on glucose dehydrogenase reaction with the glucose concentration detectable range of 40 - 600 mg/dl. Accu-Answer® glucometer (ZH-GO1) (Guilin Zhongul Technology Co. Ltd, Guilin, China) with detectable range of 20 - 600 mg/dl, On Call® Plus IIglucometer (Acon Laboratories Inc. San Diego, CA, USA) with detectable range of 20 - 600 mg/dl, Fine test® glucometer(Auto-coding Premium (Osang Healthcare Co. Ltd, South Korea) with detectable range of 10 - 600 mg/dl and Tyson Bio® Evolve glucometer (Tyson Bioresearch Inc., Zhuang, Taiwan) with detectable range of 20 - 600 mg/dl were all based on the glucose oxidase method(Gerber & Freeman, 1986). The results are equivalent to plasma glucose values in all the glucometers (D'orazio *et al.*, 2005; Steffes & Sacks, 2005).

Blood glucose concentration was determined in the laboratory using glucose test kit (Quimica Clinica Aplicada (QCA), Spain) based on GOD-POD method (Glucose oxidase method, Trinder, 1969) for *in-vitro* determination of blood glucose in serum or plasma.

The working reagent (1 ml) was thoroughly mixed with 0.01 ml of serum sample and standard sample respectively and allowed to stand for 10 minutes at room temperature. The absorbance of both the samples and standard were read against the contents of the blank at 505 nm using a Cole Parmer 1200 spectrophotometer (Cole-Parmer Instrument Co., USA). The glucose concentration was obtained using the formula below(Trinder, 1969; IDF, 2012).

$$\text{Glucose Conc. } (\frac{\text{mg}}{\text{dl}}) = \frac{Absorbance\ of\ sample}{Absorbance\ of\ standard} \times 100$$

The data generated were subjected to statistical analysis using Correlation Coefficient and Student's t-test ($p<0.05$) using IBM®SPSS® Statistics, Version 25 and Bland Altman Plot (Bland & Altman, 1986).

RESULTS

There was significant ($p<0.05$) positive correlation ($r = 0.70$) between Accu-Answer®glucometer and the laboratory method.

In Table 1, the mean values (64.77 ± 1.21 mg/dl) generated by Accu-Answer®glucometer was not significantly ($p>0.05$) different when compared with the value (62.61 ± 0.90 mg/dl) generated by the laboratory method. The mean values generated by Accu-chek® Active (72.73 ± 1.61 mg/dl), Fine test® (74.37 ± 1.53 mg/dl), BG Chek® (75.73 ± 2.14 mg/dl) and Tyson Bio® Evolve (83.17 ± 1.94 mg/dl) glucometers were significantly ($p<0.05$) higher when compared with the

mean value (62.61 ± 0.90 mg/dl) generated by the laboratory method while the value (55.17 ± 1.74 mg/dl) generated by On Call® Plus II glucometer was significantly lower ($p < 0.05$) when compared with the laboratory method.

In the Bland Altman Plot, the solid line represents the line of actual average agreement of the data while the dashed lines represent the 95% limits of agreement of the data. Therefore, Bland Altman Plot shows agreement between the Accu-Answer®glucometer and the laboratory method as all the data fall within the limits of agreement (Figure I).

TABLE I: BLOOD GLUCOSE CONCENTRATION (MG/DL) OF 30 SHEEP DETERMINED WITH DIFFERENT METHODS

Methods	Means ± Standard error of mean	Standard deviation	Minimum values	Maximum values
Accu-chek®Active	72.73 ± 1.61*	8.82	62.00	86.00
Accu-Answer®	64.77 ± 1.21	6.64	52.00	77.00
On Call® Plus II	55.17 ± 1.74*	9.55	36.00	88.00
Fine test®	74.37 ± 1.53*	8.36	45.00	91.00
BG Check®	75.73 ± 2.14*	11.71	59.00	94.00
Tyson Bio® Evolve	83.17 ± 1.94*	10.65	63.00	99.00
Laboratory method	62.61 ± 0.90	4.93	47.83	69.57

***Asterisked values are significantly different from the laboratory method ($p<0.05$).**

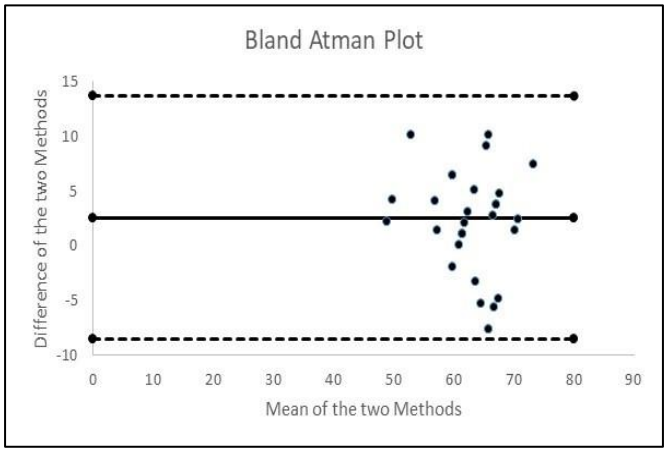

Figure I: Bland Altman Plot for Accu-Answer® glucometer in sheep.

DISCUSSION

The correlation coefficient (r = 0.70) showed significant positive correlation and the result of Bland Altman Plot indicates strong agreement between the Accu-Answer® glucometer and the laboratory method.

The values generated by Accu-Answer® glucometer is in agreement with the laboratory method. Accu-chek® Active, Fine test®, BG Check® and Tyson Bio® Evolve PCGs overestimated the values while On Call® Plus II underestimated the blood glucose concentration.

However, while the values generated by Accu-chek® Active, Fine test®, BG Check® fell within the total allowable error margin based on ASVCP guidelines (Gerber & Freeman, 2016) Tyson Bio® Evolve PCG overestimated the values by over 30%.

The American Society for Veterinary Clinical Pathology (ASVCP) guidelines on quality assurance for portable blood glucose meter (glucometer) use in veterinary medicine requires 95% of blood glucose measurements fall within ±20% for glucose results ≥ 75 mg/dl and within 15% for glucose results < 75 mg/dl (Gerber & Freeman, 2016).

Therefore, Accu-Answer® PCG may be used in sheep for monitoring, diagnostic and research purposes with reasonable accuracy. Accu-chek ®Active,On Call® Plus II, Fine test® and BG Check® glucometers may be used with caution while Tyson Bio® Evolve glucometers may not be appropriate for blood glucose determination in sheep.

In our previous studies, Accu-chek® Active, Accu-Answer®,Fine test® andTyson Bio® Evolve glucometer agreed well with the laboratory method in rabbits (Okorie-Kanu *et al*., 2025a) while in goats, cattle, fish, layer chickens and rats, Accu-chek® Active glucometer agreed well with the laboratory method but Tyson Bio® Evolveglucometer overestimated the blood glucose concentration in these species (Okorie-Kanu *et al*., 2018ab, 2021, 2025b).

CONCLUSION

Accu-Answer® glucometer may be used to determine blood glucose concentration in sheep with reasonable accuracy. Accu-chek® active, On Call® Plus II, Fine test® and BG Check® glucometers may be used with caution while Tyson Bio® Evolveglucometer may not be appropriate in sheep.

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