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A White Paper from FOSS

Rapid methods for fat analysis in the meat industry

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Dedicated Analytical Solutions

Introduction

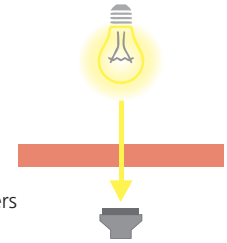
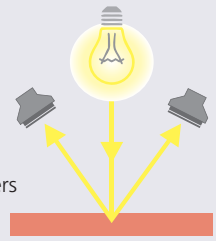
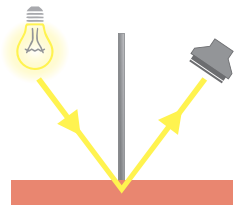
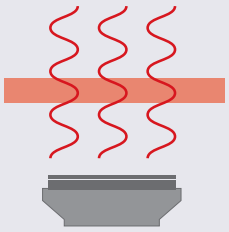
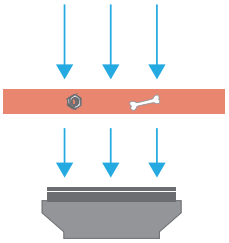
Laboratory analysis is common to the meat industry. However, rapid analytical methods at the production floor are now also bringing huge advantages to the meat industry. This white paper explains the different options that are available and the relative performance. Specific examples are taken from the FOSS product portfolio.

It is well known that fat content is one of the most important parameters to control in the meat industry. Control of fat content is important for the manufacturers of raw meat, i.e. the cutting and boning plants, as well as the manufacturers for processed meat products.

Technologies

A number of technologies for rapid fat analysis are available. Each has its advantages and disadvantages. All methods for rapid analysis are based on "indirect" analytical methods. That means the result is not from a direct measurement, as is the case for many of the traditional laboratory methods. As they are indirect methods, they have periodically to be verified against the reference methods. An overview of technologies is shown in Table 1.

Table 1. Overview of technologies for rapid fat analysis in the meat industry.

Technology	Characteristics	Parameters
NIR transmission NIR light is transmitted through the meat sample.	Penetrates 1-2 cm of meat. Requires homogeneous samples. Wavelength range below 1100 nm and hence limited spectral information. Measures fresh and semi-frozen meat.	Fat Protein Moisture Collagen (BEFFE) Salt + other parameters 
NIR reflection NIR light is reflected off a meat sample surface. The diffusely reflected light collected.	Only penetrates the upper few millimetres of the sample. Works best with homogeneous samples. Wavelength range up to 2500 nm and hence more detailed spectral information. Measures fresh and semi-frozen meat.	Fat Protein Moisture Salt + other parameters 
NIR lateral transmission* A meat surface is illuminated with NIR light. The transmitted light is detected from the same surface, but in other positions. Diffusely reflected light is excluded.	Penetrates deeper into the sample compared to NIR reflection. Handles less homogeneous samples better than other NIR methods. Wavelength range below 1100 nm and hence limited spectral information. Measures fresh and semi-frozen meat.	Fat Protein Moisture Salt 
Microwave A guided microwave spectrometer sends low microwave electromagnetic energy through the meat.	Penetrates through the meat in a pipe system. The microwave energy can be used to measure the moisture content and calculate the content of other parameters. Works only for non-frozen products.	Fat Protein Moisture 
X-ray transmission X-rays are transmitted through the meat sample.	Works well with inhomogeneous meat. Measures both fresh and frozen meat. Can be designed to measure all meat without sampling.	Fat Weight Foreign objects (metal and bone) 

*"Lateral transmission" is in some texts described as "transflectance". The most correct description is, however "lateral transmission" since "transflectance" also includes traditionally reflected light.

Applications

The choice of technology depends on the application. With X-ray transmission on a conveyor belt all meat is measured and foreign objects can be detected. With most NIR methods more parameters (fat, protein, moisture etc.) are available, but only a part of the meat is measured. The use of rapid fat analysis can typically be divided into at-line analysis based on sampling and a number of in-line applications as shown in Table 2.

Table 2. Overview of rapid fat analysis applications in the meat industry.

Application			
Installation point	**Sample type**	**Method/Technology**	**Typical fat accuracy**
At-line (bench/lab). Not real time as time is needed for sample preparation and analysis.	Homogeneous sample. Non-frozen meat (semi-frozen may be OK). Sample size maximum 200 g.	Surface scanning (NIR reflection) or scanning through sample (NIR transmission).	~ 0.5 – 1.5% + sampling error, i.e. uncertainty of taking a small representative sample from batch.
In-line. After the grinder. Real time.	Homogenous meat. Generally non-frozen meat and meat pieces of max 15-25 mm in diameter. Some systems can allow for larger meat pieces.	Surface scanning of sample (NIR reflection and NIR lateral transmission).	~ 1 – 2% Main part of error is from only scanning a portion of the batch.
In-line. After the grinder. Real time.	Non-frozen meat (inhomogenous sample).	Scanning through sample (Microwave, X-ray).	~ 1 – 2% Main part of error is from only scanning through a portion of the batch.
In-line. Before and after the grinder. Real time.	All types of raw meat (inhomogenous). Fresh and/or frozen. No limitation on size of meat.	Scanning through all meat (X-ray).	~ 0.5 – 1.0% All meat is measured.

The different applications are described in more detail below

At-line (bench/lab) solutions

This type of analytical method has been used in the meat industry for at least two decades.

Most applications are based on the AOAC approved FoodScan using NIR transmission. MeatScan is another instrument from FOSS that uses the transmission technology. FoodScan and MeatScan can in most cases be considered as "plug and play" solutions which is an advantage compared to many competing solutions that have to be calibrated before they can be used.

Compared to in-line analytical solutions, at-line and laboratory solutions have the disadvantage that only a small fraction of the total batch is analysed. The challenge is to take a representative sample and experience shows that this is difficult to do.

Surface scanning in-line solutions
A number of available fat analysers are assessing the fat content from scanning the surface of the meat (NIR reflection and NIR lateral transmission). An example of such analytical solution is the ProFoss Meat Analyser using the reflection principle.

Using lateral transmission instead of reflection is in some cases an advantage as the light penetrates deeper into the meat. This makes the measurement less sensitive to the meat size and a larger portion of the batch is measured.

The solutions are normally placed after the first grinder (coarse grinder) since they do not work well with very inhomogeneous meat. Adjustment for fat content (fat standardisation) can be made before the final grinding takes place if the scanning shows a deviating fat level. Even though these solutions are placed in-line not all the meat is measured and that is the main disadvantage.

In-line methods scanning through some of the meat
For ground meat based production, a couple of analytical solutions scanning through part of the meat are available. The solutions are based on microwave or X-ray technology. Both types of solutions can be mounted on the tube of the coarse grinder and are therefore to some extent similar to the previously mentioned NIR based in-line solutions.

The microwave solutions measure the moisture content in the meat and based on that value an indirect estimate for the fat content is calculated. The offered microwave solutions can be mounted on the tube of an existing grinder. The microwave solutions have the disadvantage that they can only measure fresh meat. It cannot be used for frozen products which to a large extent are used as raw material by manufacturers of processed meat products. Hence, if a meat plant wants to use the microwave solution when receiving frozen raw material, they will have to invest in a defrosting system.

The X-ray solutions can measure fresh as well as frozen meat.

Both solutions scan a larger proportion of the meat compared to the previously mentioned NIR solutions, but there is still a large sampling error associated with this type of equipment.

In-line methods scanning through all of the meat
X-ray is the only technology which can measure all of the meat on a conveyor regardless of the size of the meat pieces or whether it is fresh or frozen.

MeatMaster II from FOSS is such a solution. It has a capacity of up to approx. 38 tons/hour for analysis of raw meat. It measures:
- Fat content,
- Weight and
- Scans for foreign objects (metal and bone).

According to Table 2 MeatMaster II is the most accurate solution for in-line fat analysis offered to the meat industry and is today well recognized as the "gold standard" for fat analysis.

MeatMaster II can be used both by manufacturers of raw meat trimmings (cutting and boning plants) as well as by manufacturers of processed meat products using trimmings as their raw material.

The cutting and boning plants can use MeatMaster II for optimizing the fat content in their trim categories while at the same time checking for foreign objects, both for trimmings leaving the plant in cartons or in large 1000 kg combos.

The manufacturers of processed meat products can use MeatMaster II for scanning the raw material for foreign objects as well as for fat standardisation of batches. FOSS offers a software package that ensures complete integration of MeatMaster II into the production process.

As described here, all other in-line fat analysers for fat standardisation are placed after the coarse grinder, whereas MeatMaster II can be placed before the coarse grinder. This allows for an inspection of all raw materials for foreign objects, which could otherwise contaminate the production. Foreign objects may lead to cassation of a whole batch or damage to the production equipment, e.g. the grinder.

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