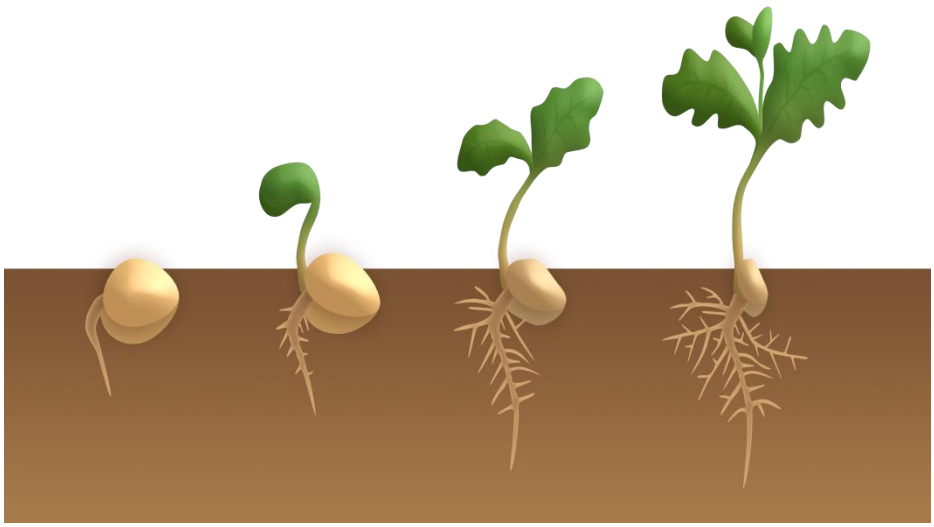
Application Of Spectral Technology In Seed

1. Introduction to seed testing

1.1 The importance of seeds

Seeds play a vital role in agricultural production. They are the starting point for crop growth and reproduction, and determine the yield, quality and stress resistance of crops. High-quality seeds can not only increase the growth rate of crops, but also enhance their resistance to pests and diseases, reduce the use of pesticides and fertilizers, and thus protect the ecological environment. The seed structure consists of embryo, endosperm, etc. The moisture content of seeds and other parameters have a certain impact on the activity of seeds.



1.2 Seed detection parameters

① Cleanness: It evaluates the cleanliness of seeds, that is, the proportion of seeds without impurities or inclusions.

② Purity: refers to the percentage of seeds that meet the characteristics of the variety in the tested seeds

③ Germination rate: refers to the percentage of the number of tested seeds that germinate within a specified number of days to the total number of tested seeds

④ Seed vitality: When it is urgent to understand the seed germination rate in a short period of time or when some samples still have a large number of dormant seeds at the end of germination, the biochemical method of vitality can be used to quickly estimate the vitality of seeds. Use 2,3,5-triphenyl tetrazolium chloride (abbreviated as tetrazolium, TTC) colorless solution as an indicator. After being absorbed by the living tissue of the seed, this indicator accepts hydrogen in the dehydrogenase of the living cells and is reduced to a red, stable, non-diffusible and water-insoluble phenyl formamide. Based on this, the staining reaction of the embryo and endosperm tissue can be used to distinguish between viable and non-viable seeds.

⑤ Water content determination

⑥ Enzyme activity

Correlation between seed chemical composition and seed vitality:

① Starch: The starch content has an obvious linear relationship with its germination time.

② Protein: In recent years, it has been found that there is a high correlation between seed vitality and protein content

③ Fat: Studies have shown that under aging treatment (natural aging, artificial aging) conditions, the internal crude fat content of soybean seeds and the vitality indicators such as seed germination potential, germination rate and germination index are all significantly positively correlated.

④ Enzyme: Enzyme is a biochemical regulator during seed germination. The conversion of each substance requires the guidance of enzymes. The conversion of each chemical component into nutrients required for seed germination is inseparable from the influence of enzymes. The activity of enzymes in seeds and their effects on seed germination and stress resistance.

⑤ Fatty acids: There is a significant negative correlation between seed vitality and fatty acid values.

⑥ Plant hormones: Different hormones can be added according to actual needs and the concentration of hormones can be appropriately adjusted to directly affect seed germination and seedling growth, improve seed vitality, and ultimately achieve the purpose of serving production.

⑦ Minerals: Using appropriate low-concentration trace element solution to pre-treat seeds has a positive effect on promoting seed germination, enhancing seed vitality and thus ensuring the field emergence rate.

2. Methods of non-destructive testing (seed)

2.1 Principle

As the key data of agricultural production, the non-destructive testing of seed quality has always been a hot topic in the field of non-destructive testing of agricultural products. It focuses on the detection of seed content, variety classification, disease detection, pest detection, mold infection detection, germination ability detection and transgenic detection.

1.2 Chemical composition of seeds

Crop seeds mainly contain chemical components such as sugars, lipids, and proteins. Their chemical components are closely related to seed quality and are important reference indicators for seed quality grading. At the same time, screening parents with high nutritional value is the key work of breeders in breeding new varieties. Non-destructive and efficient acquisition of seed chemical component information helps to speed up the breeding process of superior varieties, thereby shortening the breeding cycle.

1.3 Seed testing scheme

① NIR spectroscopy (IR Spectrometer + NIR Analyzer)

Principle: Near infrared spectroscopy analysis technology is a detection technology that uses the absorption, scattering, reflection and transmission characteristics of light to analyze the test object. The sample can be qualitatively or quantitatively analyzed through the absorption spectrum and physical analysis and chemical analysis results of the sample.

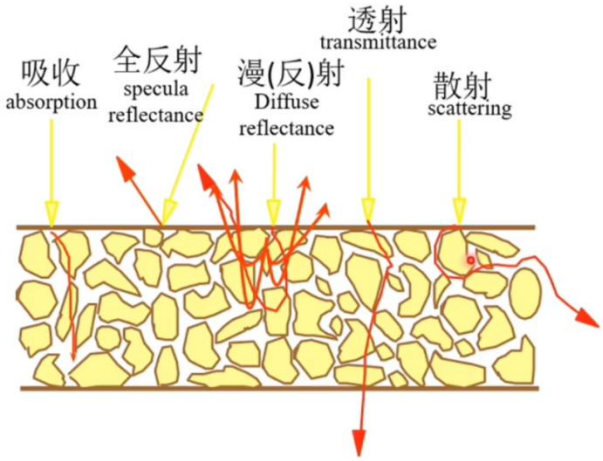
Near-infrared spectroscopy can provide rich spectral information of crops;

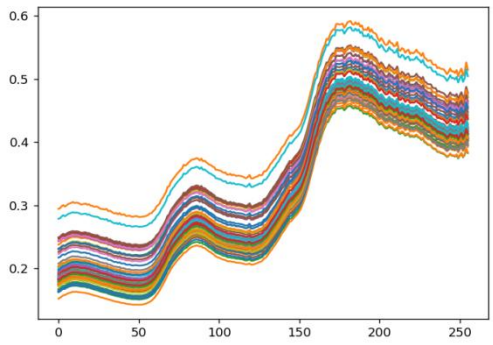
The molecular vibration frequencies of hydrogen-containing groups such as O-H, N-H and C-H in organic molecules are different, and absorption peaks with different intensities will appear at different wavelengths.

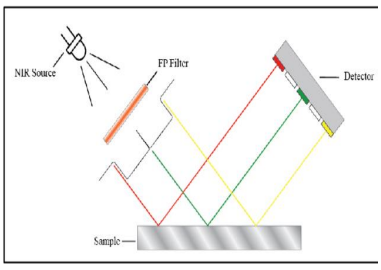
Spectra that reflect sample information (water content, soluble solids, titratable acid, starch, etc.);

Realize the prediction of seed quality, nutritional indicators, varieties, etc.

Application areas: component content detection, variety classification, pest detection, vitality detection, seed aging, fungi and fungal toxins, etc.







Advantages: non-destructive testing + fast speed + no sample pretreatment required + simultaneous detection of multiple parameters

② HSI

Principle: Hyperspectral imaging technology measures the reflectance spectrum of samples. On the one hand, it can collect surface feature information of samples, and on the other hand, it can obtain information such as the internal physical structure and chemical composition of samples. When the chemical composition of the sample is unevenly distributed and there are differences in the detection position of the sample, it will not affect the research on seed quality detection using hyperspectral imaging technology, thereby causing errors in the test results.

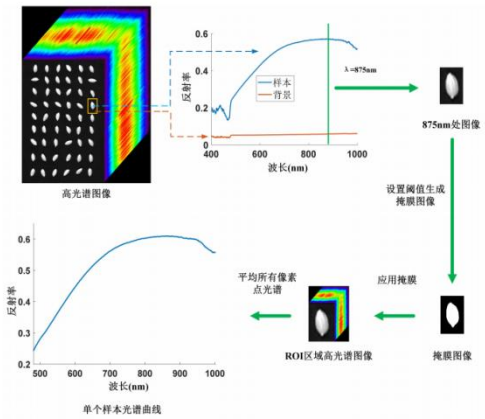
Hyperspectral imager technology is a technology that combines spectroscopy and imaging;

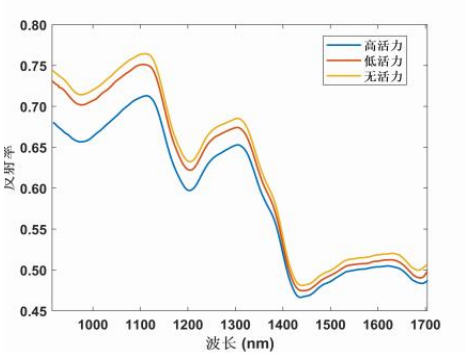
Measure the continuous spectrum of each pixel in the scene with fine wavelength resolution;

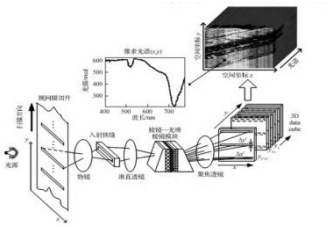
Spectra that reflect sample information (water, soluble solids, titratable acid, starch, etc.);

Realize the prediction of seed quality, nutritional indicators, varieties, etc.

Advantages: non-destructive testing + high efficiency + comprehensive analysis + effective prediction of multiple parameters







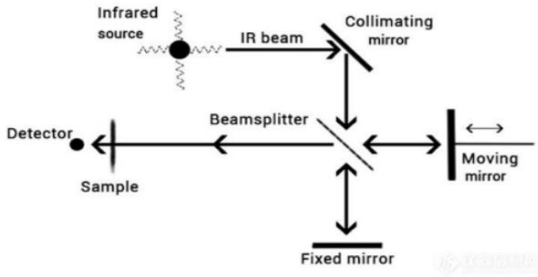
③ FT-IR spectroscopy

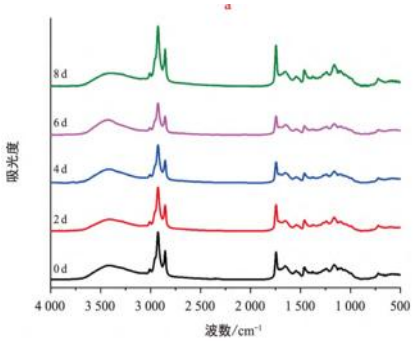
Principle: Measuring the absorption spectrum of a substance in the mid- and far-infrared bands can accurately characterize the chemical composition and chemical bond structure of the substance.

Fourier spectroscopy is a spectral analysis technology that decomposes light signals into different frequency components through Fourier transforms to obtain information on the composition and structure of the substance;

It can detect trace components of seeds, such as protein, fat, and carbohydrates;

By analyzing spectral information, the nutritional value and germination rate of seeds can be determined;





Advantages: non-destructive testing + high speed, high sensitivity + no sample pretreatment required + provides molecular structure information

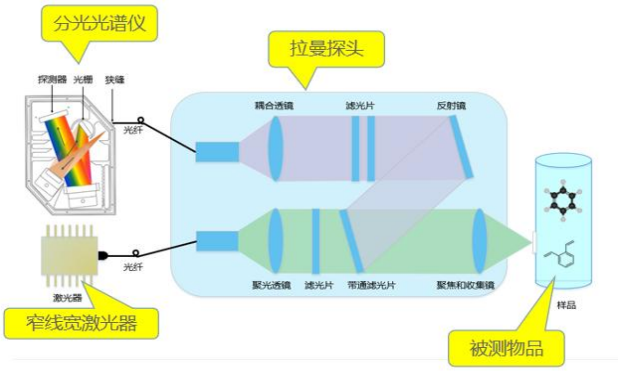
④ Raman analysis

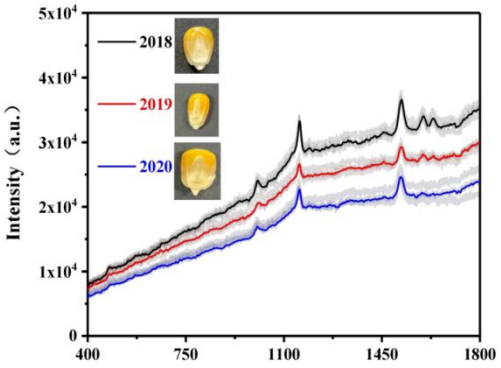
Principle: Raman measurement is the fingerprint spectrum of substances. Through laser excitation, different substances will emit different Raman spectra. It has the characteristics of being fast, non-destructive, and does not require sample pretreatment.

Raman spectroscopy is based on the principle of Raman scattering to analyze the composition and composition of substances;

It can test the key components of fat and protein in seeds;

By analyzing the Raman spectrum, you can understand the pathogenic microorganisms or chemicals in the seeds;





Advantages: non-destructive testing + high efficiency + online monitoring and real-time analysis + simultaneous measurement of multiple parameters

2. Optosky Spectral Products

Near infrared grain analyzer——IR2300

OPTOSKY 奥谱天成

Working principle and detection parameters

- Near-infrared transmission spectroscopy technology, seed water molecules and other components have a strong absorption effect on infrared light
- Measurement of seed parameters:
- Water
- Fatty acids
- Starch
- Can be built-in with a variety of seed vitality models

Test items and results

Wheat seed testing

Product Features and Applications

1% Accurate measurement results

30s Fast detection speed

Nondestructive Testing

easy to use

- Rapid laboratory seed vitality test, no reagents required;
- High cost performance, multiple seed vitality models can be built in;

Application Areas

Application

Seed Quality Testing Center

Seed tripartite testing unit

Near infrared seed detection and analysis instrument——IR2000pro

OPTOSKY 奥谱天成

working principle

- Near-infrared diffuse reflectance spectroscopy technology, the instrument illuminates from bottom to top, and can study seed components
- Measure seed parameters:
- Water
- Fatty acids
- Starch
- Built-in professional near-infrared modeling software, which can monitor seed vitality, monitor seed germination process, and study seeds to assist in the development

Test items and results

Wheat Seed Analysis Research

Features

Wide range of applications

Easy to operate

Nondestructive Testing

Modeling software

Rapid laboratory seed testing has a wide range of applications and can test rapeseed and other seeds (which cannot be penetrated by the penetration method);
Equipped with professional near-infrared modeling software, it is convenient for scientific researchers to study and analyze seeds

Application Areas

Application

农科所

育种站

Non-Contact Infrared Online Moisture Analyzer——GY1000

OPTOSKY 奥谱天成

working principle

- Near-infrared reflectance spectroscopy technology, water molecules have a strong absorption effect on infrared light
- Measurement of seed parameters:
- Grain seed moisture
- Grain, bean and other seed moisture

Test items and results

Seed moisture content test

Features

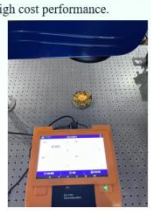
0.5% Accurate measurement

25ms Fast detection

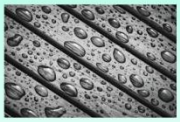
Nondestructive Testing

Contactless

It can be hoisted in the seed testing center to quickly test the moisture content of seeds (compared to the standard drying method and the rapid drying moisture tester);
It can be used as a moisture function component of other real-time seed testers, with high cost performance.



Application Areas



Seed moisture content measurement

Application

Seed Company

Market Agricultural Science Station

College of Agriculture

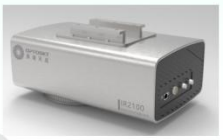
Seed supply station

Online NIR Spectrometer——IR2100

OPTOSKY 奥谱天成

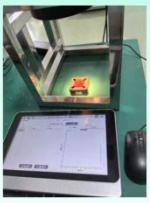
working principle

- Near-infrared diffuse reflectance spectroscopy technology, water molecules have a strong absorption effect on infrared light
- Measurement of seed parameters:
- Water content
- Fatty acids
- Starch, sugar content
- Online seed detection, sorting, grading
- Non-contact measurement
- Built-in model detection



Test items and results

Online seed grading and sorting



Infrared spectrum of seeds

Features

Accurate results

High-resolution

Nondestructive Testing

Online measurement

Online seed parameter rapid detection and analysis;
It can be placed in the laboratory for seed vitality measurement, or integrated into the seed online detection system as a functional module

Application Areas

Online seed testing system

Online seed grading and classification system

Hyperspectral Seed Detector——ATH3500

OPTOSKY 奥谱天成

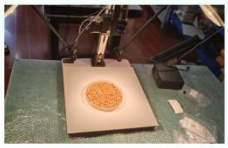
working principle

- By capturing the spectral reflection information of seeds in a continuous and narrow band, analyzing the spectral characteristics at different wavelengths, and then obtaining the chemical composition, physical structure and other properties of seeds, rapid and non-destructive detection of seed quality, type and other information can be achieved.
- Measurement of seed parameters
- Seed damage
- Seed impurities
- Water, protein, fatty acids
- Detection of seed vitality parameters

Test items and results

Soybean Seed Testing

Corn seed testing



Features

Many detection parameters | **Accurate results**

Nondestructive Testing | **Easy to operate**

Compared with near infrared, hyperspectral can perform additional detection of seed damage, seed impurities, and nutrient components in seed distribution. (The price is slightly higher than near infrared)
A corresponding vitality model can be established to monitor seed vitality;

Application Areas

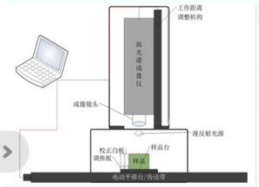
Application

Hyperspectral seed selection instrument——ATH2000

OPTOSKY 奥谱天成

working principle

The reflected light of the sample is captured by the spectral camera through the lens, and a one-dimensional image and spectral information are obtained. As the electronically controlled mobile platform (or conveyor belt) drives the sample to run continuously, continuous one-dimensional images and real-time spectral information can be obtained.
Measurement of seed parameters
Number of seed spikes, total number of grains, grain length, etc.



Test items and results

Seed copying

Features

≤3% Small error | **60s/plant** Fast detection speed

Real-time collection | **efficient**

It can be used for rapid seed selection in agricultural production and seed production
Real-time measurement

Application Areas

Agricultural

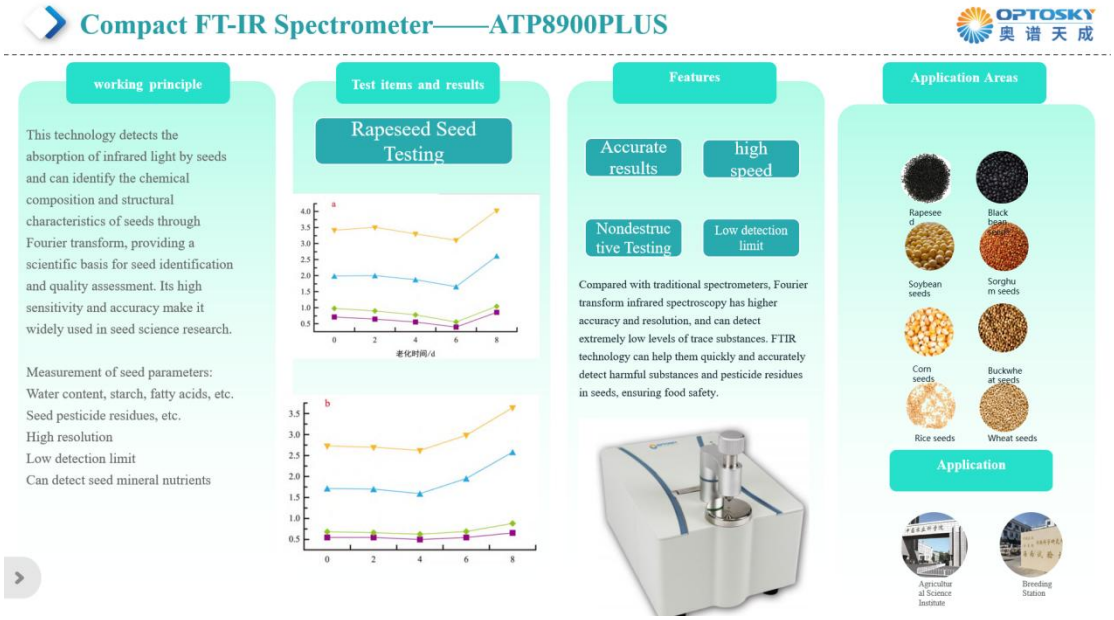
Seed production

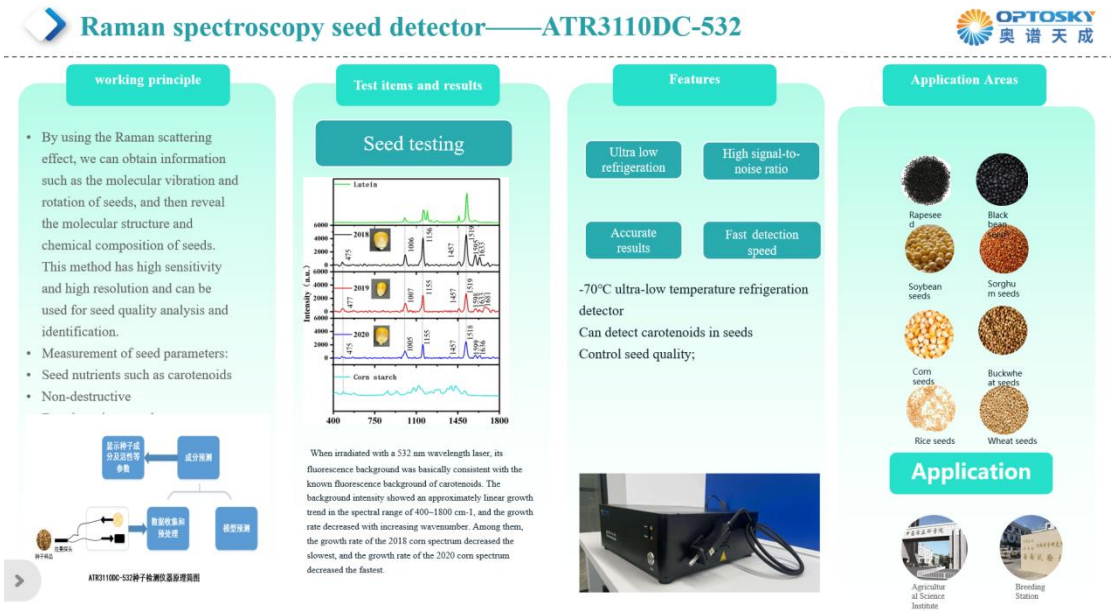
Application

Farms and breeding centers

中国种子 CHINA SEED

Seed Company





3. Seed testing application cases

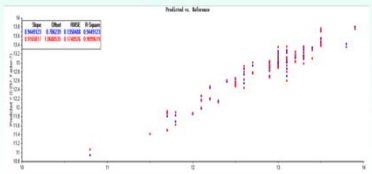
Rice seed composition testing

Rice seed component testing is an important part of ensuring seed quality. If the quality of seed components does not meet the standards, it may lead to seedling deformities, dwarfing, weak disease resistance, and reduced yields. Therefore, rice seed component testing is crucial. Near-infrared spectroscopy technology is non-destructive, fast, and accurate, and can effectively identify aging characteristics in seeds, such as changes in fatty acids, moisture, and other components. This method has important application value in the seed market and can help improve the efficiency and accuracy of seed quality testing.

Near infrared spectroscopy

Rice

Fatty acid



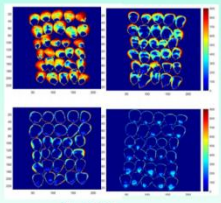
Sample Modeling

Moisture measurement data distribution

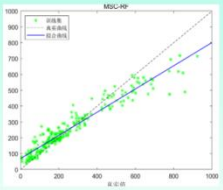
Using near infrared to detect the content of fatty acids and water in rice seeds can determine the freshness of rice seeds.

Spectral detection of seed aging (aging)

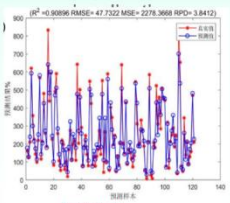
Hyperspectral imaging



Corn aging



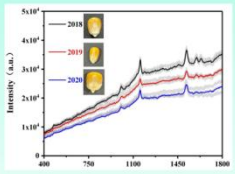
Maize Activity Model Prediction



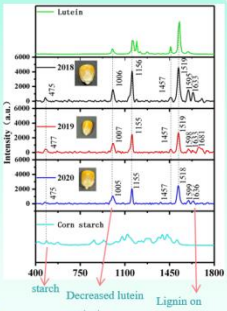
Corn activity prediction value

Through hyperspectral analysis, the optimal model is used to convert the predicted value information into image information for visualization distribution, and visualization distribution diagrams are drawn for four different time periods during the aging process to achieve online detection of corn kernel freshness. The obtained visualization distribution diagram is helpful to help us quickly determine the conductivity and freshness of the stored corn.

Raman spectroscopy



When irradiated with a 532 nm wavelength laser, its fluorescence background is basically consistent with the known fluorescence background of carotenoids. The background intensity shows a nearly linear growth trend in the spectral range of 400~1800 cm-1, and the growth rate decreases with the increase of wave number. The growth rate of the 2018 corn spectrum decreases the slowest, and the growth rate of the 2020 corn spectrum decreases the fastest. This fluorescence background has been observed in carotenoid solutions and biological matrices containing carotenoids.

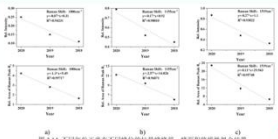


starch

Decreased lutein content

Lignin on the outer crust

The lutein content, peak intensity and peak area values are negatively correlated with time, which confirms the previous speculation about the extravasation of carotenoids.



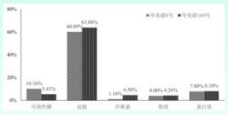
ATR3110DC-532

Seed variety identification test

The commercial value of crop seeds and their resistance to pests and diseases are directly related to seed varieties. With the continuous advancement of the technology for breeding new crop varieties, the varieties of the same type of crops are rich and diverse, which also brings certain difficulties to the identification and authentication of different varieties. The development of rapid identification and classification technology for seed varieties is conducive to ensuring the health and stability of the seed market and reducing the flow of inferior seed varieties into the market. In view of the variety requirements of different types of crop seeds, existing research has studied the identification and classification of seed varieties based on the internal composition, structural characteristics and external morphological characteristics of seeds.

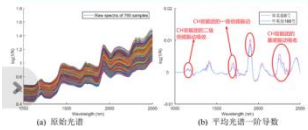
Near infrared spectroscopy

Near-infrared spectroscopy has an absorption effect on the double and combined frequencies of hydrogen-containing groups such as carbon-hydrogen bonds, nitrogen-hydrogen bonds and hydrogen-oxygen bonds in corn seeds. Since different varieties of corn seeds contain different hydrogen-containing groups, the near-infrared spectral characteristics they reflect are different. Therefore, the use of near-infrared spectroscopy technology can achieve the purpose of identifying different varieties of corn seeds.



Content of internal components in two varieties of sweet corn seeds (Huameitian No. 8 and Huameitian No. 168)

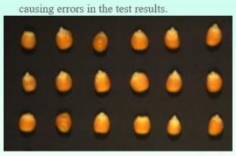
The two adjacent absorption peaks at 1724 nm and 1760 nm correspond to the absorption region of the first harmonic vibration of functional groups such as -CH, -CH2 and -CH3. The fundamental frequency combination absorption of carbohydrate functional group vibration is usually above 2000 nm. From this spectrum, two other adjacent absorption peaks are observed at 2310 nm and 2348 nm, which can be attributed to the fundamental frequency vibration absorption of functional groups such as -CH, -CH2 and -CH3.

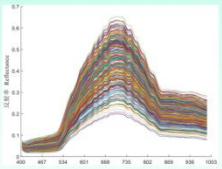


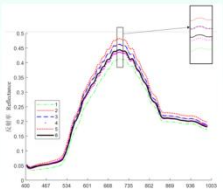
(a) 原始光谱 (b) 平均光谱一阶导数

Hyperspectral imager

Hyperspectral imaging technology can collect surface feature information of samples on the one hand, and obtain information on the internal physical structure and chemical composition of samples on the other hand. When the chemical composition of samples is unevenly distributed and there are differences in the detection positions of samples, it will not affect the research on seed quality detection using hyperspectral imaging technology, thereby causing errors in the test results.







Average spectral response of 6 varieties of corn seeds (Huawan 267, Longping 206, Huawan 263, Longping 208, Huawan 617, Longping 259) due to the proportion of starch, fat, water and other compounds.

Spectral Detection of Heat Damage in Seeds

Heat damage to seeds

Prone to mildew

The moisture content of newly harvested seeds is as high as 25~45%, which makes them very prone to mildew and anaerobic respiration, producing alcohol that poisons the seeds. Therefore, the seeds must be dried promptly after harvest to reduce the moisture content to a level that can be safely stored.

Heating required

The moisture content of sweet corn seeds after maturity and dehydration is higher than that of ordinary corn seeds, and the high sugar content causes the seeds to dry slowly. Conventional natural ventilation drying is difficult to achieve the requirements of timely drying, and heat drying is required with the help of a heat source.

Vulnerable

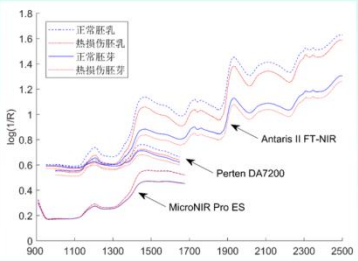
Microwave drying has the advantages of fast speed, high thermal efficiency and uniform heating. However, improper control of the temperature and rate of microwave drying will cause damage to the seeds, leading to loss of germination ability and reducing the germination rate of the seed batch.

Difficult to detect

Sweet corn seeds that are damaged by heat do not change in color or appearance, so traditional visible light image analysis technology cannot be used to detect the heat damage. Identification requires manual germination tests, which is a time-consuming and labor-intensive process.

Near-infrared spectroscopy for thermal damage detection

The embryo of sweet corn seeds is a heat-sensitive material and is easily damaged by heat, which affects seed germination. Heat damage causes changes in the properties of components such as protein, starch, and fat in sweet corn seeds. Near-infrared spectroscopy is used to qualitatively identify and detect heat damage in sweet corn seeds. Spectral analysis technology and multivariate analysis methods are used to analyze the characteristic spectral information of normal seeds and heat-damaged seeds.



The relative absorption of sweet corn seed samples at the first and combination frequencies is greater than that at the second and third frequencies. The wavelength ranges of 1700-1800nm and 2300-2400nm correspond to the first and combination frequency absorptions with -CH3, -CH2 and -CH as the main functional groups, respectively.

IR2000Pro Desktop Near Infrared Spectrometer

IR2300-25 Desktop Near Infrared Spectrometer

Seed Vitality Test

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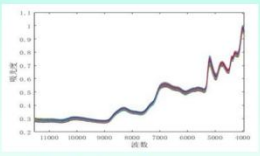
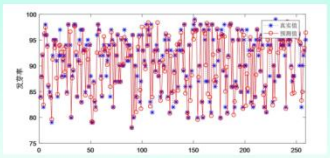
Near infrared spectroscopy

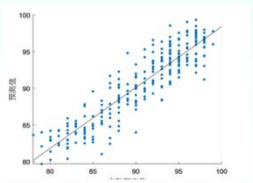
Rice seed samples



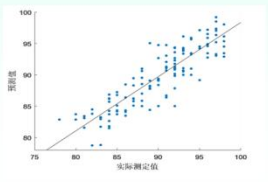
Near infrared spectrum of seeds



Calibration samples



PLS Calibration Model Results



Model prediction results

The rice seed vitality prediction model was established by applying near-infrared spectroscopy analysis technology, and the purpose of obtaining the germination rate of rice seeds by measuring the near-infrared spectral data of rice seeds was achieved. It was proved that the model can be used to determine the germination rate of rice seeds, and the stability and prediction performance of the model are good. The use of spectral data processing algorithms such as MCCV method and UVE method can effectively improve the prediction performance of the model. The rice seed germination rate determination model based on near-infrared spectroscopy established by PLS+BP method can accurately determine the germination rate of rice seeds. At the same time, this study also provides a reference for the determination of germination rate of other crop seeds.

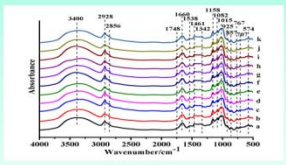
Seed Vitality Test

OPTOSKY 奥谱天成

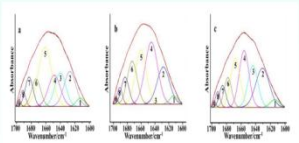
Fourier spectrum To further understand the mobilization of nutrients, curve fitting analysis was performed on the spectra of polysaccharides, protein amide I region and fat characteristic region. The results showed that with the increase of initiation concentration, the relative content of soluble sugar in seeds during germination showed a trend of first increasing and then decreasing. At the same time, the difference in the content of fat, protein and polysaccharides in seeds was the basis for judging seed vitality.

Fourier spectroscopy

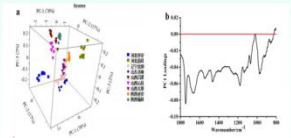
Customer samples



Fourier spectra of different millet seeds



Fitting curve in the range of 1700-1600cm-1



PCA graph and main contribution graph of millet seeds