Improving Method Reproducibility and Efficiency in Food Testing: How Can Liquid Handling Automation Help?

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INTRODUCTION

Routine food testing laboratories often perform multiple workflows and procedures which require significant manual pipetting steps. These steps can be repetitive, laborious, and require a high degree of operator skill to avoid errors and ensure accuracy of results. These workflows are typically people-intensive and require careful adherence to the process to maintain reproducibility. However, manual processes can complicate the situation, as multiple personnel repeating routine tasks will inevitably have small variations in their ability to conduct the work. To ensure method reproducibility, every lab manager is faced with these questions:

- How can this process be done more quickly?
- How can we remove errors in reproducibility between staff?
- Is there a more efficient process?

The implementation of laboratory automation to replace manual workflows provides a solution to these issues. However, barriers to investment, implementation, and training to adopt even simple laboratory automation can feel challenging. While automation is often associated with the replacement of people, automated liquid handling instead enables laboratory personnel to focus on higher value tasks by relieving time-consuming manual processes, like pipetting.

This white paper describes how innovations in automated liquid handling technology have lowered the barriers to adoption, and shares the process and experience of Eurofins Nutrition Analysis Center (Des Moines) in trialling an automation system to improve laboratory efficiency.

WHY ARE FOOD TESTING LABORATORIES CONSIDERING AUTOMATION?

Food testing laboratories are increasingly looking towards automation to improve efficiency and reduce costs associated with routine methods. Automation of laboratory operations refers to any activity where manual processes are replaced with inanimate, automated procedures. Solutions may include robotics or software-based tools, or a combination of both. Automation is particularly helpful in routine and repetitive operations that may include sample preparation, data processing, liquid handling, and sample transport.

Laboratory automation tools provide multiple benefits for routine food testing laboratories, including the ability to deliver high-quality data in a timely and efficient manner. One of the biggest benefits is the reduction in method variability when a manual process is replaced by automation, through improved precision and reliability.

Additionally, automation can enable laboratories to increase workloads and throughput while minimizing the need to correspondingly increase staffing levels. Current laboratory staff can then also focus on more high-value and meaningful work when the need for repetitive and time-consuming tasks are reduced. Cost benefits also include possible reduction in solvent volumes when compared with manual processes, thereby decreasing reagent and waste removal costs.

As a result, there is a corresponding reduction in laboratory personnel's contact with chemicals, which can reduce health and safety risks to employees.

Liquid handling in calibration standard and sample preparation is one of the most cost-effective types of automation applicable to routine food analysis laboratories. Commercially available automation solutions for sample preparation can perform functions such as liquid extraction, mixing, centrifugation, evaporation, dilution, and more. However, smaller robotic solutions that focus on specific workflows like liquid handling and pipetting can be a more cost-effective way to gain the benefits of automation with a faster return on investment (ROI). Laboratories can use these solutions to automate manual processes and improve efficiency, providing both improved throughput as well as cost savings.

ADOPTING LIQUID HANDLING AUTOMATION

The automation of routine liquid handling has been shown to minimize variability, improve traceability, and simplify method transfer. This capability improves efficiency in the lab, while also allowing scientists to spend more time on value-added tasks – such as method development and validation, data analysis, and data interpretation. Additionally, removing time-consuming manual tasks enables analytical scientists to make decisions faster.

While there are convincing arguments for automating liquid handling workflows for food analysis, laboratories may have concerns about adopting automation solutions. One of these concerns includes the costs of implementation. Another item of concern is sample carryover (also called memory effect) in liquid handling systems that originates from general laboratory contamination and sample preparation. As a result, some analysts prefer to trust their own capabilities with manual processes.

However, innovative automated liquid handlers, such as the Andrew+ pipetting robot, address these concerns by reducing errors introduced by sample carryover. Andrew Alliance (owned by Waters Corporation) is known for its intuitive automation technology that includes robots and cloud-native software for liquid handling. The Andrew Alliance portfolio includes the Pipette+; the Andrew+ liquid handling robot supported by additional connected devices and tools; and OneLab, an intuitive cloud-native software that enables fast, flexible, and traceable sample preparation capability. These solutions are designed to be more cost-effective, and can save time by improving data quality and reducing errors introduced by sample carryover.

One of the biggest considerations in adopting laboratory automation like the Andrew+ is the frequency of the repetitive event. For example, the automation of highly repetitive, time-consuming tasks performed consistently will be more cost-effective than the automation of an action performed occasionally or intermittently. It is vital for each laboratory to assess the cost-benefit for integrating automated solutions into their methodology. Laboratory automation solutions like the Andrew+ offer a faster return on investment for routine food testing laboratories looking to streamline parts of their analytical process. Furthermore, leveraging the same solution on multiple methods can further increase efficiency and productivity.

ANDREW ALLIANCE ANDREW+ LIQUID HANDLING ROBOT

The Andrew Alliance™ Andrew+ flagship liquid handling robot's ability to reduce human error while improving laboratory efficiency and reproducibility are the primary benefits to routine food analysis workflows. The Andrew+ pipetting robot and OneLab™ Software offers liquid handling automation without the need for extensive programming or engineering experience. OneLab cloud-native software also enables full traceability of protocols for consistent method transfer, as well as the ability to graphically design pipetting protocols in minutes. These protocols can then be executed straight away in any laboratory in the world – even allowing the remote monitoring of ongoing experiments.

In addition to pipetting liquids, the Andrew+ liquid handler can perform a wide range of complex experimental steps, such as column and plate grabbing and maneuvering. The use of different laboratory tools by the Andrew+ robot is further supported by an ever-expanding range of Dominos; a modular solution that enables Andrew+ to use a broad range of consumables. Integrating compatible mixing, heating and cooling instruments can enable automation of more complex workflows. The Andrew+ can also improve traceability, with built-in intelligence that pinpoints the source of the error if a method fails.

EUROFINS SAVES TIME AND REDUCES POTENTIAL ERRORS WITH LIQUID HANDLING AUTOMATION

The Eurofins Nutrition Analysis Center, in Des Moines, Iowa, specializes in analyzing feed, commodities, pet food, human food, and dietary supplements for nutritional content. The laboratory's services include:

- Macronutrients, such as proteins, carbohydrates, and lipids
- Micronutrients, such as vitamins, minerals, and amino acids
- Nutrition labeling, including nutrition testing as mandated by the U.S. FDA Nutrition Labeling and Education Act (NLEA)
- Shelf life and stability, such as storage capabilities, microbiology, rancidity, and sensory

With a wide range of clients across multiple industries, the Eurofins Nutrition Analysis Center is continuously looking to improve laboratory efficiencies wherever possible. Like any nutritional laboratory, sample preparation is a critical stage in Eurofins' analytical methods. After a recommendation from Waters personnel, the Eurofins team decided to trial the Andrew+ automation solution to remove manual liquid handling processes that were time consuming and could potentially introduce human error.

The Andrew+ robot's ability to enable time savings, allowing more time for data analysis, while also reducing the risk of errors introduced by manual processes, was the primary benefit for Eurofins. Additionally, the Andrew+ robot and OneLab Software offered liquid handling automation without the need for extensive programming or engineering experience.

OneLab cloud-native software enabled Eurofins to maintain full traceability of protocols, which enables consistent method transfer. The ability to graphically design pipetting protocols quickly and then execute them immediately in any lab in the world is valued, as is the remote monitoring of ongoing experiments.

The Eurofins Nutrition Analysis Center started by conducting trials with the Andrew+ to ensure it was able to meet the laboratory's needs. These trials included specific tests to measure the robot's performance when compared with the manual process currently used by laboratory personnel. It was also vital that results of the automation trials were validated, so they could provide this evidence to their customers showing equivalent or superior performance of the Andrew+ robot.

Based on the trial data, Eurofins calculated that the Andrew+ automation system could save between 30 to 60 minutes of an analyst's time per day. However, saving time was just one improvement. Dr. Kai Liu, Eurofins Senior Scientist, explains: "The Andrew+ actually exceeded our expectations. We explored different solvents, analytes, and volumes from 10 microliters (µL) to a 10 milliliter (mL) scale. We were looking at any methods with repetitive pipetting work where it could potentially help. Some tests included liquid transfer directly into an HPLC vial, so no further transfers were needed. When we compared the results of the manual process with the automated process, the robot was equivalent or even better [than the manual process]. Its performance met our internal requirements regarding quality as well. While the robot is not necessarily faster than a human, it is worry-free and error-free. Our analysts can use that extra 30 to 60 minutes to attend to more important tasks."

The Eurofins trial found the Andrew Alliance Andrew+ System was compatible with hexane, methanol, water, acetonitrile: water, and methanol: water solutions using volumes ranging from 0.01 to 10 mL pipetted into HPLC vials and 50 mL centrifuge tubes. (Other types of labware compatible with the Andrew+ include generic borosilicate test tubes, microplates, and micro centrifuge tubes.)

As a result, the Eurofins team concluded many of its epithelial sodium channel (ENaC) methods can benefit from an automation process that can perform various dilutions, especially when performed in the LC vial (Table 1). Almost all method calibration curves can be prepared by the Andrew+ liquid handling robot. All experimental steps are logged via the OneLab Software, enabling these methods to meet or enhance quality standards, in addition to saving manual labor.

Dr. Elaine (Wenjuan) Jobgen, Eurofins Nutrition Analysis Center's Director of Operations, explains: "We use a lot of key performance indicators (KPIs) that we keep track of every day. We set goals accordingly. So, let's say you have 8 hours of one analyst's time, and they can run about 40 samples a day. But we want to improve our efficiency to 60 samples per day. How do we get there? Laboratory automation can help us do that. Additionally, we must consider quality control measures – because quality is one of the most important factors for our clients. We must make sure any solution can duplicate the level of quality we require."

With the Andrew+ liquid handling automation system fully operational in the Des Moines laboratory, the Eurofins Nutrition Analysis Center has begun the validation process of adding the robot to the company's LC and LC-MS workflows.

	Analysis	Technique	Diluent	Operation	Total dilution ratio	Accuracy (dilution ratio)	
						Andrew+	Manual
1	Sodium	IC-CD	Water	Serial dilution: 5 mL standard solutions mix with 5 mL water and mixing	1:64	-0.5% to 3.0%	N/A
2	Retinol	LC-FLR	Hexane	Serial dilution of 1–10 mL standard solutions with hexane and mixing	1:250	-2.8% to 2.9%	-5.0% to 4.2%
3	Vitamin D3	LC-UV/Vis	Methanol	Serial dilution of 0.4–10 mL various standard with diluent and mixing	1:250	0.2% to 1.7%	-0.3% to 3.5%
4	Galactose	Elecrochemical detection	Water/ Methanol	Serial dilution of 1–3 mL of standard solutions with diluent and mixing	1:500	-0.63% to 0.65%	N/A

Table 1. Accuracy of automated serial dilution and mixing of standard solutions in different assays.[1]

	Analysis	Technique	Diluent	Operation	Total dilution ratio	Number of samples	Difference % (compared to manual results)
1	Folic acid	Microbiological turbidity	Water	Serial dilution of 0.4–10 mL standard solutions with diluent and mixing	1:125	5	-3.8% to 5.7%
2	Cysteine and methionine	LC-FLR	Water	Single dilution from 1–10 µL to 500 µL and mixing	1:50	3	Cysteine: -0.5% to 1.5% Methonine: -0.7% to 2.3%
3	Amino acids	LC-UV/Vis	Water	Single dilution from 100 µL to 500 µL and mixing	1:5	4	Within -1.2% to 2.5% for 14 amino acids in 4 samples
4	Carnitine	LC-MS/MS	ACN/Water	Single dilution from 150 µL to 1500 µL and mixing	1:10	4	Within -1.1% to 0.4% for 3 samples and 6.7% in 1 sample

Table 2. Relative difference in food analysis results between robot and human operations in standard solution preparation.[1]

The long-term goal is to enable Eurofins scientists to spend more time on value-added tasks such as data analysis and interpretation, while also enabling improved turnaround time for clients, and better quality results. The Eurofins team credits its ability to continuously ensure the most efficient and accurate tests are used and validated to the ongoing collaboration between the company's nutritional analysts, instrumentation vendors like Waters, and Eurofins' clientele of food manufacturers.

ADOPTING AUTOMATION

Automating manual processes like liquid handling in routine food testing laboratories can potentially transform the food testing industry by improving method performance and increasing laboratory throughput and efficiency. Continuous developments in analytical chemistry enable method developers to refine older methods and find newer techniques that provide more robust, faster, and inexpensive procedures.

Evolving automated liquid handling solutions for quantitative analysis have made it easier to deliver a sample that is reproducible. The result is a simple, logical workflow that increases throughput and leads to the development of robust methods.

Innovations in automated liquid handling enable laboratories to reduce bottlenecks and waste, while delivering more information faster. These solutions also enable the easy transfer and validation of current methods, streamline analytical workflows, and help reduce laboratory operational costs.

These advantages combined with the flexibility, cost efficiency, and small footprint of automated liquid handling robots and software – like the Andrew+ liquid handling solution and OneLab Software – are enabling laboratories to streamline their workflows and improve the quality of results for complex analyses.

"While the robot is not necessarily faster than a human, it is worry-free and error-free. And our analysts can use that extra 30 to 60 minutes to attend to more important tasks."

DR. KAI LIU
Eurofins Senior Scientist

While the advantages are numerous, any automation system needs to be affordable, easy to learn, easy to use, and easy to maintain. Additionally, laboratories must carefully evaluate automation solutions to determine which procedures integrate effectively with existing instrumentation. Laboratories should look closely at the ROI of automated liquid handling by comparing the extensive number of samples that can be analyzed in shorter time as compared to the manual processes. ROI also can take many other forms, including improvements in the quality of the data, throughput or efficiency gains, and the ability for personnel to focus on more important tasks.

Dr. Jobgen explains how Eurofins considered the ROI of the Andrew+ prior to purchasing the liquid handling robot for the Des Moines laboratory: "We look at efficiency, but also quality as well. We wanted to automate the liquid handling process because it takes a lot of pipetting, which is time consuming and does have a small risk of human error. Originally, we were looking at a system from another vendor because it was used in one of our sister labs in Europe. But that changed when the team learned about the Andrew Alliance Andrew+ automation system. It met our needs, plus it was much less expensive than the other one we were considering. We see many benefits, including the improved consistency in liquid handling for sample preparation."

To ensure that they can offer their customers the most efficient and comprehensive service, food testing laboratories should make the most of partnerships with instrument vendors and industry colleagues to adapt to new testing requirements quickly and seamlessly. Collaboration enables the continued optimization of methods for analysis, and vendors are facilitating these advances with dedicated automation solutions like Waters and Andrew Alliance instrumentation and software. These comprehensive solutions enable food laboratories to meet compliance requirements, decrease operation costs, increase productivity, protect brands, and most importantly, help ensure public health and safety.

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