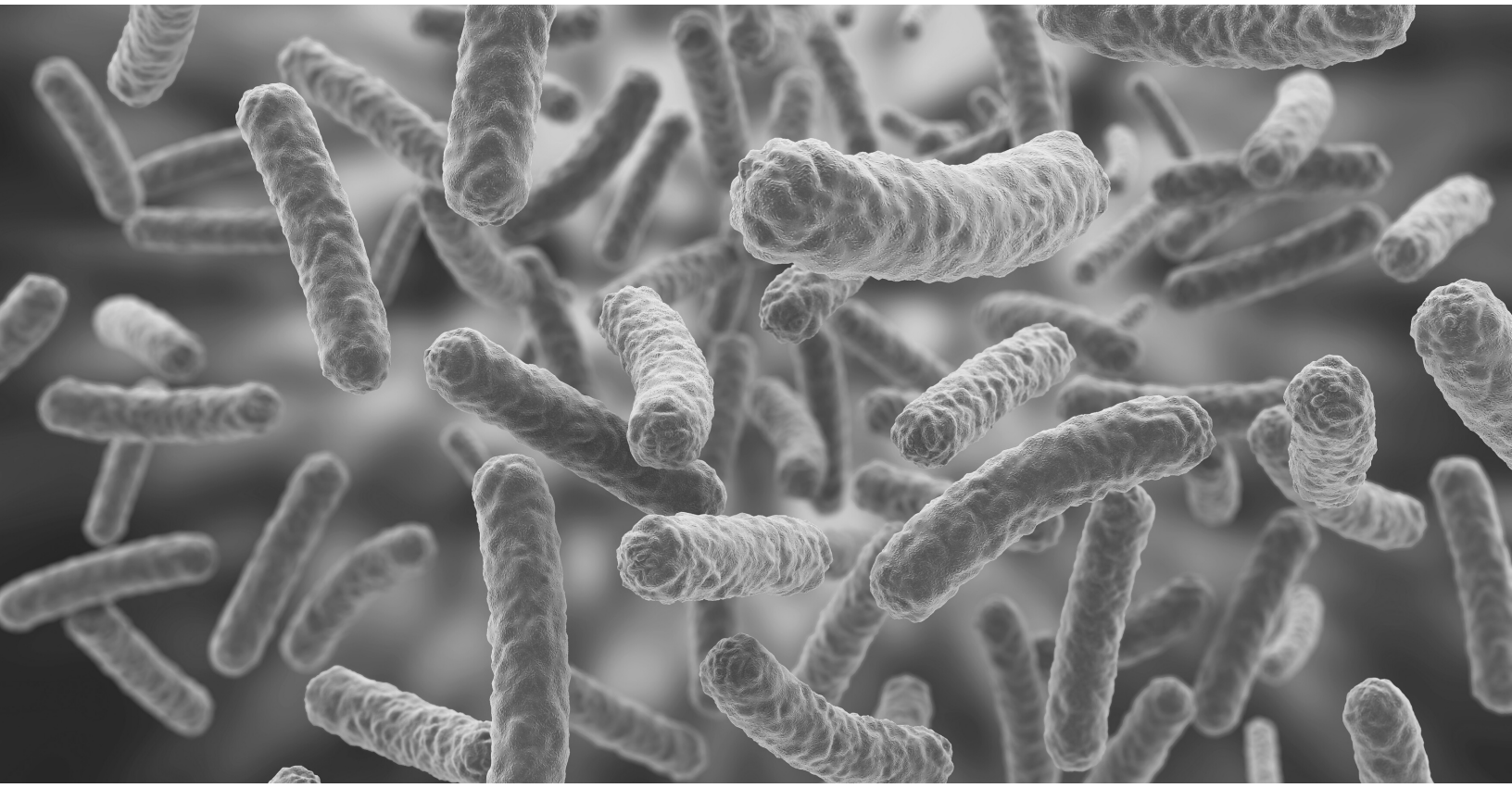
Impedance flow cytometry
and it's use in monitoring food processing environments



A Romer Labs® Publication
Distributed by Vendart Diagnostics Pty Ltd
14/128 Station Road, Seven Hills NSW 2147
(02) 9139 2850
sales@vendart.com.au
www.vendart.com.au

VENDART DIAGNOSTICS

ROMER Romer Labs®

Editorial

Filling the Gaps in Your Environmental Testing Program with Flow Cytometry

The presence of bacteria in food and beverage manufacturing facilities can affect product shelf life and quality. Pathogens can even lead to foodborne illness. This is why cleaning and disinfection are paramount to securing food safety and protecting your reputation and your business.

But cracking down on something you can't see isn't always easy and straightforward. Visual inspection can help, but it isn't enough by itself. Traditional microbiological methods often don't allow for preventive control and preoperational actions as lab results take days. ATP tests, while simple and fast, quantify biological residues, which are not a meaningful proxy for disinfection efficacy. Yet despite these limitations, you are expected to make informed decisions, fast.

Here we discuss impedance flow cytometry and how it can give food producers immediate, on-site verification of their environmental testing programs. I open with a look at the 5 most stubborn gaps in any environmental testing program and go into detail about why traditional testing methods can miss, for example, viable but non-culturable or psychrotrophic bacteria – and why this is a problem.

My colleague Cristian Ilea continues with a discussion about impedance flow cytometry and the new CytoQuant® flow cytometer. With CytoQuant®, food producers can get an instant look at bacteria and particle residue concentrations on their production surfaces. A quick look at the inner workings of CytoQuant® and how it is able to quantify bacteria and residues instantly rounds out the issue.

At the end of the day, too much is at stake—in terms of consumer safety and company reputation—for food producers to have to wait for days to get vital information about their cleaning and disinfection program. This is what motivated us to explore flow cytometry and, ultimately, to develop CytoQuant®.

Stefan Widmann

R&D Team Lead, Romer Labs

Content

5 gaps in your environmental monitoring program

Even the best-planned cleaning and disinfection monitoring programs have their blind spots. Stefan Widmann takes a closer look at five of the most likely – and most dangerous – gaps in your environmental monitoring program and explains what they are, why you should care about them, and what you can do about it.

By Stefan Widmann, R&D Team Leader, Romer Labs

While we do not yet know all bacteria species that can become VBNC, we know some that do; they count indicator organisms, adulterants and pathogens among their numbers.

#1

Viable but non-culturable (VBNC) microorganisms

For a long time, microbiologists assumed that any bacteria that failed to grow on normal culture media were dead. Subsequent research revealed that there is a third state beyond culturable and dead: viable but non-culturable (VBNC). In general, bacteria in the VBNC state do not multiply but are still alive, as shown by their metabolic activity. Most relevant to us is the fact that they can become culturable after resuscitation and thus proliferate in food. Moreover, some pathogenic bacteria will not grow in the absence of a host and need only to survive in food until ingestion to cause illness.

There are many reasons why bacteria can go into the VBNC state; starvation, incubation outside the temperature range optimal for growth, elevated osmotic concentrations, levels of oxygen concentration, or exposure to white light are just some causes. The specific traits of the bacteria strain in question determine what exactly causes bacteria to enter this state.

Why should you care?

Some bacteria able to enter the VBNC state are of concern for food manufacturing. While we do not yet know all bacteria species that can become VBNC, we know some that do; they count indicator organisms (such as *Klebsiella aerogenes* and *Klebsiella pneumoniae*), adulterants (such as *Lactobacillus plantarum* and *Lactococcus lactis*) and pathogens (such as *Salmonella Typhimurium*, *Campylobacter coli* or *Listeria monocytogenes*) among their numbers.

Having identified them, we must now ask whether these bacteria could return to a fully culturable and potentially pathogenic state. Microbiologists were, for a long time, in the dark on this question, as it is difficult fully to separate VBNC bacteria from culturable ones. Researchers have solved this problem, in part, by using a statistical approach: they dilute high numbers of VBNC bacteria to the point that it is nearly impossible for any culturable bacteria to remain. The bacteria are then counted after a defined period of time. If high degrees of growth are observed, the only possible conclusion is that bacteria have left the VBNC state and have become culturable. A further corollary is that if they can return to a culturable state, they can also become pathogenic again. There are examples of exactly this phenomenon leading to outbreaks. For example, VBNC *E. coli* O157 were suspected in an outbreak in Japan in 1997, as the total numbers of *E. coli* were insignificant and shigatoxigenic strains such as O157 could cause illness in very low numbers.

#2

Anaerobic and microaerophilic bacteria

Anaerobic bacteria or, more generally, anaerobic microorganisms, can be divided into three groups: obligate, aerotolerant and facultative. As their names indicate, they each have special requirements regarding the air, or more precisely, the oxygen, surrounding them. Obligate anaerobes such as *Clostridioides difficile* are harmed by oxygen and will die shortly after exposure. Aero-tolerant bacteria such as *Clostridium botulinum* cannot make use of oxygen and will neither

die nor grow in its presence. Facultative anaerobes can use oxygen but do not need it for growth, as is the case with *E. coli*. There is also the group of microaerophilic bacteria such as *Campylobacter* that need some oxygen to grow, albeit in much smaller amounts (1-2%) than in normal air but can be inhibited in aerobic conditions.

Why should you care?

Several pathogenic bacteria have these special growth requirements. Currently, thermotolerant *Campylobacter* species are cause for worry among public health professionals. On average, every other chicken is infected with *Campylobacter*, making poultry meat one of the most common causes of food poisoning. In the EU, illnesses caused by *Campylobacter* species occur twice as often as those caused by *Salmonella*. Of the anaerobic group, a *Clostridia* species such as *C. botulinum* is responsible for the foodborne illness known as botulism, often transmitted through canned (i.e., oxygen-poor) food, in which *C. botulinum* can thrive and produce the compound botulinum, which is toxic to humans. Another Clostridia species, *C. perfringens*, is the most common source of food poisoning in the US and Canada and causes symptoms such as abdominal cramping and diarrhea. The risk of *C. perfringens* infection correlates especially strongly with food kept or stored in warm conditions for longer periods of time, which favors their growing to infectious numbers (104 cfu/g).

The Great Plate Count Anomaly

Some estimates indicate that only 1% of bacteria can be cultivated with the knowledge and techniques currently at our disposal. The "great plate count anomaly" is the term we use to describe the observation that microscopic cell counts are significantly higher than corresponding counts of "colony forming units" on agar plates. A couple of examples can illustrate this phenomenon best: while 50% of the microorganisms of the oral flora can be cultured with agar plates, most of the gastrointestinal flora cannot be cultured at all. The reasons for this are numerous, but the organism community surrounding the species in question, including other bacteria as well as plants and animals, may play an important role.

Aerobic plate count methods rely on very general media, which do not support the growth of most bacteria groups. Technically, this is not really part of the great plate count anomaly, as some bacteria are able to grow on special agar plates under special conditions (such as anaerobic or microaerophilic conditions).

Why should you care?

The great plate count anomaly does not pose significant problems in day-to-day testing runs, as aerobic plate counts for indicator microorganisms are specific to a given production environment and, as such, are always relative to an established baseline determined for that production environment.

Plate methods are very time-consuming, requiring an incubation period of up to ten days, depending on the protocol in effect.

Psychrotrophic Pseudomonas species are the microorganisms most often responsible for spoilage in aerobically stored chilled meat.

However, plate methods are very time-consuming, requiring an incubation period of up to three days, depending on the protocol in effect. There are direct methods that do not require a cultivation step to count bacteria; microscopes provide a comprehensive view of bacteria but are also very time-consuming. While direct methods such as flow cytometry are common in water treatment facilities, they are not common in the food industry.

#4

Psychotrophic bacteria

Psychrotrophic bacteria can grow at temperatures as low as 0 °C, with optimal and maximal growth temperatures above 15 °C. This makes such microbes especially problematic for foodstuffs and beverages such as raw meat and milk stored at low temperatures for longer periods of time. The psychrotrophic groups of bacteria most commonly found in food are the Gram-negative genera *Pseudomonas*, *Aeromonas*, *Achromobacter*, *Serratia*, *Alcaligenes*, *Chromobacterium* and *Flavobacterium* as well as Gram-positive genera such as *Bacillus*, *Clostridium*, *Corynebacterium*, *Streptococcus*, *Lactobacillus* and *Microbacteria*. *Listeria monocytogenes* and some strains of *Clostridium botulinum* are also known to be able to proliferate at refrigeration temperatures.

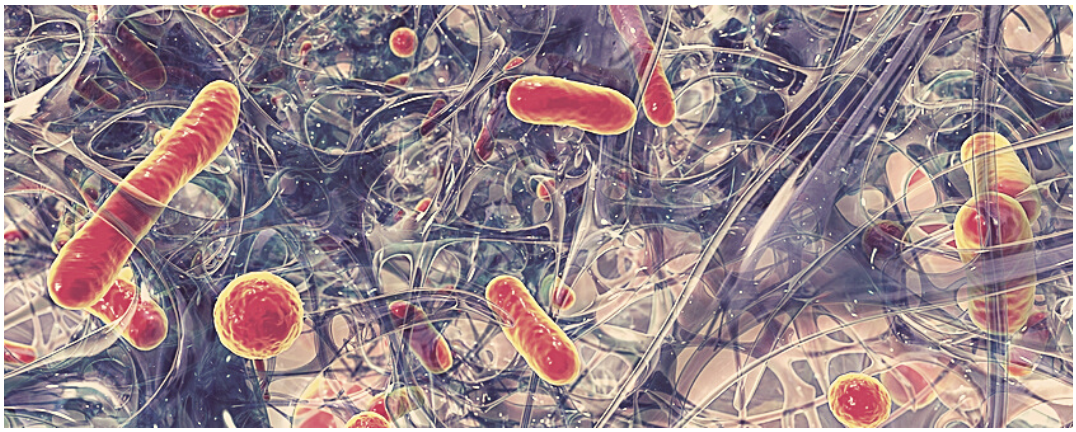
Why should you care?

Psychrotrophic bacteria are adulterants and can significantly diminish the quality and the shelf life of food. Chilled production facilities and storage tanks offer a favorable environment for the multiplication of these bacteria species. In chilled milk, for example, *Pseudomonas fluorescens* can produce both proteases and lipases. Hence, species belonging to the *Pseudomonas* genus are regarded as typically responsible for technological difficulties, as the proteases and lipases they produce can cause milk fat and proteins to degrade, giving milk a greyish color and bitter taste. *Pseudomonas* species are the microorganisms most often responsible for spoilage in aerobically stored chilled meat. It is well known that *Pseudomonas* species are very robust and able to withstand stressful environmental conditions that would inhibit the growth of other spoilage microorganisms. In vacuum-packed, refrigerated raw meat, the microflora is dominated in most cases by psychrotrophic lactic acid bacteria. Moreover, growth of pathogens during refrigerated storage could lead to serious illness.

#5

Biofilms

Microorganisms are able to colonize surfaces by forming a polymeric matrix in which multiple microbial species may be present; this is known as a biofilm. Evidence shows that the ability to form and survive in biofilms is not restricted to specific groups of microorganisms. In fact, the vast majority of bacteria are able to form biofilms. Biofilms may therefore be composed either of monocultures or of several different microorganism species. Some



researchers have suggested that the complex structure of mixed biofilms renders them more stable and more resistant to cleaning chemicals. The initial population that binds to the surface can change the properties of that surface, allowing for those that come later to adhere via cell-to-cell association; in some cases, the attachment of a second species may increase the stability of the biofilm population. For example, studies show that *L. monocytogenes* is more likely to adhere to steel in the presence of *Pseudomonas*.

Why should you care?

Biofilms that form on food processing equipment and other food-contact surfaces act as a persistent source of contamination, threatening the overall quality and safety of food products and possibly resulting in foodborne diseases as well as economic losses. Spoilage microorganisms are known to be responsible for almost a third of losses in food supply chains, making biofilm prevention and control a priority in the food industry. Microorganisms that form or thrive in biofilms are more resistant to disinfection, making them problematic in a wide range of food industries. Other effects of biofilms such as the corrosion of metal surfaces are a further critical concern in the food industries. In either case, the presence of biofilms in a food factory puts human health at risk. The degree of risk is dependent on the bacterial species forming this three-dimensional, living structure.

How do you close these gaps? The potential of flow cytometry

Food producers generally do not have many options at their disposal. Those that offer a modicum of precision, such as vital staining in combination with microscopes, can quantify VBNC bacteria but are time-consuming and require special equipment. All groups of anaerobic and microaerophilic bacteria – with the notable exception of facultative anaerobes – can grow on classic agar plates, but only under carefully controlled oxygen levels.

Yet agar plates are no panacea. Agar plates are able to count only approximately 1% of known species of bacteria and take days to deliver results – up to 10 days in the case of psychrotrophic bacteria. ATP methods, while fast, do not quantify bacteria and are of only limited use in detecting bacteria from biofilms; the kinetic data from freely suspended planktonic cells should not be used as a reference as the release of ATP is much lower for biofilms. Moreover, ATP traces coming from food residue or fungi can easily overshadow the ATP released by bacteria, as eukaryotic cells contain 10 million times more ATP than prokaryotic cells. Accordingly, ATP devices used to detect biofilms tend to have a much higher limit of detection, meaning that they are not as sensitive as they would be when detecting free-floating bacteria.

Each of these five cases has shown just how difficult it can be to detect bacteria and residues on food production surfaces; the shortcomings of the most common detection methods, such as plating and ATP testing, are as stubborn as they are well-documented. What can food producers do to close the gaps that cultural methods and ATP testing leave behind? In the next article, my colleague Cristian Ilea discusses the potential of impedance flow cytometry and the CytoQuant® flow cytometer, a new solution that immediately quantifies bacteria and residue particles on surfaces.

ATP traces coming from food residue or fungi can easily overshadow the ATP released by bacteria, as eukaryotic cells contain 10 million times more ATP than prokaryotic cells.

Flow cytometry and verification of cleaning and disinfection in food manufacturing facilities

Food safety depends in large part on the hygienic conditions in food manufacturing facilities. High levels of spoilage bacteria can affect the shelf life and quality of foodstuffs, while the presence of pathogens (such as *Salmonella* and *Listeria*) can lead to serious illness. Food manufacturers must be diligent in keeping their processing environment clean and free of pathogenic microorganisms to prevent the cross-contamination of the final product. But how is this currently being done?

By Christian Ilea, Head of Marketing and Product Management

Food manufacturers need a quick method that directly quantifies both bacteria and residue particles and is not influenced by disinfectants and temperature.

Visual inspection

While visual inspection is a prerequisite, it is in and of itself not sufficient. It is a subjective and imprecise means of verifying proper cleaning. More importantly, even if a surface has no apparent residue, this does not mean it is immaculate. Visual inspection cannot ensure that all food residues from the previous run have been cleaned away or that a sanitizer has effectively reduced the microbial level on the surface.

Microbial enumeration with culture-based methods

These are the traditional methods for monitoring the hygiene of the processing environment. Generally, there are two ways to perform sampling: contact-based and swabbing-based. With contact-based methods, plates or dip-slides are placed on the surface to be sampled and then incubated. Swabbing-based sampling is carried out with swabsticks or sponges that are rinsed in a buffer solution which is then inoculated into sterile media and incubated. The main limitation of these traditional methods of microbial determination is the amount of time it takes to obtain results. Furthermore, most species of bacteria cannot be cultivated on agar, a phenomenon known as the great plate count anomaly.

ATP detection

Adenosine triphosphate (ATP) is a nucleotide that cells use to deliver energy. It can be thought of as the molecular “unit of currency" for energy within all living cells. Energy is transferred when ATP breaks down into its nucleoside and free phosphate. Hydrolyzing the covalent links of the phosphates liberates energy that is used for reactions. Commercial ATP test systems harness the luciferin/luciferase reaction, which is very common in nature, to generate light with the energy provided by ATP. The more light is emitted, the more ATP is present, which could indirectly indicate more food residues or (potentially) more microorganisms. Yet there is one important caveat: as these systems rely on an enzymatic reaction, potential inhibitors or less than optimal environmental conditions could elicit faulty results. Environmental temperature could increase reaction times, whereas light could make it difficult to obtain correct readings. Furthermore, disinfectants can interfere with the reaction, meaning that there may not be a real correlation between living bacteria present on the surface and the results of the ATP measurement. Hence, ATP-based methods are normally used to test surfaces before the application of the disinfectant.

ATP methods harbor a further disadvantage: they depend in their applicability on the nature of the food being processed. Most foods leave behind residue containing large amounts of ATP, which surpass by several orders of magnitude the amounts contained within bacterial cells. Practically, this means that ATP systems cannot be used to assess the microbial con- tamination of surfaces in most food processing facilities. Although no bacteria can be directly counted, ATP systems are widely employed because results are generated within seconds, a time-to-result available in no other commonly available technology until now.

Introducing flow cytometry

Flow cytometry (FCM) refers to a group of techniques that use optical or electrical signals to detect and measure certain physical or chemical properties of cells and particles suspended in a fluid. Nearly 300 studies conducted between 2000 and 2018 assessed **FCM** as a tool to characterize microbial water quality. This research was able to illustrate the value of FCM in water treatment, distribution and reuse. There is now a body of research documenting successful applications of FCM robust enough to suggest that it could reasonably and realistically see widespread adoption as a routine method for water quality assessment.

What does all of this have to do with the assessment of cleaning and disinfection efficiency in food manufacturing facilities? Methods previously common in water quality determination were often limited by low sensitivity, high labor and time requirements, susceptibility to interference from inhibitory compounds, and difficulties in distinguishing between viable and non-viable cells. (These all sound familiar, don't they?) But beware: fluorescence flow cytometers are generally unwieldy, expensive devices that require highly trained staff to operate.

Getting the power of flow cytometry into a handheld device

To make FCM a viable solution for cleaning verification in food processing facilities, it needs to come in a portable format that is simple and easy to use, yet accurate enough to provide reliable counts of bacteria and residue particles in environmental samples. This has been made possible by the use of impedance flow cytometry. Impedance flow cytometry is a specific kind of flow cytometry: instead of optical systems such as laser technology, impedance flow cytometers employ an alternating current at varying frequencies which enable the device to detect and count cells and residue particles separately. While optical-based flow cytometers are only able to count cells labeled with dyes, impedance flow cytometers can perform the same operation without any need for labeling. Compared to other flow cytometric devices, they are compact, portable and battery-powered, enabling them to be used where the sample is taken.

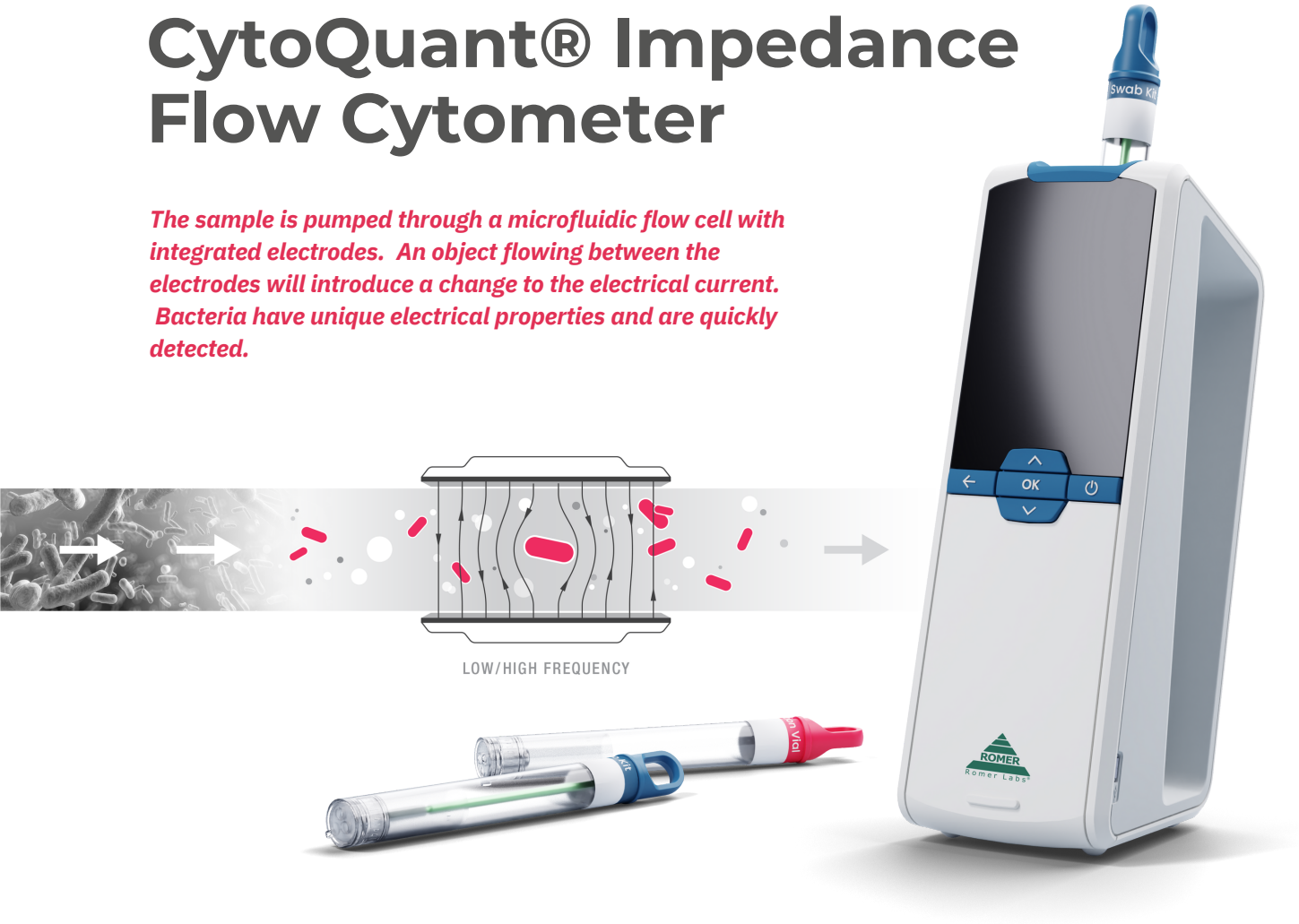
How can impedance flow cytometry distinguish between cells and residual particles?

The electro-magnetic properties of bacteria enable flow cytometers to distinguish them from other particles. The cytoplasm and the cell membrane of a bacterium change the electrical field in unique and identifiable ways. While the electrical current will move through metallic particles mostly unimpeded, non-conductive particles resist the field. Intact bacteria, however, resemble both non-conductive and conductive particles: the cell membrane prevents low frequencies from penetrating it, causing it to resemble non-conductive particles; at high frequencies, however, the electrical current penetrates the membrane. The microelectrodes in the impedance flow cytometer generate these electrical fields and enable the device to quantify the changes in conductivity and resistance in terms of separate measurements of intact cells and particles.

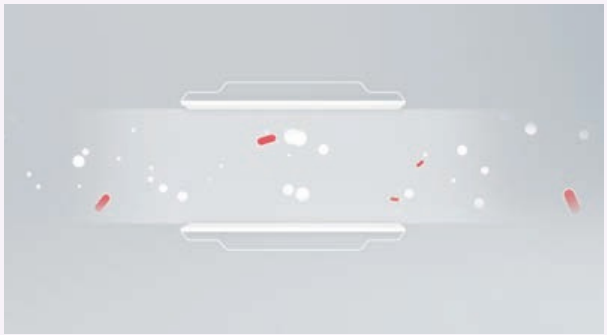
Impedance flow cytometers employ an alternating current at varying frequencies which enables the device to detect and count cells and residue particles separately.

CytoQuant® Impedance Flow Cytometer

The sample is pumped through a microfluidic flow cell with integrated electrodes. An object flowing between the electrodes will introduce a change to the electrical current. Bacteria have unique electrical properties and are quickly detected.



How impedance flow cytometers identify bacteria



Bacteria (in red) and particles flow through the microfluidic channel of the cytometer.

Microelectrodes in the microfluidic flow channel generate electrical fields at high and low frequencies.

Application of impedance flow cytometry to food safety: introducing CytoQuant®

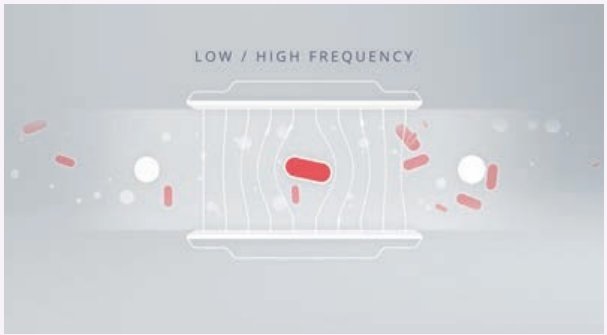
As mentioned above, one advantage that impedance flow cytometers hold over other kinds of cytometric devices is their portability. Light, small, and battery-powered, they can operate in the field and at critical control points where hygiene is an overriding concern.

The CytoQuant® impedance flow cytometer is designed for use in just such areas, including food production facilities and clean rooms. Impedance flow cytometry brings considerable advantages to food producers looking to verify their food safety and cleaning programs: the fast and separate quantification of bacteria and residue particles (which can serve as an indicator for the cleaning efficacy), the sensitivity of the method, and the robustness of the swabbing kit and the cytometer itself.

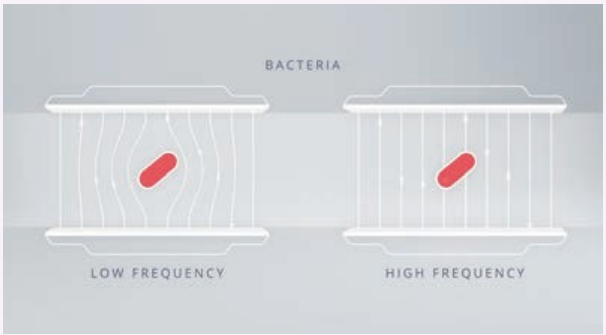
The CytoQuant® system is easy to use, as the device handles all the work except swabbing. A test run begins by swabbing a predefined area (e.g., 20 x 20 cm or 8 x 8 in) of the surface to be tested. The swab is placed in a tube containing a proprietary, conductive solution. After shaking the swab kit to suspend the bacteria, the user inserts it into the CytoQuant®. Two needles penetrate the bottom of the tube, connecting the liquid to the flow system in the device. Then, after the solution is introduced to the flow system, it is passed by the electrodes in the flow cell. After 30 seconds, the device registers separate results for bacteria and particles and displays them on the screen.

Revolution or evolution?

The CytoQuant® mobile flow cytometer enables the immediate, on-site verification of cleaning and disinfection procedures in food production facilities or other areas where hygiene is crucial. By directly quantifying bacteria and residue particles on surfaces without the negative influence of disinfectants or temperature, it provides substantial advantages over ATP devices, while the 30 second time-to-result makes it a perfect enhancement to hygiene programs that already use cultural methods. Considering the huge potential of impedance flow cytometry, it may at some point come to be regarded as equal to or even replace cultural methods as the standard in cleaning verification. This would amount to a true revolution in the field.



Bacteria and particles influence the electrical field as they flow between the electrodes.



The unique fingerprint of bacteria: the electrical field can only penetrate the cell membrane of bacteria at high frequencies. At low frequencies, the isolating quality of the membrane prevents this.

Impedance flow cytometry and its use in monitoring food processing environments

What is flow cytometry, how does it work, and what application could it have in the monitoring of food processing environments? Florin Soptica and Stefan Widmann answer these questions and more.

By Florin Soptica, Product Manager, Romer Labs; and Stefan Widmann, R&D Team Leader, Romer Labs

Impedance flow cytometry is a powerful variant of flow cytometry as it is very robust and can be used to assess cellular characteristics that are otherwise impossible to measure without the use of molecular tags, such as cell membrane integrity.

What is flow cytometry?

Flow cytometry refers to a group of techniques that use a laser or electrical field to count cells suspended in a fluid and to determine some of their physical or chemical properties. Optimally, only one cell at a time flows through the microfluidic channel of the cytome- ter, which detects variations in the wavelength of light or in electrical charge as each cell or other particles pass through. As flow cytometry generally requires large and expensive devices as well as fastidious preparato- ry steps, the method has traditionally been limited to laboratory use in fields of application such as research
and medicine.

Deploying impedance flow cytometry to count both cells and residue particles

Impedance flow cytometry is derived from the technology underpinning Coulter particle counters, which can size and count particles suspended in electrolytes based on changes in impedance caused by the displacement of electrolytes by the particles. By measuring multiple frequencies at the same time for each passing particle, impedance flow cytometry can discriminate between particles based not only on size, but also electrical properties. This is a powerful variant of flow cytometry as it is very robust and can be used to assess cellular characteristics that are otherwise impossible to measure without the use of molecular tags, such as cell membrane integrity. Therefore, instead of a laser, an impedance flow cytometer employs an alternating current, the varying frequencies of which enable the device to detect, measure the size of and separately count membrane-intact cells and other particles. Compared to other flow cytometric devices, impedance flow cytometers can be light, portable and battery-powered, enabling them to be used where the sample is taken. How do impedance flow cytometers tell the difference between cells and other particles?

Impedance flow cytometry takes advantage of the unique electromagnetic properties of the cell membrane and cytoplasm to distinguish bacteria from other particles. A cell's membrane and cytoplasm influence the electrical field in a way that is different from other particles in the sample. An example using metallic (conductive) particles, non-conductive particles and intact cells can illustrate this principle most clearly. Regardless of the frequency of the electric field, the conductivity of metallic particles will permit the electrical field to pass through unimpeded. Contrariwise, non-conductive particles such as polystyrene will resist the electrical field; the current will only advance in the liquid medium, which leads to a measurable volume displacement correlating with the particles in the flow channel. Intact cells, however, are unique in that they resemble both non-conductive and metallic particles, depending on the frequency of the electric field. At low frequencies, the isolating quality of a cell's membrane prevents the electric field from penetrating it, leading to the same kind of displacement as with non-conductive particles. Higher frequencies, however, can partially penetrate the membrane; as such, cells are

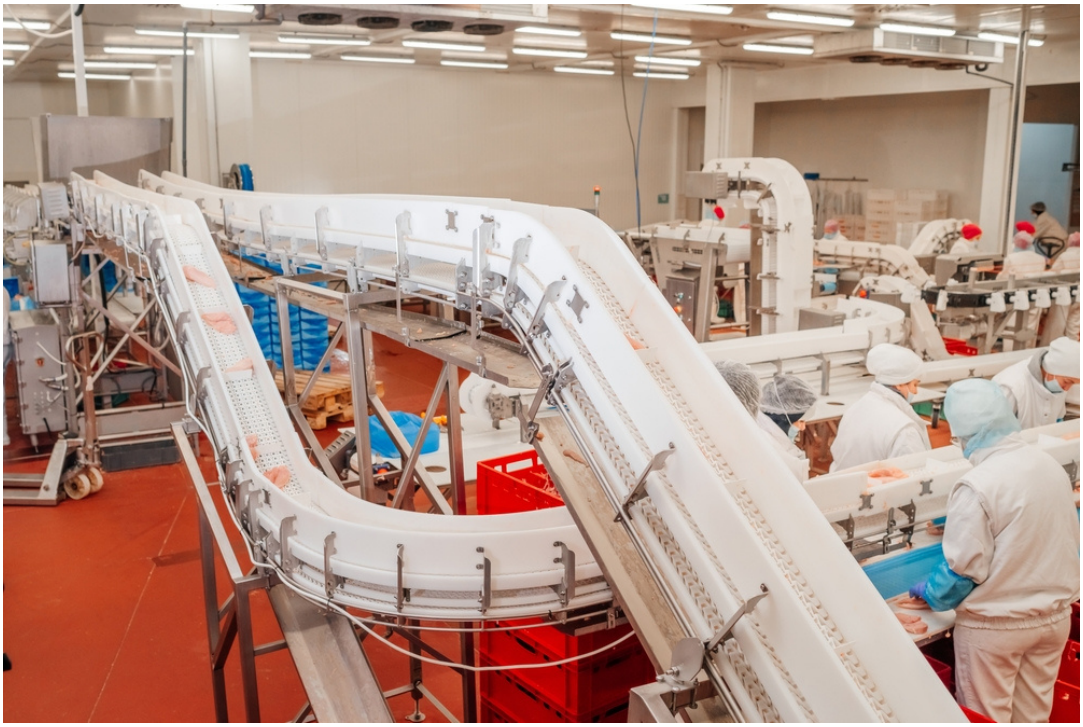
similar in conductivity to metallic particles. The microelectrodes in impedance flow cytometers generate fields at both low and high frequencies, allowing the device to detect these changes in conductivity and resistance and attribute them in precise numbers to either intact cells or other particles. The detector identifies the target as a bacterium based on the varying degree of impedance or conductivity at these frequencies. The user then receives separate counts of intact cells and other particles.

How does impedance flow cytometry compare to cultural methods?

Cultural methods, the use of agar plates in particular, are the traditional approach to monitoring the sanitation of food processing environments. Yet cultural methods, though well established, have several disadvantages concerning their speed and scope. Cultural methods are slow, requiring between one and ten days for bacteria to grow into countable colonies. These methods measure only what is culturable under the specific conditions of a given test run; a species or other grouping of bacteria may require a specific agar or liquid medium at an exact temperature, degree of light, or humidity, to name just a few variables. Cultural methods also can make no claims to comprehensive measurement of all bacteria in a sample. The "great plate count anomaly," a conundrum well-known in microbiology, observes that only a small fraction of bacteria in a habitat can be retrieved by culturing. Bacteria in a viable but non-culturable (VBNC) state are alive, but due to stress, idiosyncrasies or less than optimal environmental factors cannot grow on agar or in liquid media. In some cases, they can be cultured after resuscitation, a process that, again, is time-consuming. Some pathogenic bacteria, such as *E. coli* O157, have been known to enter a VBNC state only to proliferate in later stages down the food chain or in human hosts after ingestion.

Furthermore, anaerobic and microaerophilic bacteria require the absence of oxygen or levels of oxygen lower than that of normal atmospheric conditions, respectively. The bacteria in these groups that are culturable require special incubation conditions, adding to the cost of analytical tests.

Impedance flow cytometers count all bacteria that pass through the flow channel, regardless of their state (culturable, VBNC, non-culturable, dormant) or growth requirements. Such direct, immediate quantification broadens the scope of a hygiene control program; bacteria that do not multiply until coming into contact with food or potential hosts can also be targeted with impedance flow cytometry. It also allows for taking immediate action whenever cleaning and disinfection does not go according to plan.



Impedance flow cytometers count all bacteria that pass through the flow channel, regardless of their state (culturable, VBNC, non-culturable, dormant) or growth requirements.


95%
14:18
Home
Measurement
31 000
intact cells/ml
102 000
particles/ml
B82
ID
OK

VENDART

DIAGNOSTICS

SEE WHAT OTHERS DON'T SEE.

CytoQuant® quantifies bacteria & residues in 30 seconds

Get separate, precise counts for bacteria & residues on production surfaces.

VENDART DIAGNOSTICS

Contact us:
sales@vendart.com.au

(02) 9139 2850
vendart.com.au