

Vision-based spectroscopy - current technologies and future systems from x-ray to NIR

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Why is vision-spectroscopy in FOOD quality assessment interesting?

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- Remove subjective judgments – fair trade
- Avoid time-consuming sampling and reduce the analysis burden on the laboratory / production
- Make optimal use of raw material at all times
- Improve production efficiency by avoiding out of specification products / re-work
- Detect contamination, foreign material, visual damage and blend in of other products.

Meat



- Fat measurements on the carcass is used for payment purposes.
- Fat measurements on the primary cuts are hardly ever done.
- Fat measurements on trimmings are widely used.
- 10% – 30% of the meat is defined as trimmings (boneless).
- Usually used for hamburgers, sausages and minced meat for the consumer.

What can be done with X-Ray?

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Measure ALL meat trimmings passing through your production with an accuracy better than 1%

Get information about fat content, weight and foreign object contamination - even for frozen and packaged raw material

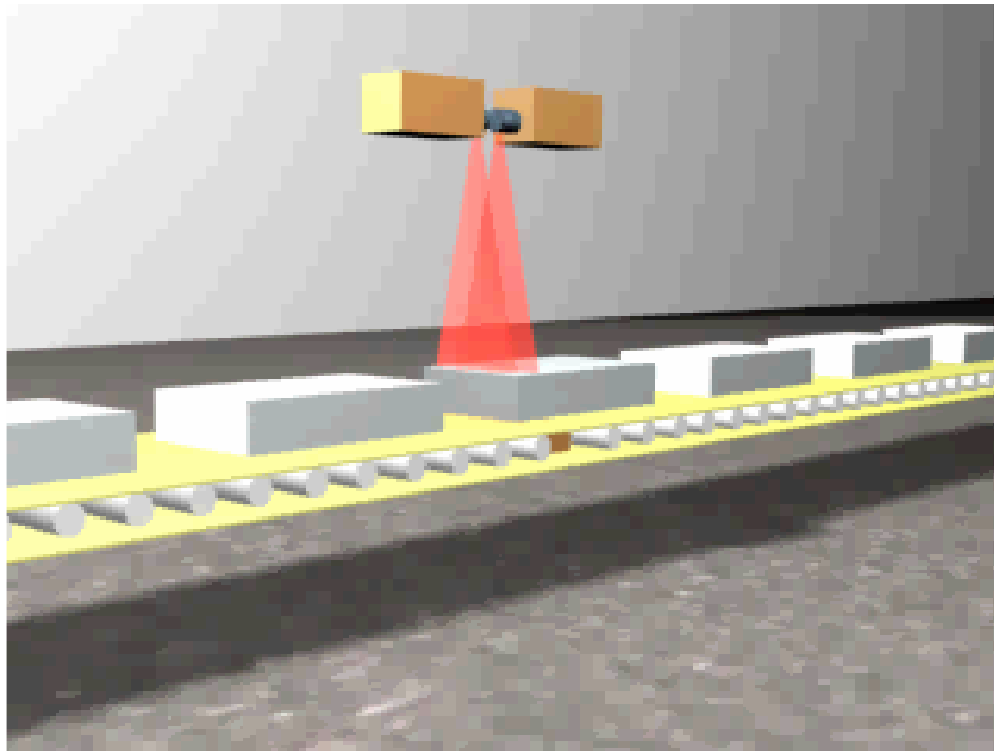
Measure meat and trimmings at up to 20 tons / 45.000 lbs per hour



Dedicated Analytical Solutions

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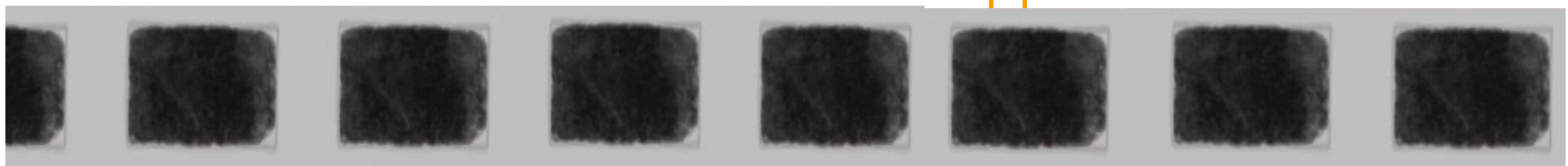
Meat: Measurement System



Measurement system consists of two separate x-ray generators and two separate detectors.

This is unique for the MeatMaster and ensures optimal and market leading performance and stability.

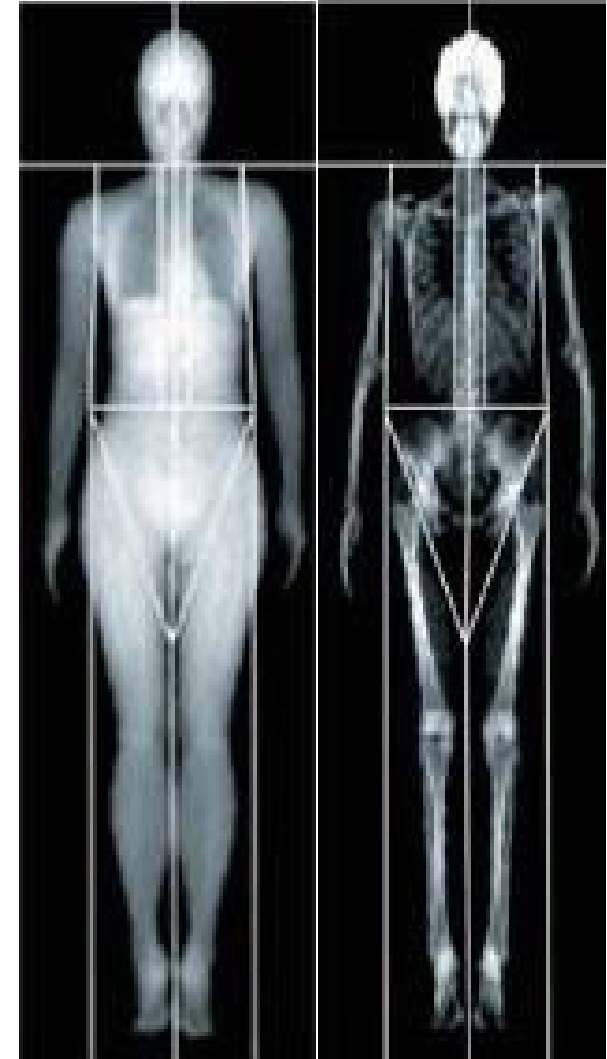
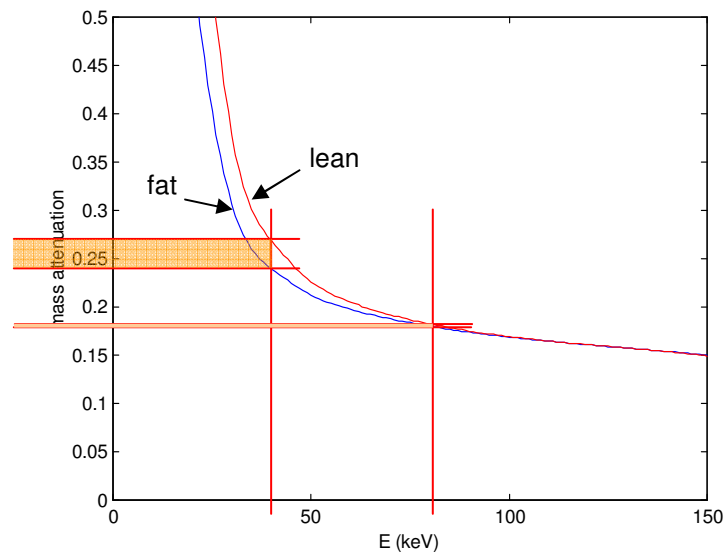
Analysis takes place inside a closed cabinet allowing MeatMaster to be operated in compliance with all safety standards



The technology is called DEXA
(Dual Energy X-Ray Absorptiometry)

Invented and applied in the medical industry for measuring bone density and body composition

Based on the principle that lean tissue has a higher density than fat tissue and stops x-rays better

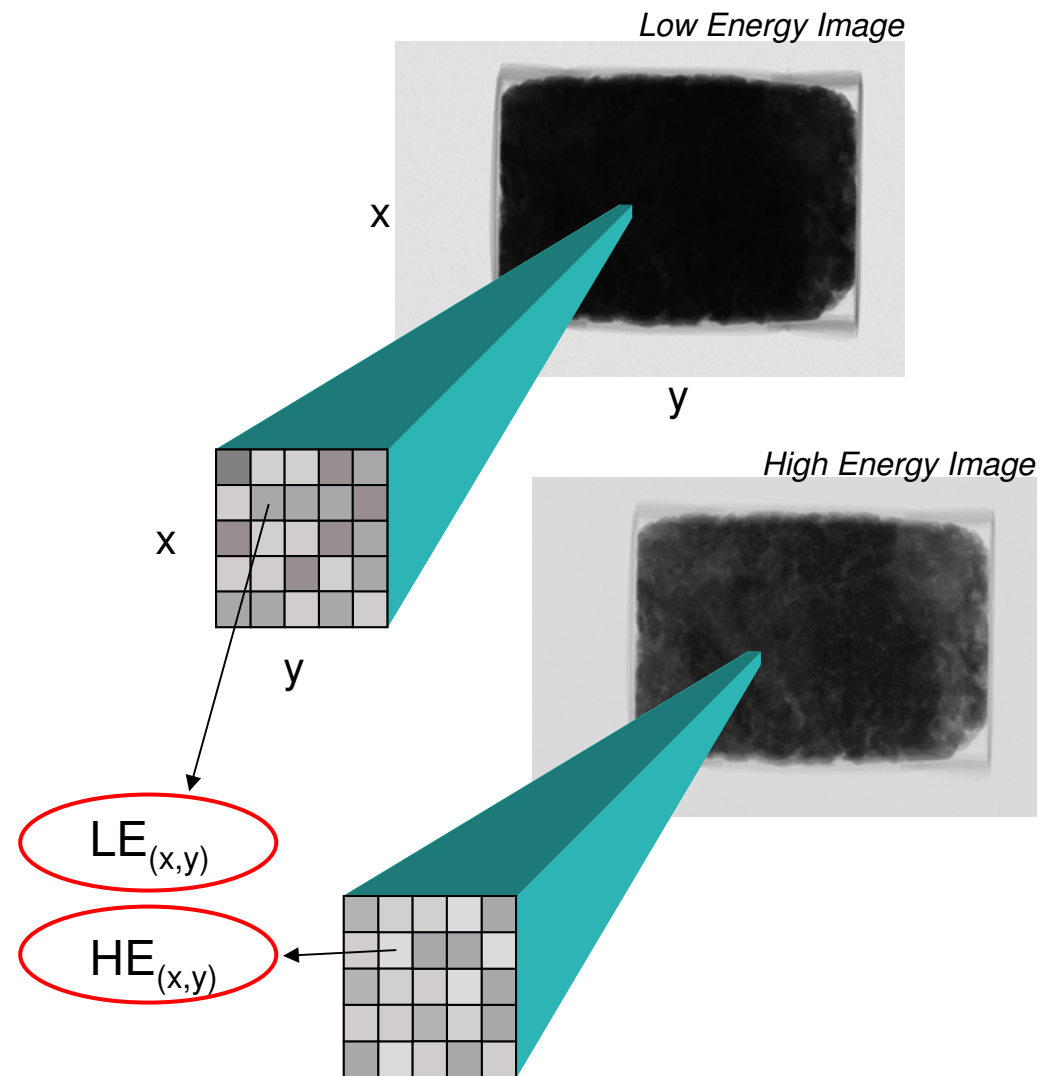


Data Handling



- When one sample is acquired, the calculation starts immediately
- Fat and thickness is calculated in every image point
- The weighted fat average is calculated for the sample as well as the summed weight
- A batch consists of a number of samples and holds the average fat and the summed weight

The sample data is made up of image points organized in rows and columns.



Patented calibration



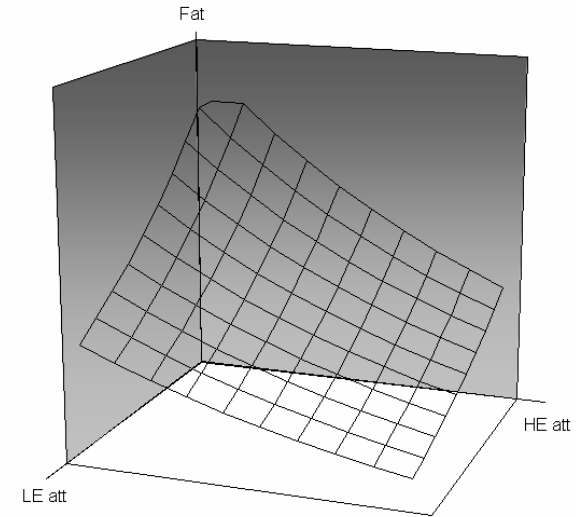
The MeatMaster uses a proprietary and patented calibration system

89 samples of meat with varying mass and fat content is used

The calibration includes meat from beef, pork and poultry

The calibration also includes frozen meat

The MeatMaster has a built-in QC system which clearly tells the operator when the system is ready for production



The QC measurements have passed (15-01-2008)

System ready for production

Fat avg.:	40.9% (41.0%)	Weight avg.:	14.3kg (14.6kg)
Fat standard deviation:	0.09 (<0.5)	Weight coefficient variation:	0.00% (<0.5%)
Fat deviation from nominal:	-0.08% (<1.0%)	Weight deviation from nominal:	-0.4kg (<0.5kg)

The system will need to be calibrated in 100 days (24-04-2008)

Was the QC measurement performed correct?

$$\text{Fat} = k1 * \text{LE} + k2 * \text{HE} + k3 * \text{LE}^2 + k4 * \text{HE}^2 + k5 * \text{LE} * \text{HE} + k6 * \text{LE}^2 * \text{HE} + k7 * \text{LE} * \text{HE}^2 + k8 * \text{LE} / \text{HE} + k9 * \text{LE}^2 / \text{HE} + k10 * \text{LE} / \text{HE}^2 + k11 * (\text{LE} / \text{HE})^2 + k0$$

$$\text{Mass} = b1 * \text{LE} + b2 * \text{HE} + b0$$

The algorithms are patented

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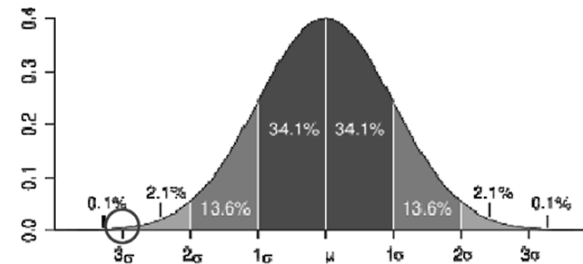
Fat / Lean:

- The MeatMaster will measure the fat% / Chemical Lean with an error of less than 1% fat / lean <typically 0.6%>
(1 Standard Deviation < 1% fat / lean in 20kg / 44lbs samples. For larger batches the accuracy increases)
- This means that you can specify that 95% of your production will be within a safe margin of $\pm 2\%$

$$\sqrt{\frac{\sum_{i=1}^n (x_i - \bar{x})^2}{(n-1)}}$$

Weight:

- The MeatMaster will measure the weight with an error of less than 2%
(1 Standard Deviation < 2% weight on loose meat)
(1 Standard Deviation < 1% weight on meat in boxes)
- The MeatMaster weight is usually not used for accounting purposes but is sufficient accurate for formulation

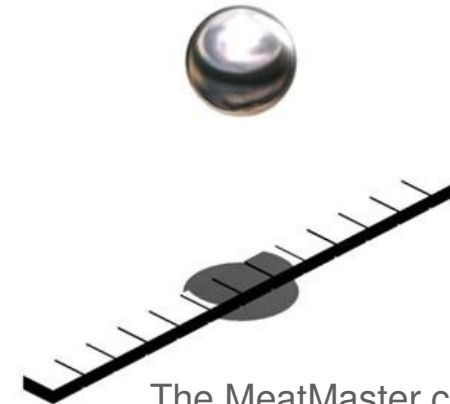


Metal:

- The MeatMaster will find metal parts down to 3mm size in product up to 200mm / 8 inch thickness
(99% detection without false alarms)
(density > 7.85 g/cm³, fe and non-fe)
- This means that you can protect you equipment from damage due to metal contaminants

Bone:

- The MeatMaster will detect bone down to 10mm size in product thickness up to 200mm / 8 inch
(99% detection without false alarms)
(density > 1.8 g/cm³)
- This means that you can send boneless product without the risk of the occational bone.



The MeatMaster contains a unique detection system capable of finding metal and bone while also measuring the fat and weight

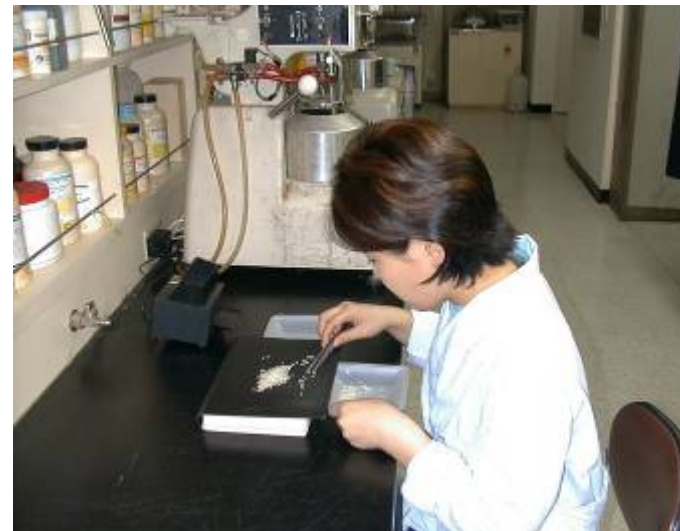
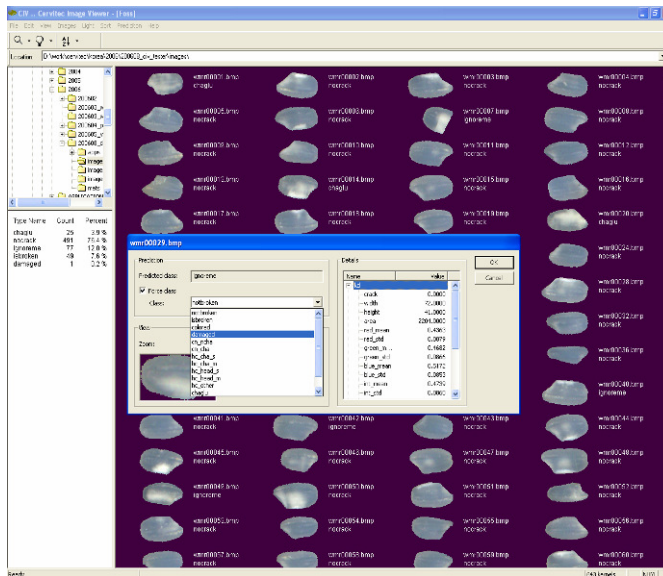
Increased consumer protection
Reduced risk of product recall
Reduced consumer risk liability

Grain

Grain - Why automatic grain analyzer?

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- Breeding requires objective methods for optimal selection
- More detailed information, new possibilities
- Secure and Improve the grain quality to consumer
- Trade requires more objectives methods (fair trade)



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Infratec 1241



**Manual
inspection**

Grain Quality



Subjective method:

- ◆ Based on written descriptions and image examples
- ◆ Requires long experience and training
- ◆ Analysis results depend on external conditions (such as light)



Infratec 1241



Cervitec 1625

Rice Quality

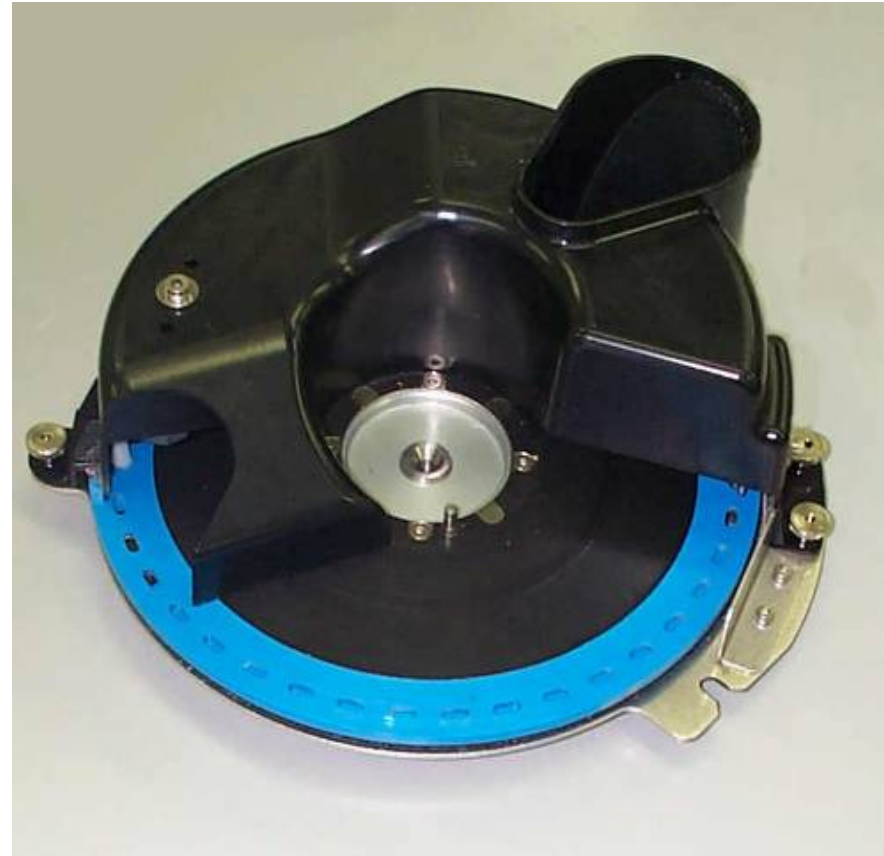
Cervitec 1625 (Rice)



Cervitec 1642 (wheat)



- + Well defined positioning
 - + Small area -> good optimisation of light condition, distances, focus etc.
 - + Multiple cameras (easy sync.)
 - + Transmitted light
- Needs to be optimised for each crop



Grain - Cervitec Visual Inspection

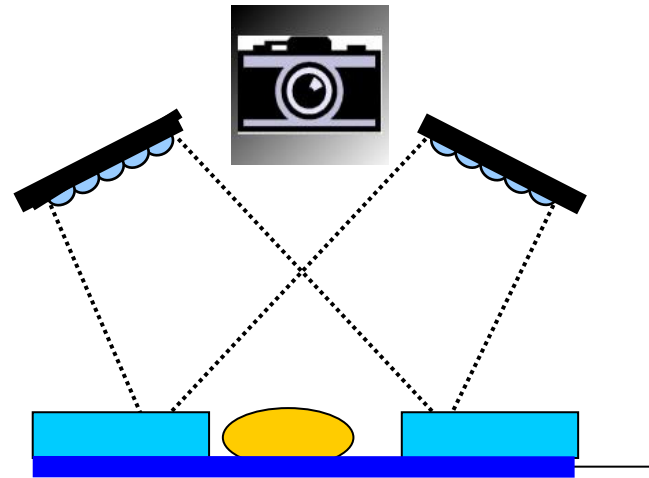
**PATENTED
TECHNOLOGY**

FOSS

Camera 1

Reflectance

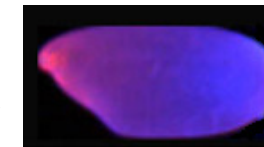
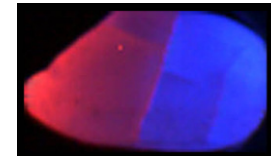
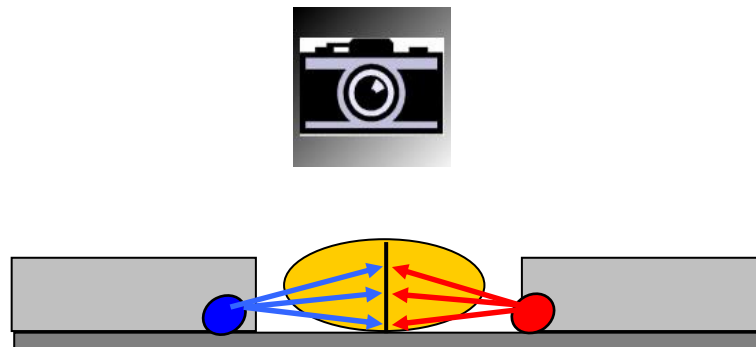
White light



Camera 2

Transmission

Red/Blue light



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- **Moisture**
- **Protein**
- **Amylose**






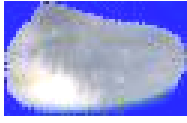





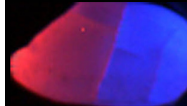

Cervitec 1625

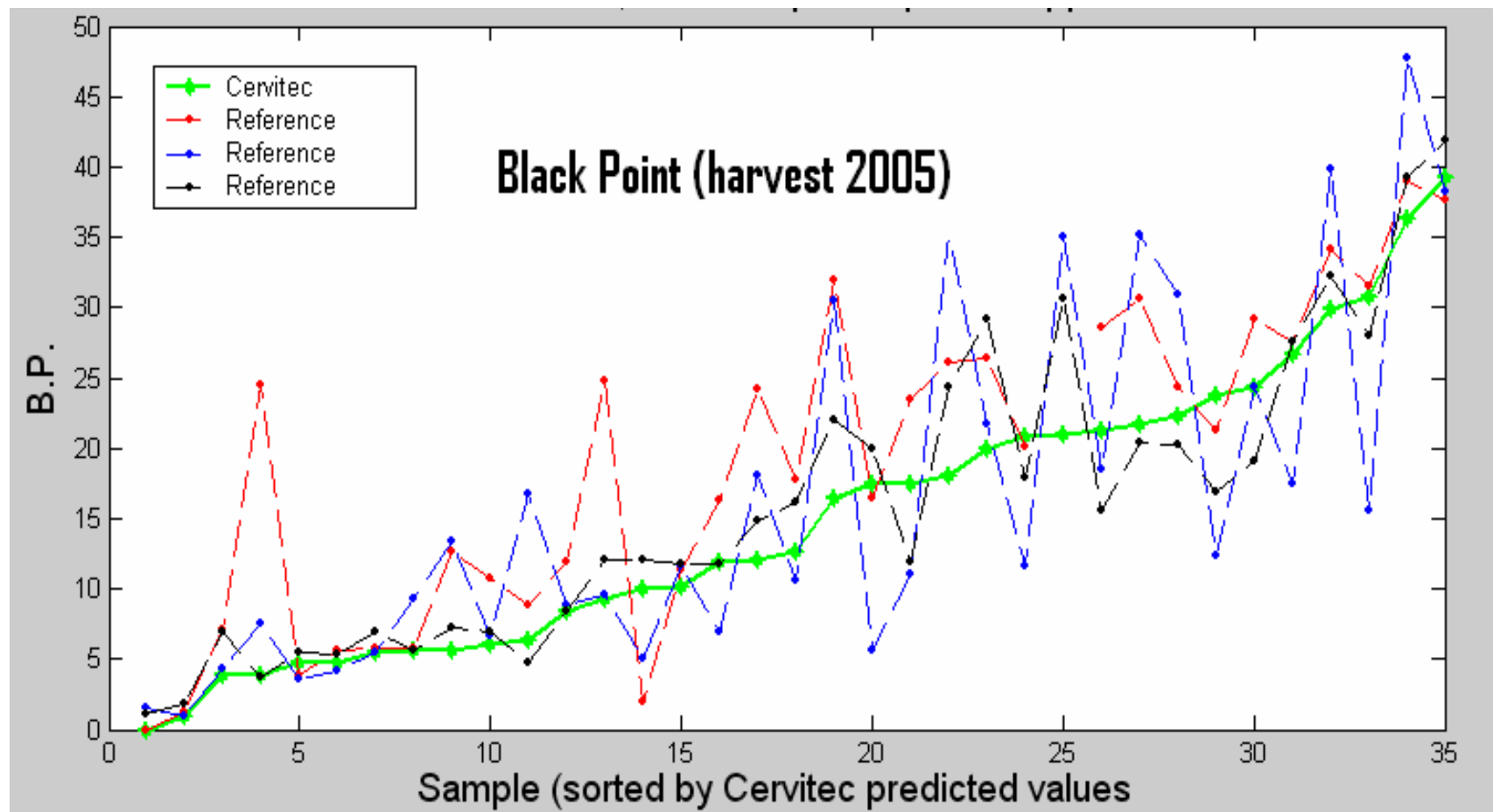
- **Head**
- **Chalky**
- **Cracked**
- **Damaged**
- **Coloured**
- **Broken**



Rice Check



	Brown	Polished	Comment
Head			
Chalky			Immature
Malformed			Damaged
Coloured			
Broken			
Crack			
Dead			



- X-Ray
 - Future standard for fat, weight, and foreign object detection in meat
 - Foreign detection interesting within other areas

- VIS/NIR - grain
 - Replacement of inspectors with vision assessment
 - Automatic assessment
 - Online quality check
 - Single kernel VIS/NIR
 - Combined VIS/NIR prediction models