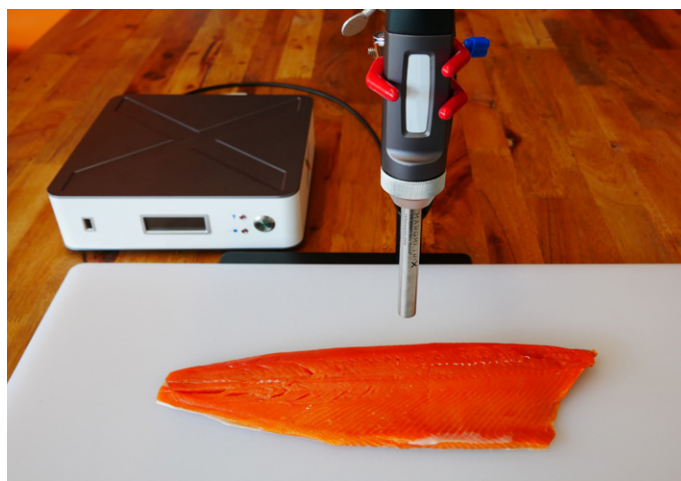




## Improving cultivated meat production with Raman spectroscopy solutions

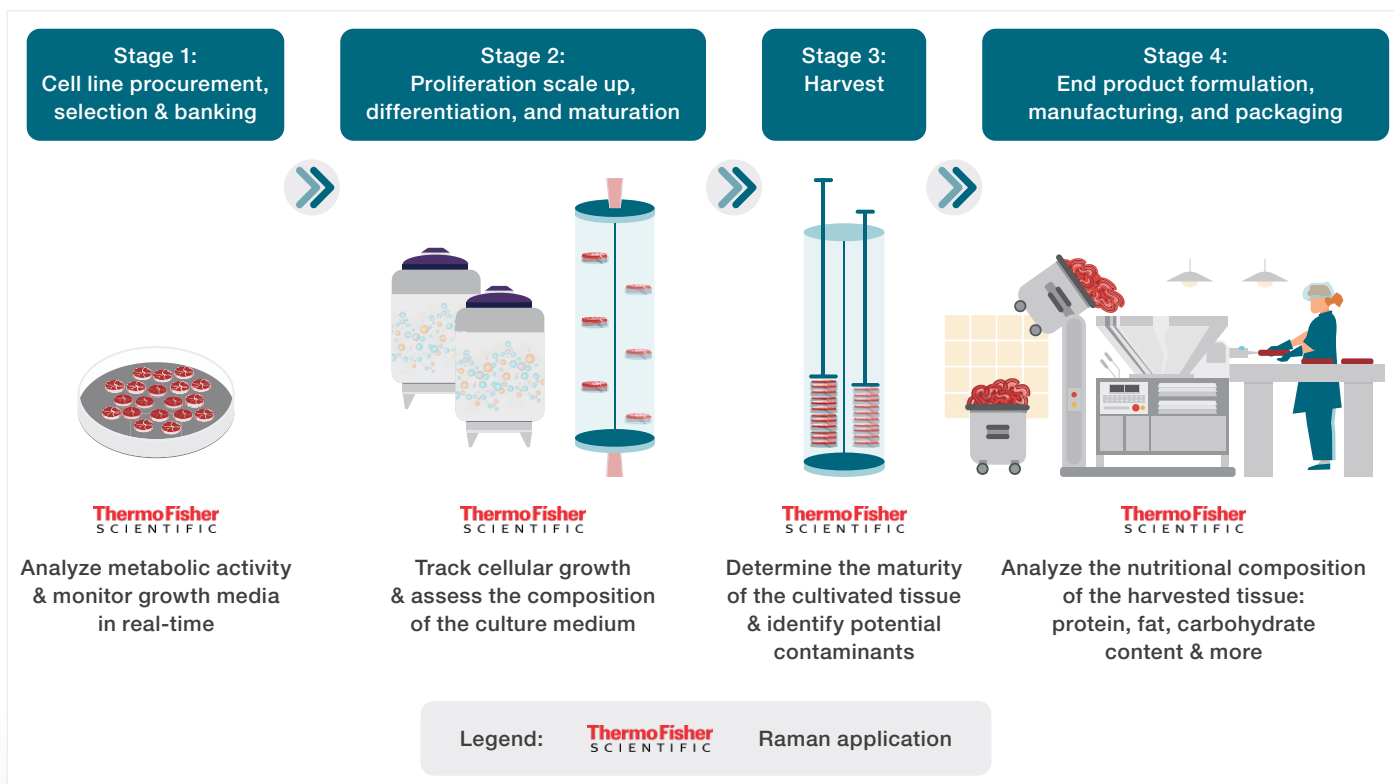
Traditional protein production methods have long been associated with extensive environmental damage, including deforestation, water pollution, and habitat destruction. As the world's population continues to grow, there is an urgent need for alternative sources of protein that are sustainable, efficient, and environmentally friendly. Enter cultivated-meat, which is revolutionizing the way we consume protein.

Raman spectroscopy technology presents a transformative opportunity for cultivated meat producers, offering a multitude of benefits to enhance productivity, accelerate time-to-market, optimize bioreactor utilization, and minimize waste associated with suboptimal batches. Raman spectroscopy empowers cultivated meat producers to unlock unparalleled levels of efficiency and maximize the full potential of their operations.



A solid-state Raman spectroscopy system, the MarqMetrix All-In-One Process Raman Analyzer has no moving parts, making it ideal for continuous process monitoring (including in-line, at-line, or off-line) and routine laboratory analysis.

## Optimizing cultured meat production with Raman spectroscopy



## Thermo Scientific™ MarqMetrix™ All-In-One Process Raman Analyzer

### Benefits

- Small, rugged, stable process analyzer
- Complementary analysis to your existing technology
- Raman spectroscopy models are available to help you monitor unique parts of your processes



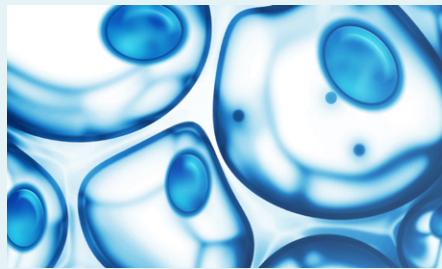
With a small footprint and no moving parts, the MarqMetrix All-In-One Process Raman Analyzer makes Raman analysis portable and puts decision-makers at the point of measurement.

### Selected cultivated meat applications

The MarqMetrix All-In-One Process Raman Analyzer empowers allows carbon capture companies to:



Monitor metabolite concentration



Measure cell density, viability, osmolarity



Achieve real-time monitoring, control, and optimization of the bioreactor environment



# Using Process Raman Spectroscopy in cultivated meat production

Cultivated meat, also known as lab-grown meat or cell-based meat, is a rapidly growing industry that aims to provide a sustainable and ethical alternative to traditional animal agriculture. While the technology for producing cultivated meat has advanced significantly in recent years, there is still much to be done to optimize the production process and ensure consistent quality of the final product.

One technology that has shown promise in addressing these challenges is Raman spectroscopy. Raman spectroscopy is a non-destructive analytical technique that can be used to identify and quantify the chemical composition of a sample. This makes it an ideal tool for analyzing the complex biological components of cultivated meat. In this article, we cover the seven benefits of using Raman spectroscopy for cultivated meat production.

## Cultivated meat: Benefits of using Raman spectroscopy

### Better cultivated meat process monitoring

One of the biggest challenges in producing cultivated meat is maintaining consistent quality from batch to batch. Raman spectroscopy can be used to monitor the composition of the cell culture media, the growth medium in which the cells are cultivated, to ensure that it remains consistent and free of contaminants. By monitoring the growth medium, it is possible to optimize the nutrient composition to enhance the growth and quality of the cells.

### Faster analysis times

Traditional analytical techniques can take hours or days to produce results. Raman spectroscopy, on the other hand, can provide results in minutes, allowing for real-time monitoring and rapid adjustments to the production process. This can significantly reduce production time and costs.

### Affordability

Raman spectroscopy allows companies to monitor and optimize production processes in real-time, which minimizes waste and achieves more efficient production outcomes. Unlike other analytical technologies, a solid-state Raman spectroscopy system like the MarqMetrix All-In-One Process Raman Analyzer does not require costly consumables or constant calibration, significantly lowering the cost of ownership. As the cultivated meat industry continues to scale, Raman spectroscopy will play a crucial role in reducing costs and improving sustainability.

"Raman spectroscopy allows companies to monitor and optimize production processes in real-time"

### **Non-destructive analysis**

Unlike many traditional analytical techniques that require destructive sample preparation, Raman spectroscopy is a non-destructive technique for identification and analysis of samples. The non-destructive nature of Raman spectroscopy, coupled with in-line monitoring or contact-less use ensures that valuable samples remain intact and can be further utilized, reducing waste and the need for additional production. This makes it a more sustainable and cost-effective option for analyzing cultivated meat samples.

### **High accuracy and specificity**

Raman spectroscopy is highly accurate and specific in identifying different biological compounds in a sample. This makes it an ideal tool for identifying and quantifying the complex components of cultivated meat, such as proteins, lipids, and nucleic acids. By understanding the chemical composition of the final product, it is possible to optimize the production process to ensure consistent quality and meet regulatory requirements.

### **Versatility**

Raman spectroscopy can be used to analyze a wide range of sample types, including solids, liquids, and gases. This makes it a versatile tool for analyzing different stages of the cultivated meat production process.

### **Scalability**

Raman spectroscopy can also play a crucial role in helping the cultivated meat industry scale sustainably. As the industry continues to grow and demand for cultivated meat increases, it is essential to find ways to optimize production processes and reduce costs. By reducing production time and minimizing waste, companies can produce more cultivated meat at a lower cost, making it more accessible to consumers.

### **Final thoughts**

In conclusion, Raman spectroscopy is a powerful analytical tool that can provide a range of benefits for cultivated meat production, including improved process monitoring, faster analysis times, non-destructive analysis, high accuracy, specificity, and versatility. By incorporating Raman spectroscopy into the production process, it is possible to optimize the production of cultivated meat and ensure consistent quality from batch to batch.

Moreover, as the industry scales, there will be a greater need for regulatory compliance and quality control. Raman spectroscopy's accuracy and specificity make it an ideal tool for ensuring that cultivated meat products meet the necessary regulatory requirements.



# Process Raman Spectroscopy for cultivated meat: Frequently asked questions

Raman spectroscopy has emerged as a valuable tool in various industries, including the cultured meat industry and bioreactor analysis. Its capabilities for measuring analytes, monitoring processes, and ensuring product quality make it an indispensable technology. In this context, the following questions explore the applications and implementation of Raman spectroscopy in the cultured meat industry:

## What can Raman spectroscopy measure in the cultured meat industry?

Raman spectroscopy is a powerful analytical technique that can measure various analytes in cultured meat production, providing valuable insights for process monitoring and quality control. Specifically, it can accurately analyze key components such as glucose, lactate, and amino acids, and more.

## How is Raman spectroscopy used in bioreactors?

Raman spectroscopy provides insights into the chemical composition and concentration of analytes within the bioreactor, including nutrients, metabolites, and product formation. It enables researchers and operators to monitor key components such as glucose, lactate, amino acids, and other relevant molecules in real time. This information helps optimize culture conditions, ensuring optimal nutrient supply, and maintaining desired metabolic activities.

Furthermore, Raman spectroscopy enables detection and identification of impurities, contaminants, and by products that may impact the quality of the cultured meat. This early detection capability enables timely interventions and adjustments, reducing the risk of suboptimal product outcomes.

## How can Raman spectroscopy be implemented for online monitoring in bioreactors?

Implementing Raman spectroscopy for online monitoring in bioreactors involves the use of specially designed probes. Thermo Fisher Scientific offers probes like the Thermo Scientific™ MarqMetrix™ Bioreactor BallProbe™ Sampling Optic, which features industry standard connections and is capable of withstanding high temperatures and steam exposure typically encountered in bioreactor environments.

This probe is also available as a single-use instrument. These probes can be seamlessly integrated into the bioreactor system, allowing real-time measurements of crucial analytes.

Additionally, Thermo Fisher Scientific offers the Thermo Scientific™ MarqMetrix™ Proximal Probe Sampling Optic, which enables measurements through the walls of glass or plastic vessels. This feature provides convenience and flexibility in monitoring samples without the need for invasive sampling techniques.

## Does the use of lasers in Raman spectroscopy for bioreactor analysis pose any risks or damage to the cultured cell culture?

The non-invasive nature of Raman spectroscopy makes it a valuable tool for bioreactor analysis. It enables continuous monitoring without disrupting the culture, minimizing the need for time-consuming and labor-intensive sampling procedures. The real-time data provided by Raman spectroscopy allows for prompt decision-making and adjustments during the bioprocess, optimizing productivity and product quality.

## Can the MarqMetrix All-In-One Process Raman Analyzer be used for cell culture media monitoring?

By utilizing Raman spectroscopy, the MarqMetrix All-In-One Process Raman Analyzer can accurately measure and track critical analytes such as glucose, lactate, amino acids, and other relevant molecules in the cell culture media. This allows for comprehensive monitoring of key components necessary for maintaining optimal cell growth and productivity.

The MarqMetrix All-In-One Process Raman Analyzer offers the advantage of being an integrated solution, combining the necessary hardware, software, and probes for efficient and seamless monitoring. It provides reliable and accurate data, enabling researchers and operators to make informed decisions and adjustments during the cell culture process.



# MarqMetrix All-In-One Process Raman Analyzer

## with TouchRaman Immersion Technology

### Raman insights in 15 minutes

The MarqMetrix All-In-One Process Raman Analyzer is the ultimate quality assurance, product development, and research tool. With the MarqMetrix All-In-One Process Raman Analyzer, businesses can conduct real-time, non-destructive and immediate analysis without sample preparation.

The Thermo Scientific™ MarqMetrix™ BallProbe™ Sampling Optic utilizing our patented TouchRaman™ Immersion Technology makes precise and accurate measurements simple to execute and understand. Our one-button hardware and easy-to-use software will have you taking highly accurate Raman measurements in less than 15 minutes out of the box.

Priced to be installed at all points of need, the MarqMetrix All-In-One Process Raman Analyzer is easily integrated into your existing process and eliminates the need for costly scientists.

### Raman Spectroscopy on the road

With a small footprint and lower cost, the MarqMetrix All-In-One Process Raman Analyzer makes Raman analysis portable and puts decision-makers at the point of measurement.

Pack your MarqMetrix All-In-One Process Raman Analyzer in a protective case and take it to the point of need. Factory calibration ensures continuous and precise process analysis out of the box.

### Features & benefits

- Non-destructive and immediate analysis without sample preparation
- Reduces cycle times and increases product yields
- Easy installation and operation
- Small footprint
- Factory calibration for hardware stability and portability

### Applications

- Biopharmaceutical manufacturing
- Pharmaceutical manufacturing
- Food and beverage processing
- Polymer and plastic manufacturing
- Hazardous chemical applications

Plug in.  
Measure accurately.  
There is no step three.





**MarqMetrix All-In-One Process Raman Analyzer**  
**with TouchRaman Immersion Technology**

Everything needed to take high-quality Raman measurements is combined into a single unit: the MarqMetrix All-In-One Process Raman Analyzer includes a spectrometer, laser, Thermo Scientific™ MarqMetrix™ Fiber BallProbe™ Sampling Optic, and acquisition computer.

Performance	
Excitation wavelength	785nm
Excitation power	10-450mW
Detector	Thermally stabilized CCD (2-Stage TEC)
Spectral range	100-3250 cm <sup>-1</sup>
Resolution	6.5cm <sup>-1</sup> average across spectral range
RMS dark noise	≤16.5 counts @ 10 sec integration

Physical properties	
Size	H 7.7cm
	W 25cm
	D 25cm
Fiber connections	FC/PC (both excitation and collection)
Probe	MarqMetrix Fiber BallProbe Sampling Optic
Mounting options	Stackable
Operating temperature range	15°C to 33°C
Operating humidity range	Non-condensing

Product safety	
Safety features	1 keyed
	Laser interlock switch, electronic laser trigger
Laser certification	Class 3B laser device reported to the FDA

Included peripherals	
Wireless keyboard, mouse, HDMI, monitor	



Electrical	
Input voltage	90-264 VAC
	50-60Hz
Operating voltage	12VDC, 2A

Onboarding control system	
Software	Raman suite
Controller	Integrated PC (Windows 10 OS)
Onboard storage	128 GB standard
Onboard I/O	1 RJ-45 ethernet Port 3 USB 3.0
Video output	1 display port 1.1 (VGA, DVI or HDMI with adaptor)







# MarqMetrix Bioreactor BallProbe Sampling Optic

## with TouchRaman Immersion Technology

### Engineered for repeatable measurements

The MarqMetrix Bioreactor BallProbe Sampling Optic is designed specifically to meet the requirements of the bioprocess industry. With the durability to handle the rigors of sterile practices, including CIP/SIP and offline autoclaving, the MarqMetrix Bioreactor BallProbe Sampling Optic is precisely manufactured for repeatable measurements batch-to-batch, probe-to-probe, and month-to-month.

### Sanitary construction for bioprocessing

Made from sanitary finished (15Ra) 316L stainless steel and exclusively sourced high-purity sapphire optics, the simplicity of design prompts an ease of use that eliminates user-to-user variation.

The form factor of the MarqMetrix Bioreactor BallProbe Sampling Optic is matched to the classic design of dissolved oxygen (DO) bioprocess probes—12mm diameter, Pg13.5 fittings, with 220mm and 120mm immersion lengths. The MarqMetrix Bioreactor BallProbe Sampling Optic comes with a stainless steel protective cap that shields the internal optics of the probe during autoclaving and storage.

### Features & benefits

- Accurate and repeatable measurements
- Durable design, resistant to sterilization (CIP/SIP)
- Protective cap shields the probe's internal optics during autoclaving and storage
- Compatible with standard Pg13.5 ports
- Ease of use eliminates user-to-user variation

### Applications

- Cultivated meat production
- Biopharmaceutical manufacturing
- Pharmaceutical manufacturing

Simple design for ease of use  
and consistent measurements.



**MarqMetrix Bioreactor BallProbe Sampling Optic with TouchRaman Immersion Technology**

The utility of the MarqMetrix Bioreactor BallProbe Sampling Optic is optimized when paired with our filtered fiber-optic interface, creating the MarqMetrix Fiber BallProbe Sampling Optic—a complete sampling solution for accurate and repeatable Raman measurements.

However, the MarqMetrix Bioreactor BallProbe Sampling Optic can be purchased as a stand-alone product for use with existing fiber-optic Raman probes.

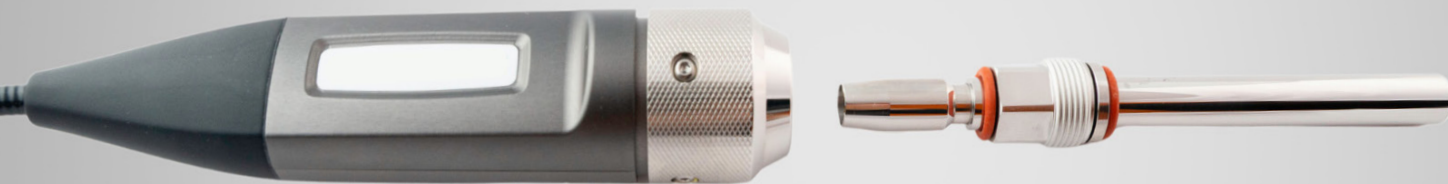
Wetted materials	
Probe body	12mm diameter 316L stainless steel Sanitary finish 15Ra
Immersion optics	8.00mm diameter UV-grade sapphire ball
Sealing materials	High-temperature epoxy

Specifications	
Standard probe length	220mm or 120mm (immersion)
Probe OD (outside diameter)	0.472 in. (12.0mm)
Sample working distance	TouchRaman (sample contacts BallProbe lens)
Continuous operating temperature range	-20°C to 150°C
Pressured design condition	6,000psi (413 bar)
Compatible wavelengths	500-1100nm
Fittings	Pg13.5, with beveled Telfon washer and viton o-ring



Operating conditions
Suitable for intermittent exposure to most dilute and concentrated acids (hot & cold),bases and most organic solvents including ethanol, THF, ethyl acetate, acetone, DCM, toluene, pentane and acetonitrile
Avoid exposure to aqua regia, heated formic acid, mixed acid, TFAA

Related products
MarqMetrix All-In-One Process Raman Analyzer - a single-unit spectrometer, laser, and acquisition computer
MarqMetrix Fiber BallProbe Sampling Optic - filtered fiber optic interface specifically designed for the MarqMetrix BallProbe Sampling Optic and MarqMetrix All-In-One Process Raman Analyzer



# MarqMetrix Single-Use Bioreactor BallProbe Sampling Optic

## with TouchRaman Immersion Technology

### Sterile construction for high value batches

Made from sanitary finished (15Ra) 316L stainless steel and exclusively sourced high-purity sapphire optics, the Thermo Scientific™ MarqMetrix™ Single-Use Bioreactor BallProbe™ Sampling Optic offers accurate and precise Raman measurement without compromising the sterility of your high-value batches.

Packaged in tear away bags, the probe can be sterilized via autoclave, EtO or integrated into larger single-use systems and gamma sterilized (50kGy). Designed for ease of use, it is simple to connect the sterile probe to the fiber optic interface of the Raman system enabling powerful real-time chemical insights. To ensure batch purity, simply dispose of the probe when process is complete.

### Engineered for bioprocessing conditions

Created to meet the requirements of the bioprocessing industry, the MarqMetrix Single-Use Bioreactor BallProbe Sampling Optic is compatible with standard Pg13.5 ports. Measure media nutrient levels, viable cell density, and more with probes that match the form factor of dissolved oxygen (DO) bioprocess probes. The standard configuration includes a welded flange that prevent the probe from backing out of the port and fixes the immersion lengths at 220mm and 120mm.

### Features & benefits

- Accurate and repeatable measurements
- Single-use, disposable probe for high-value batches
- Sterilizable via autoclave, EtO, gamma (not provided sterilized)
- Compatible with standard Pg13.5 ports
- Customization available for integrators

### Applications

- Biopharmaceutical manufacturing
- Pharmaceutical manufacturing
- Cultivated meat production
- Industrial fermentation

Sterile, single-use  
design for batch purity.



## MarqMetrix Single-Use Bioreactor BallProbe Sampling Optic

### with TouchRaman Immersion Technology

The MarqMetrix Single-Use Bioreactor BallProbe Sampling Optic can also be customized to meet integrators' specific application needs.

The MarqMetrix Single-Use Bioreactor BallProbe Sampling Optic is easily coupled to the Thermo Scientific™ MarqMetrix™ Single-Use Fiber Head – the fiber optic interface to the MarqMetrix All-In-One Process Raman Analyzer device.

The newly designed MarqMetrix Single-Use Fiber Head has a proprietary fitting that makes securely attaching and detaching the MarqMetrix Single-Use Bioreactor BallProbe Sampling Optic a breeze. End users must have a MarqMetrix Single-Use Fiber Head to use MarqMetrix Single-Use Bioreactor BallProbes Sampling Optic (standard FiberHeads can be converted to the Single-Use Fiber Head model).

#### Wetted materials

Probe body	12mm diameter 316L stainless steel Sanitary finish 15Ra
Immersion optics	8.00mm diameter UV-grade sapphire ball
Sealing materials	USP class VI and ISO 10993-5 certified epoxy

#### Specifications

Standard probe length	Fixed immersion length: 220mm or 120mm (optionally, probes can be purchased without a fixed flange - allowing variable immersion length up to 220mm)
Probe OD (outside diameter)	0.47 in. (12.0mm)
Sample working distance	TouchRaman (sample contacts BallProbe lens)
Continuous operating temperature range	5°C-150°C
Pressured design condition	6,000psi (413 bar)
Fittings	Pg13.5, with silicone o-ring
Compatible sterilization methods	Autoclave, EtO, Gamma (50kGy)



Standard probe lengths: 120mm and 220mm (immersion).

#### Operating conditions

Suitable to intermittent exposure to standard bioprocess cleaning solutions, organic solvents, and most dilute acids and bases.

Avoid exposure to aqua regia, heated formic acid, mixed acid, TFAA

#### Related products

MarqMetrix All-In-One Process Raman Analyzer - a single-unit spectrometer, laser, and acquisition computer

MarqMetrix Single-Use FiberHead Sampling Optic Head - filtered fiber optic interface specifically designed for the MarqMetrix Single-Use Bioreactor BallProbe Sampling Optic and MarqMetrix All-In-One Process Raman Analyzer

Learn more at [thermofisher.com/marqmetrixAIO](https://thermofisher.com/marqmetrixAIO)

**thermo** scientific

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