



## Milk and Dairy

- FT-NIR Analyzers for QC in the Lab and Production

# FT-NIR Spectroscopy for the Analysis of Milk and Dairy Products



Bruker Optics' FT-NIR analyzers for quality control in the lab and production are easy to use, reliable and cost effective. As they are all based on the same FT-NIR platform, users can choose the right analyzer for the job without having to compromise on precision and accuracy, ensuring data integrity today and in the future.

## • FT-NIR Analyzers for Milk and Dairy Products

Bruker Optics' dairy portfolio ranges from small footprint, touch screen accessible, dedicated analyzers to multiple channel analyzers for the full range of samples and fully automated in-process systems for closed loop control. Any type of milk and dairy product of any consistency can be rapidly analyzed to:

- Improve efficiency of laboratory operations
- Check the identity and quality of raw materials while optimizing their usage
- Optimize production by tightening targets and preventing out-of-spec product while reducing downtimes
- Increase product quality and consistency with tighter control
- Verify final product specifications and streamline compliance with regulatory guidelines

### Analyze any sample at any time

Typical parameters analyzed by Bruker Optics' FT-NIR analyzers in the dairy industry include quantification of fat, protein, lactose, moisture, total solids and more as well as confirmation of identity/quality and measurement of batch conformity.

Any sample form, be it liquid, semi-solid or solid can be analyzed in seconds throughout the process: in the lab, at-line near production or in-line directly in the process.

### Pre-calibrated systems for ease of implementation

All Bruker Optics' dairy analyzers are delivered with product-specific calibrations for rapid and successful implementation including but not limited to:

- Raw, skimmed, processed and condensed milk
- Whey and whey concentrate
- Cream and whey cream
- Whey protein and lactose concentrate
- Permeates and retentates
- Skim, whole milk and whey powders
- Cheese (soft, hard, sliced, processed, white cheese, curd, etc...)
- Butter (salted, un-salted)
- Yoghurt, desserts and ice cream
- Milk drinks

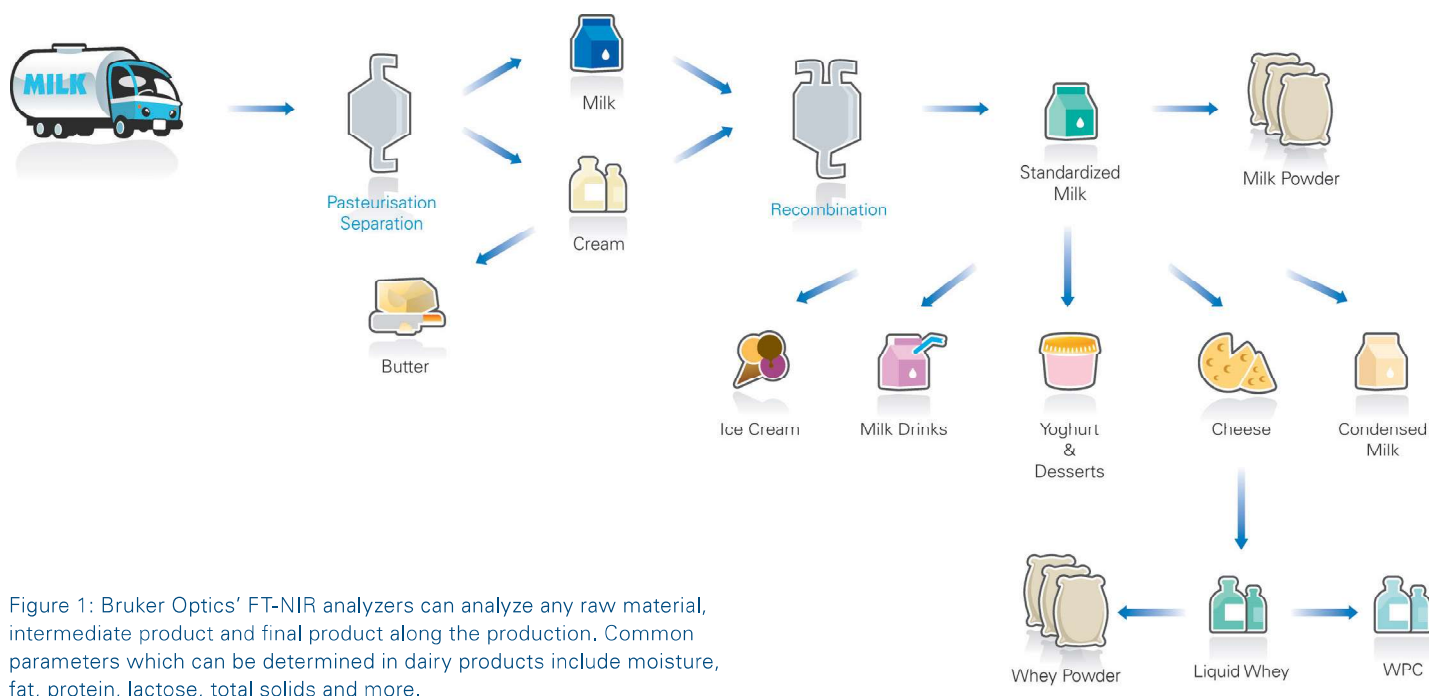


Figure 1: Bruker Optics' FT-NIR analyzers can analyze any raw material, intermediate product and final product along the production. Common parameters which can be determined in dairy products include moisture, fat, protein, lactose, total solids and more.

## ● **FT-NIR Analyzers** for Milk and Dairy Products

### **Improve your business**

Lab and shift personnel can quickly and easily analyze samples, resulting in a dramatic increase in the total number of samples that can be tested per day, especially when compared to conventional testing methods. Moreover in-process FT-NIR can monitor continuously. Either way, more frequent testing results in tighter control and dairy companies can realize direct cost savings with FT-NIR by

- More precise standardization of milk
- Consistent control of fat content in cream
- Optimization of moisture or total solid content in cheese, yoghurt and butter
- Tighter control of protein, fat and total solids in spray tower feeds and moisture content of milk powder in the fluid bed dryer
- Real-time adjustment of total solid content in cheese and curd

An investment in the instrument will also enable you to establish testing protocols to:

- Verify the identity and quality of vitamins and premixes, emulsifiers, starches, minerals, sugars, sweeteners and more
- Analyze Edible Oils for Iodine value, trans and free fatty acids, fatty acid profile and peroxide value
- Monitor composition and efficiency of cleaning and disinfecting solutions

### **Bruker - your partner for dairy product testing**

Bruker has been driven by the idea to always provide the best technological solution for each analytical task for more than 50 years now. Being one of the world's leading analytical instrumentation companies, Bruker systems cover a broad spectrum of applications in all fields of research and development and are used in all industrial production processes for the purpose of ensuring quality and process reliability.

Bruker Optics is the world leading manufacture of FT-NIR instruments for a wide range of industries including food and dairy manufacturing. Our optical analyzers combine an unrivalled flexibility and easy operation with state-of-the-art spectrometer technology. Software controlled optical modules, optimized sampling accessories and the user friendly operator interfaces guarantee excellent results from day one.

### **Certified quality throughout the process chain**

Highest quality and excellence in manufacturing are key values that guide our business. Full commitment to our robust quality systems in the whole process chain helps us to achieve these goals.

Continuous surveillance and improvement ensures the entire compliance to the internationally accepted quality management standard ISO 9001.





## • Applications

### Milk and liquid milk products

Milk, the starting point of any dairy product, is one of the best controlled food products in the world. The composition of raw milk changes by season and region, which makes the standardization step necessary to maintain consistent milk quality during the processing steps.

The optimal analytical solution for raw milk and liquid milk products is the combination of **MPA II** with the **Liquid Sampling Module (LSM)** – a dual system that can switch software controlled between a powerful homogenizer and a peristaltic pump for sample treatment and transport, depending on the product and its viscosity. The dual concept allows the analysis of any liquid milk and dairy product in an optimal way either homogenized or not. In contrast to standard FTIR milk analyzers all kinds of even viscous liquid dairy products can be analyzed due to the comparably large pathlength of 1 mm (1000 µm) of the flow cell.

Bruker Optics' new **MIRA** infrared (IR) milk analyzer for liquid samples (Figure 2) comes pre-calibrated and offers a simple and cost-effective way for the quality control of raw milk, processed or standardized milk, whey and cream. The built-in homogenizer ensures high repeatability and accuracy. Optionally, the freezing point can be determined within the same measurement.

### Raw milk and other milk types

Raw milk is generally preheated and homogenized before measurement to assure highest precision and repeatability. In terms of accuracy and repeatability this FT-NIR approach is equivalent to the traditional FTIR systems but is offering more options. Typical accuracies are in the range of 0.03% or better for fat and protein and repeatabilities are in the magnitude of 0.001%. The MPA II and LSM come with dedicated calibration



Figure 2: The MIRA is an easy-to-use milk analyzer based on (mid) infrared spectroscopy.



packages that can be utilized for any milk type ranging from raw milk, skim milk, standardized milk to UHT milk.

### Liquid milk products

Not only milk, but liquid milk derivatives and milk products can be easily measured using the same setup, regardless of the composition of the product. Due to the uniquely large path length of the measurement cell (1 mm), even highly viscous samples such as condensed milk and concentrates can be readily analyzed. These types of samples do not require homogenization or even should not be homogenized before the analysis.

The MPA II is also ideal for sugar-containing products such as yoghurt drinks, flavored milk and even products containing fiber, like cat's milk.

The LSM is designed to be flexible so that for these sample types, an operating mode using the peristaltic pump can be selected via software control. This enables users to switch back and forth between any sample type without making adjustments to the hardware.

In addition to the different milk types, the following samples can be analyzed without any pre-processing by the MPA II. Typical dairy calibrations include but are not limited to:

- Whey and whey concentrate
- Whey protein and lactose concentrate
- Cream and whey cream
- Permeates and retentates
- Condensed milk, sweetened condensed milk
- Milk drinks, e.g. based on yoghurt
- Melted ice cream

# • Applications

## Solid and semi-solid dairy products

Solid and semi-solid dairy products include a large variety of product types from various milk powders to cheese varieties, yoghurts and other semi-solid products like intermediates in the dessert production. Almost any product can be analyzed by FT-NIR utilizing a reflection measurement. In the lab or near production the MPA II, MATRIX-I or TANGO with an integrating sphere provides a simple way of sample presentation and analysis. The sample is filled in a cup, quartz Petri dish or disposable Polystyrene Petri dish and put on the instrument. The reflection analysis is done from the bottom and the sample is rotated acentrically during the measurement in order to collect more sample information and to level out in-homogeneities. For process analysis a wide range of probes and accessories enable on-line and in-line FT-NIR analysis of any solid or semi-solid product.

### Milk and Whey powders

NIR is a well-established method for the rapid, simultaneous analysis of moisture, fat and protein content in milk powder, in the laboratory as well as at-line and on-line. Parameters such as ash or lactose content can also be analyzed.

Producers in the dairy industry monitor these parameters to:

- Optimize the moisture content
- Increase product consistency
- More efficiently utilize energy (e.g. optimization of the drying process)
- Reduce final product testing in the laboratory

In the laboratory, the measurement of milk powder is a simple reflection measurement through the quartz bottom of a sample cup. The cup is simply filled with the sample and after the measurement it can easily be cleaned by pressurized air or brushing out any residual sample with a soft brush.

The calibrations cover the full range from whey powder, skim and whole milk powder to cream milk powder.

### Yoghurt, desserts and ice cream

Many companies produce a wide range of products with many different flavors and textures, from plain yoghurt and desserts to fruit and chocolate flavored products.

With NIR spectroscopy, the typical quality parameters such as fat, protein and dry matter can be determined very quickly at-line or in the production area. Only one calibration model per parameter is required, no matter what flavors or ingredients are being added, i.e. yoghurt with chocolate flakes can be analyzed with the same model as strawberry or hazelnut yoghurt.

Semi-solid samples are usually measured using quartz Petri dishes. If cleaning is an issue, the use of disposable Polystyrene Petri dishes makes cleaning procedures obsolete.

Liquid desserts and even melted ice creams with medium viscosities can be analyzed just like a liquid using the unique LSM to heat and transport the sample to the large path length flow cell.



### Cheese

Any of the Bruker Optics FT-NIR reflectance spectrometers including the MPA II, MATRIX-I or TANGO, can be used to measure important quality parameters such as fat, protein and total solids in seconds. One analyzer is capable of simply and accurately testing the full range of cheese from hard-, slicing-, cream-, to soft cheese. Moreover, the salt content and even pH-value can be simultaneously obtained for specific cheese types.

Grated cheese is typically sprinkled, whereas soft cheese is typically spread into the Petri dish. Users can select the method of sampling that is ideal for their needs.

### Butter

For butter production, it is important to stay as close as possible to the target concentration of the fat component, i.e. to maximize the moisture content without going out of specification. Moisture and fat in butter can easily be analyzed using FT-NIR spectroscopy.

For this application the Bruker's spectrometer MPA II, MATRIX-I and TANGO can be utilized for reflection measurements. The butter samples are filled in quartz Petri dishes or disposable polystyrene Petri dishes and placed on the window of the analyzer. A sample rotator is used to maximize the sample area scanned during the measurement.

Both, salted and unsalted butter can be analyzed for moisture. Moreover the salt content can be analyzed in salted butter.





## • Process Control

### The MATRIX-F: on-line and in-line Production Control

FT-NIR Spectroscopy is the perfect tool for process control. Frequent measurements of key parameters at multiple measurement points are automatically sent to the process control system, providing a great deal of relevant information. Rather than relying on single lab samples, plant operators with access to frequent results are able to dramatically reduce in-process variation and adjust the process in time to avoid the production of out of spec product. Critical and valuable parameters like TS in cheese production or moisture content of milk powder can be adjusted closer to the target values with a much narrower standard deviation.

During start-up or after a cleaning cycle, the FT-NIR results are used to reduce variation and increase the daily yield. In comparison to manual sampling, inline measurements help plants to control costs and increase throughput, while minimizing the risk of production errors.

Bruker Optics offers an ideal on-line and in-line solution for the quality control of any type of dairy product. The MATRIX-F can utilize different optical probes and measurement heads:

- Transmission probes for clear liquids and whey
- Transflection probes for any liquid from milk to high solid content liquids
- Measurement heads for contactless reflection measurements on any solid product, e.g. milk powder or cheese blocks.
- Reflection probes for solid and semi-solid products

Up to six measurement points in the process environment can be controlled sequentially with the built-in optical multiplexer. Any combination of probes can be used in one analyzer which is a critical advantage for processes that start with fluid milk, and end with semi-solid or solid products.





### Improve your process control and the yield

The production of milk powder is an important part of the dairy business and the capacity of modern spray towers today is enormous. Here big profit opportunities arise by controlling the powder in the fluid bed dryer and the spray tower feed by an FT-NIR process analyzer.

Especially the on-line powder analysis has a direct impact on the yield by analyzing just moisture besides other available parameters like protein, fat and lactose content.

Normally moisture analysis is performed in a production lab and samples are taken every few hours. With on-line FT-NIR, moisture results are obtained every minute with an accuracy of 0.15% comparable to the Karl-Fischer reference method. By a continuous process tracking, the moisture content can be adjusted closer to the target value with an improved consistency. Here direct cost savings by an increased yield and reduced energy costs are achieved. Moreover the risk for out-of-spec production is minimized which reduces rework efforts and downtimes. The payback time of such solution is typically less than 12 months.

Uniquely able to connect both solid and liquid probes to the same analyzer, one Bruker Optics FT-NIR instrument can multiplex up to six measurement points.

A monitoring at key points in the production process can be achieved by installing:

- Transflection probes in preparation tank or in the feed of the spray dryer
- Probe heads in the powder exiting the fluid bed dryer or in the sifter

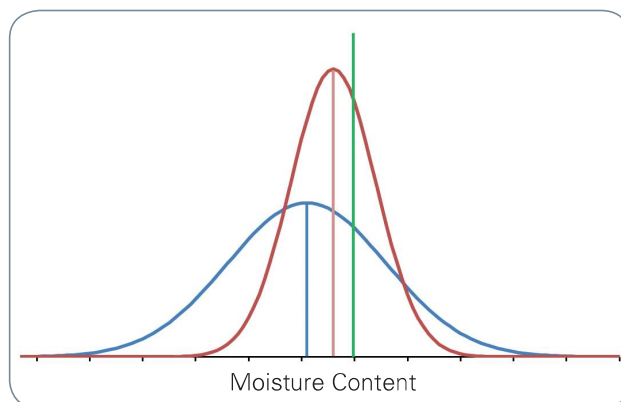


Figure 3: FT-NIR process control for increasing of product consistency by achieving a narrower distribution of moisture contents around the target and improving the yield by moving the mean closer to the target value (blue: previous control system, red: with Bruker FT-NIR, green: target)

### FT-NIR testing points in typical Spray Dried Milk Powder Process

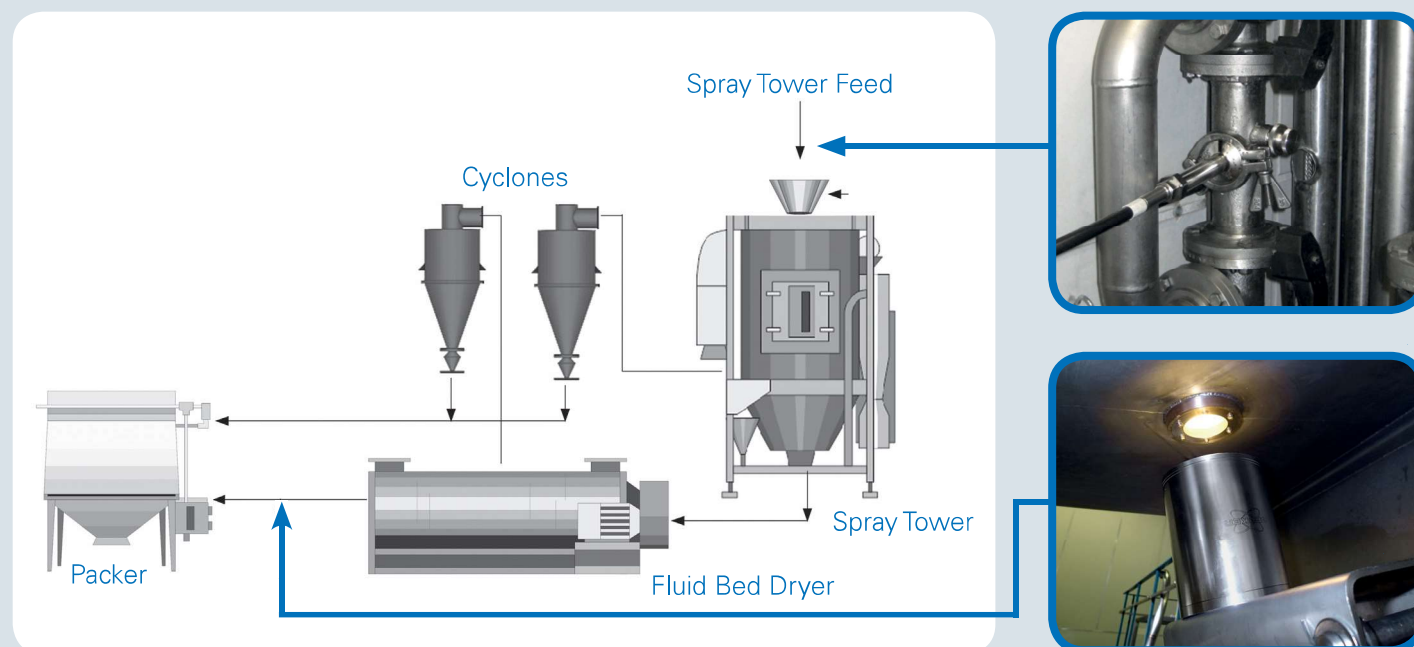


Figure 4: On-line Process analysis in Milk Powder production. Top: control of spray tower feed or alternatively at the feed tank by a transflection probe. Bottom: contact free powder analysis with probe head at the sifter of fluid bed dryer.

## • Technology

### State-of-the-Art Technology with easy handling

The Bruker FT-NIR technology incorporates state-of-the-art optics for outstanding performance and stability. The heart of the instrument is Bruker's permanently aligned RockSolid interferometer with cube corner mirrors, providing consistent high quality results, less downtime and highest stability.

Unlike flat mirrors, cube corners are practically immune to mirror tilt (i.e. angular movement of the mirror). This is an important consideration since the light returning to the beam splitter must be precisely recombined to avoid a reduction in stability, resolution, and spectral quality.

The RockSolid interferometer incorporates dual retroreflecting cube corner mirrors in an inverted double pendulum arrangement. A wear-free pivot mechanism is located at the center of mass. This design optically eliminates mirror tilt and mechanically prevents mirror shear leading to a superior resistance to vibration and thermal effects.

The wear-free nature of the bearing inside the RockSolid interferometer ensures exceptional stability and reliability even in harsh environments, making it ideal for the laboratory as well as the factory floor.

Moreover, the instrument maintains the wavelength accuracy over time - a precondition for a successful calibration transfer.

All analyzers are designed to be easily maintained by the user, and to minimize downtime and maintenance costs. Consumables such as the light source are pre-aligned modules which can be easily and quickly changed by the user.

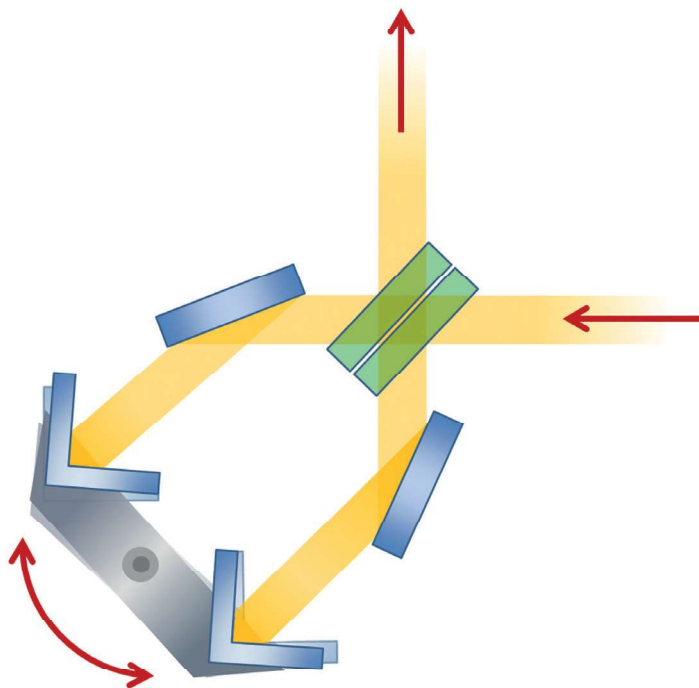


Figure 5: Bruker's well-proven RockSolid interferometer with Cube Corner Mirrors.



# • Software

## OPUS - Optics User Software

Bruker Optics' OPUS is an easy-to-use and a powerful all-in-one spectroscopy software package. It includes the most comprehensive collection of data acquisition, processing, and evaluation functions and can be completely configured to meet your needs including extended user management and access features.

For method setup there are three main functions for

- Calibration development for quantification of components and properties
- Library setup for identification of raw materials
- Conformity test for quality control

### Multi Evaluation

Using the unique OPUS Multi Evaluation (ME) function, users can set up hierarchical methods to automate different evaluation and decision steps or to perform additional calculations. With ME, an identification step can be followed by a quantification step and a conformity test; or a quantification step can be followed by an additional quantification step depending on the results of the first step. The results are displayed, and customizable reports are stored and printed.

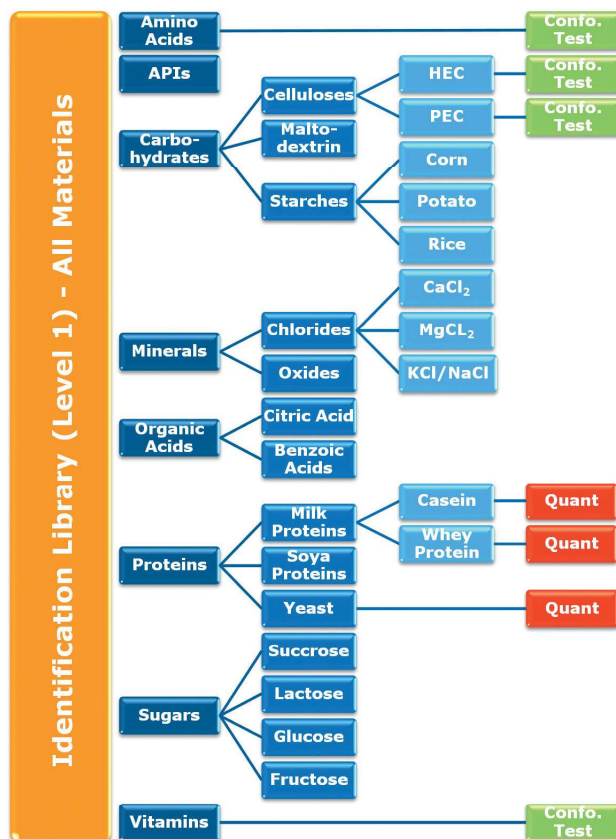


Figure 6: Example scheme of a Multi Evaluation method with Hierarchical Identification followed by Conformity Testing or Quant2 Evaluations



### In the Laboratory

The OPUS/LAB package is an intuitive and easy-to-use software interface for routine analysis tasks. It can be used by routine operators who can quickly be trained to perform analyses. The operator just selects the product to be analyzed and enters the sample ID and optional sample information. The results are visualized on screen and stored in PDF and log files readable by LIMS.

### In the Process

OPUS/PROCESS is a software package used to easily set up scenarios for automated process control and visual display of results. The scenarios can be configured with many optional settings for cyclic measurements or analysis triggered by process control systems. Triggers and results can be exchanged with PCS using Profibus DP, Modbus, 4-20mA connections or OPC.

### Data Security

OPUS ensures the safety and integrity of your data.

- No loss of data or overwriting of raw data
- Fully GMP/GLP compatible, 21 CFR Part 11 conform
- Automatically generated data history (audit trail)
- All relevant data (measurement parameters, manipulations, evaluation results, reports, etc.) are stored in one data file

### Spectrometer Diagnostics

Only a permanently monitored spectrometer can ensure the acquisition of reliable data.

OPUS includes:

- Permanent online diagnostics
- Real-time display of instrument status
- Instrument status reports
- Integrated automatic instrument tests (OQ, PQ)

## • Service and Support

Bruker Optics is staffed by expert scientists and engineers with an in-depth knowledge of instrumentation and applications in the dairy industry. Our product specialists are available to assist you with method development either remotely or in your lab. FT-NIR application scientists will assist you in the selection and use of sampling accessories, choice of optical components and software operation. We offer customized instruction and support packages to fit your needs.

Bruker Optics spectrometers are designed to provide years of trouble-free operation, but should a problem occur, a network of Bruker companies and representatives throughout the world are ready to promptly respond to your needs. Professional installations, comprehensive applications support as well as high standard of post-delivery service are commitments Bruker Optics makes to each of its customers.



Technologies used are protected by one or more of the following patents:  
US 7034944. Additional patents pending.

**Bruker Optics is ISO 9001  
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