

Introduction

The introduction of HEMAPEN™ has provided easier, well-tolerated, and more convenient sampling process for dried blood spot (DBS) collection. When compared with conventional DBS sampling systems, HEMAPEN™ offers higher level of precision while eliminating human error during collection and processing, thereby providing superior analytical accuracy. The portable and discreet nature of HEMAPEN™ reduces the burden on the patient, facilitates adherence, and subsequently contributes to the improvement in analysis.

HEMAPEN™ redefines blood collection and storage in order to improve access to near-patient sampling. Initial results demonstrate HEMAPEN™ provides a higher level of precision (CV = 1 %) than other dispensing methods (i.e. pipette, syringe, CV = 3-5 %) for blood collection. The capillary collection mechanism dispenses an accurate volume of blood, leading to superior accuracy during analysis (95 % recovery w.r.t to 87 % with conventional dispensing methods). Moreover, the integrated compartments protect samples at every stage of the process, and advanced sample tracking could be enabled by NFC technology. Further, it eliminates human error during collection and processing.

The ease of use behind HEMAPEN™ enables home-based, unassisted blood collection by non-healthcare professionals. Adoption into current healthcare systems is expected to save time, reduce healthcare costs, and improve accuracy of blood analysis.

Technical and design features



Component	Functionality
Capillaries	For accurate blood collection
DBS cartridge	Holds DBS paper disk and identification
Molded spring	Forces DBS against capillaries when pushed into the base
Desiccant	To ensure humidity control
Base	Stabilizes device, triggers contact between capillaries and paper, and locks the device

HEMAPEN™ collection workflow



- Take HEMAPEN™ out of the base.
- Collect blood.
- Tap back in the base.

Advantages of self-sampling and quantitative analysis:

- Sample collection:
 - Privacy.
 - Ease of use.
 - Collection by non-healthcare professional.
 - Increased accessibility of sample collection.
- Increased usability to potential patients.
 - Ease of sample collection & transport.
 - Reduce long-term overall costs to the healthcare provider.

Volumetric comparison

The collection methodology is assessed and compared against standard high precision blood dispensing techniques such as pipetting and positive displacement in terms of precision and accuracy of liquid collected by ratiometric measurement.

Dispensing method	Manufacturer's specification		Volumetric measurement		
	Precision	Accuracy	Precision	Accuracy	Volume
Pipette	2 %	1.2 %	0.23 %	1.60 %	3.0481 µL
Positive displacement	0.5 %	1 %	0.08 %	1.52 %	3.0457 µL
Capillary (hemaPEN)	0.75 %	0.30 %	0.35 %	0.25 %	3.0077 µL

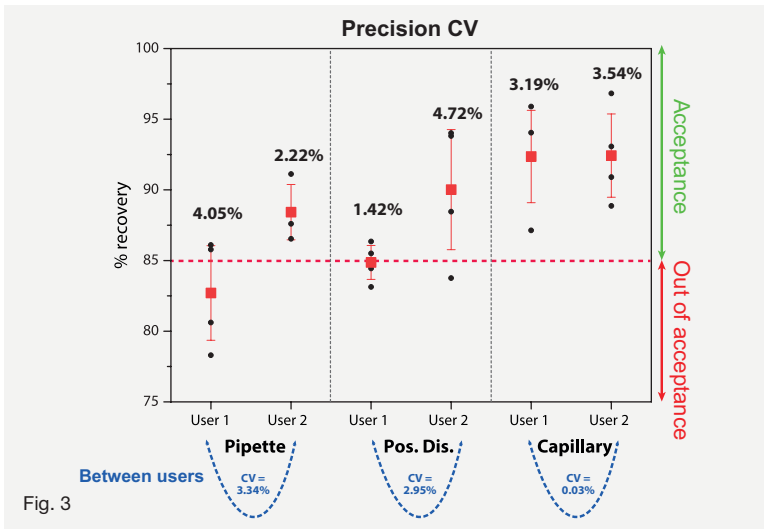
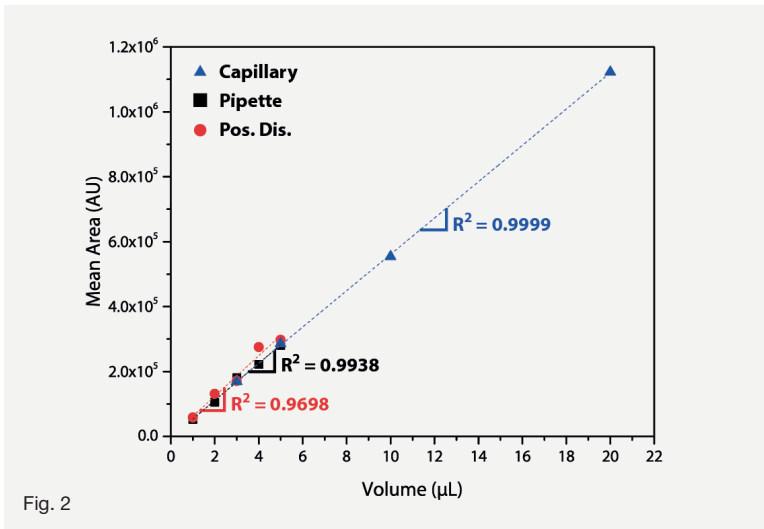
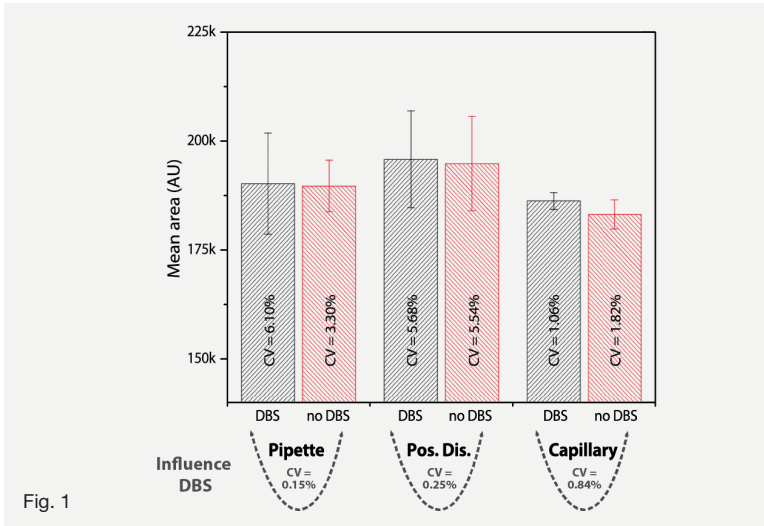
Precision and accuracy values of each dispensing method (pipette, positive displacement, capillary) obtained from each manufacturer and measured experimentally with the volumetric system Artel. Both precision and accuracy measurements match manufacturer specifications. Positive displacement shows the best precision while capillary presents the best accuracy with a mean volume dispensed of 3.0077 µL.

HEMAPEN™ Precision bio-sampling via unassisted and accurate collection of dried blood spot samples

Pawanbir Singh¹, Anne Collins², Andrew Gooley², David Bailey² and Florian Lapierre³
¹) Trajan Scientific and Medical, Crook Street, Chester CH1 2BE, UK, ²) Trajan Scientific and Medical, 7 Argent Place, Ringwood, Vic 3134, Australia
³) ASTech, the ARC Training Centre for Portable Analytical Separation Technologies, 7 Argent Place, Ringwood, Vic 3134, Australia

Comparison of dispensing methods in DBS sampling

Comparison of three collecting/dispensing methodologies (pipette, positive displacement syringe, capillary) with whole blood containing a caffeine concentration of 10 mg.mL⁻¹. Dry blood spot analysis was performed under HPLC-UV for the (1) controls, (2) calibrations, and (3) caffeine extraction in order to demonstrate the precision and accuracy of each methodology.



1. Influence of dispensing methods and DBS paper during extraction (See Fig. 1)

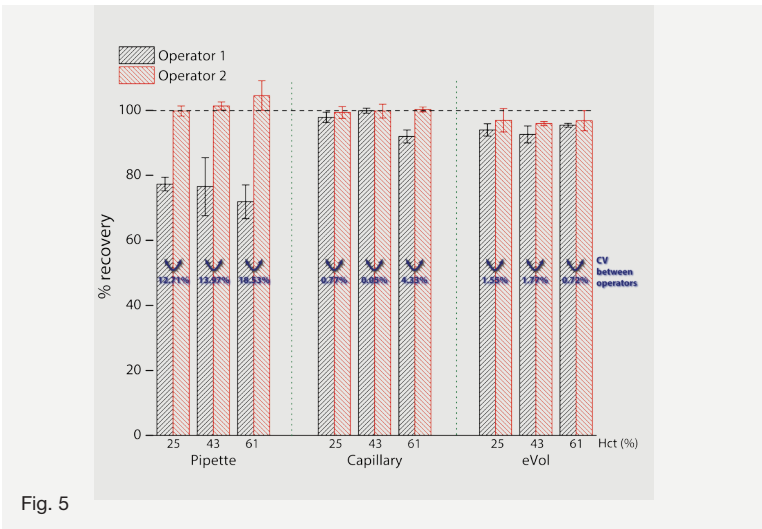
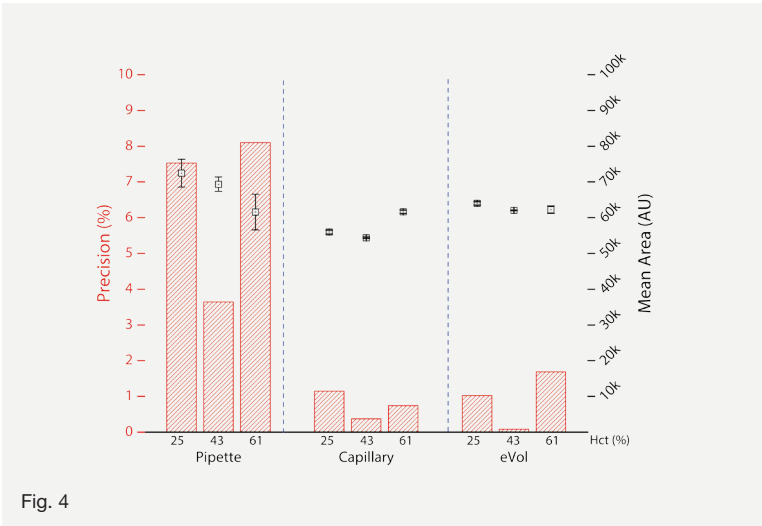
- Each dispensing method is within the regular acceptance criteria (~ 15 %).
- Capillary dispensing method has a better coefficient of variation (1 %) w.r.t to pipette (3.3 - 6.1 %) and positive displacement (5.5 %).
- Influence of DBS paper during the extraction process seems negligible with a coefficient of variation 1 % for each method employed.

2. Linearity (R²) investigation of each dispensing method. (See Fig. 2)

- Calibrations curve for different volumes of blood containing caffeine for the three dispensing methodologies.
- Pipette and positive displacement showed a R² of 0.9938 and 0.9698, respectively
- Capillary collection showed linearity with R² = 0.9999.

3. Caffeine extraction and recovery directly from pre-punched DBS. (See Fig. 3)

- Percentage recovery 85 % - within the regular acceptance criteria - for all dispensing methods.
- Coefficient of variations are below 5 % indicating all dispensing methods are precise.
- Capillary dispensing method shows best recovery percentage of 92.5 % for both users
- User difference – With pipette and positive displacement, the coefficient of variation between users is 3.34 % and 2.95 %, respectively compared to 0.03 % with the capillary method.
- Pipette and positive displacement involve individual manual handling while collecting and dispensing blood onto the DBS.
- Capillary dispensing method involves automated blood collection via capillary action, and automated blood dispensing via wicking action, thereby avoiding the influence of manual handling between operators.
- Percentage recovery 85 % - within the regular acceptance criteria for all dispensing methods.
- Coefficient of variations are below 5 % indicating all dispensing methods are precise.



4. Effect of Hematocrit on Sample Collection and Extraction (See Fig. 4)

- Mean absorbance is similar for all dispensing methods and hematocrit level.
- No hematocrit influence on the collection and dispensing of blood into the vial.
- Precision and standard deviation :
 - Pipette dispensing method had a precision variation from 4-8 % while both positive displacement and capillary maintain a precision of less than 1 % on average.
 - The high variation with pipette based dispensing method results in decreased precision.
 - Each dispensing method within the regular acceptance criteria (<15 %).

5. Effect of operator handling on recovery (See Fig. 5)

- Hematocrit level had no influence on percentage recovery from pre-punched DBS papers - same for each method and operator
- Capillary dispensing method had better percentage recovery in comparison to positive displacement and pipette based dispensing methods
- Capillary and positive displacement based dispensing methods demonstrated no influence of operator handling in terms of percentage recovery as well as the CV (1.5 % for both methods)
- Pipette based dispensing method demonstrated a striking influence of operator handling in terms of percentage recovery, CV and inter-operator CV
 - Coefficient of variation is higher (4-5 %) with pipette due to the difference in pipette operation between each dispensing
 - Percentage recovery: As controls were prepared by operator 2 with pipette, the percentage recovery is close to 100 % as same method of collection and dispensing was used. On the contrary, operator 1 has lower percentage recovery due to difference in pipette handling.
 - CV between operators can go up to 18 % (average 15 %) for pipette based dispensing methods due to difference in pipette handling.

Conclusion

HEMAPEN™ is a novel, high precision blood collection and dispensing platform. It integrates end-to-end capillary with pre-punched DBS paper for automated blood collection and dispensing. It pairs the advantage of DBS microsample stability, whilst addressing the associated limitations of known volumes, hematocrit effect and sample integrity.

The HEMAPEN™ is in development and is for investigational use only. Not Available for Sale.