COMPARATIVE STUDY BETWEEN ANALYSIS USING CONVENTIONAL METHOD AND FT - NIR SPECTROPHOTOMETER FOR VARIOUS RAW MATERIALS.

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ABSTRACT

In many areas, raw material inspection plays an important role in ensuring the quality and consistency of the final product. Although traditional methods have been used for many years, their accuracy, speed and range are often limited. Practical options have become available with the development of Fourier transform near-infrared (FT-NIR) spectrophotometers. However, a complete comparison of FT-NIR spectrophotometry and reference standards has not been made. This study fills this gap by examining the results of two methods containing different nutrients. The main aim of this study is to compare the analysis of different materials using FT- NIR spectrophotometric and conventional methods. One of the objectives is to evaluate the accuracy, efficiency, and reliability of each method for determining key raw materials. Within the scope of the study, many raw material samples were collected from different places. These data were then analyzed using FT-NIR spectrophotometric and functional methods. Key parameters such as moisture content, shrinkage, NVEE and quality were measured and compared between the two methods. The collected data will be analyzed in detail to draw important conclusions about the effectiveness of each method.

This study compares the results of FT-NIR spectrophotometry with standard methods for the analysis of Maida and groundnut raw materials. Peanuts and Maida are important ingredients in many food products and the quality of these ingredients directly affects the final result. Traditional methods of analyzing raw data can be time-consuming and require specialized personnel. In recent years, FT-NIR spectrophotometry has become a popular, rapid and non- destructive method for assessing food quality. However, its effectiveness in evaluating Maida and peanut products compared to traditional methods remains unclear. To achieve this, two methods will be used to identify various quality factors of peanuts such as moisture content, Maida loss count and moisture content. The number and moisture content specifications that must be met to obtain finished products from raw materials are less than 260-325 and 12-13% respectively. To produce the finished product, the moisture content of the peanut product must be below 10% and NVEE up to 45% respectively. Raw materials will be analyzed batch by batch according to the specifications required by the business to obtain the required results.

Keyword : *Falling Number , Non-Volatile ether Extraction [NVEE], Spectrophotometer, non-destructive, conventional methods.*

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1. INTRODUCTION

Fourier transform near-infrared spectroscopy (FT-NIR) is a nondestructive inspection technique that provides a way to identify and describe a variety of materials.
FT-NIR spectroscopy is an attractive tool for the food industry because it is simple, fast and allows non-destructive measurement of chemicals and substances. It has remote measurement versatility and easy analysis of different types and models. NIR devices can be easily deployed in fields or production lines to directly and simultaneously measure various aspects of food products. NIR is an abbreviation of near-infrared spectroscopy. The electromagnetic spectrum spans between 800 and 2500 nm and borders to the red region of visible light. When a sample is irradiated with NIR light, the absorbs the light and the matching molecular vibrations are activated. The outcome is a NIR spectrum containing absorption bands of varying molecular groups (predominantly N-H, C-H, and O-H bonds) at typical wavelengths.
Near infrared spectroscopy is abbreviated as NIR. The electromagnetic spectrum is at the border of the red region of visible light and extends from 800 nanometers to 2500 nanometers. When near-infrared light hits a sample, the sample absorbs the light and causes molecular vibrations. The result is an NIR spectrum with absorption bands at wavelengths containing various chemical groups (N-H, C-H, and O-H bonds only).
Large samples can be measured quickly using FT-NIR (typical measurement time is 15 to 30 seconds). No reagents are required, so operating costs are low.

1.1 Advantages of FT-NIR spectroscopy:

- Fast analysis: FT-NIR spectroscopy allows samples to be analyzed instantly; Results can be obtained in seconds to minutes depending on the sample matrix and target measurement.
- Non-destructive: FT-NIR spectroscopy is non-destructive; It allows samples to be reused or further analyzed compared to many traditional methods that require destruction.
- Minimal preparation: FT-NIR spectroscopy requires almost no sample preparation, thus reducing analysis time and cost.
- Multidisciplinary research: FT-NIR spectroscopy is suitable for the study of complex matrices because it can examine many aspects in a single sample simultaneously.
- Versatility: FT-NIR spectroscopy is a versatile analytical technique for the food industry because it can be used for many sample types, including solids, liquids and powders.
- Versatility: FT-NIR spectroscopy is a versatile analytical technique for the food industry because it can be used for many sample types, including solids, liquids and powders.

1.2 Compare the accuracy of the conventional analysis method and FT-NIR spectrophotometer for analyzing various raw materials.

Introduction Comparing the accuracy of FT-NIR spectrophotometry to traditional analytical methods used to measure different food products is important for any business. Traditional techniques such as spectroscopy, chromatography and wet chemistry have been relied upon for years. This process requires complex processes and skilled employees. Wet chemistry, for example, requires careful elaboration of the structure and function of chemical compounds to determine composition. Another method is chromatography, which separates the components of the sample according to their interactions with stationary and mobile phases. Although this method requires expensive equipment and skilled workers, it is intuitive and capable of controlling the combination. Spectroscopic methods, such as infrared and ultraviolet-visible spectroscopy, show the composition and structure of molecules. But they won't affect every area and they also need planning. FT-NIR spectrophotometric, on the other hand, is based on the concept of near-infrared molecular vibrations. It provides information about molecular structure and functional groups by measuring the amount of near-infrared radiation absorbed by organic molecules. The ability to quickly analyze data is one of the advantages of FT-NIR spectroscopy. It is a non-destructive and economical solution as it requires less planning than traditional methods. Additionally, FT-NIR spectrophotometers are capable of analyzing a variety of raw materials such as powders, liquids and solids. FT-NIR spectroscopy is easy to use because it is easy to use and requires little training. Traditional methods generally show the highest levels of accuracy and repeatability when applied by professionals. But with proper calibration and validation techniques, FT-NIR spectroscopy can achieve a similar level of accuracy. The sensitivity and specificity of chromatographic techniques in the identification and measurement of analytes in complex mixtures are well known. Conversely, while FT-NIR spectroscopy may not be as sensitive to minute components, it makes up for it in its adaptability to a wide variety of sample types. Because conventional methods provide calibration methods and reference standards, they are well established for quantitative analysis, an essential component of raw material analysis. However, to accurately correlate spectral data with analyte concentrations while accounting for matrix effects and sample variability, FT-NIR spectroscopy needs robust calibration models. Complex sample matrices can be too challenging for conventional methods, requiring considerable sample preparation and method development. However, FT-NIR

spectroscopy excels at analyzing such samples, including mixtures and heterogeneous materials, without requiring extensive preparation. Meanwhile, FT-NIR spectroscopy enables rapid analysis of moisture content, fat content and protein content in food matrices, reducing processing time and cost. In the petrochemical industry, gas chromatography is widely used to analyze the composition of hydrocarbons. FT-NIR spectroscopy complements these techniques by rapidly analyzing key parameters such as octane number and sulfur content. Ultimately, the choice between conventional analysis methods and FT-NIR spectrophotometry hinges on factors such as sample complexity, analysis speed, and resource availability. Leveraging the strengths of both approaches can enhance efficiency, reduce costs, and ensure product quality and regulatory compliance across various industries.

2. METHODOLGY

1.Environmental conditions:

Environmental factors such as temperature, humidity and exposure to light can have a significant effect on method performance. Traditional methods often rely on sensitive equipment and chemical reactions and can be vulnerable to fluctuating environmental conditions. For example, changes in temperature and humidity can affect the stability of reagents and calibration standards, leading to inconsistent results. Additionally, exposure to light can degrade the sample and alter measurement accuracy, especially in spectroscopic techniques such as UV-visible spectroscopy. FT-NIR spectrophotometry shows good flexibility against environmental changes due to its non-destructive nature and robust instrumentation. Near-infrared (NIR) radiation is less sensitive to changes in temperature and humidity, allowing FT-NIR instruments to maintain stability and accuracy in a variety of environmental settings. However, it is important to consider factors such as sample location and instrument calibration to minimize potential sources of variation. In general, FT-NIR spectrophotometry shows high reliability in different environmental conditions compared to traditional methods.

2.Sample properties:

The characteristics of the analyzed sample play an important role in determining the reliability of the analytical method. Traditional methods can face challenges when analyzing samples with complex matrices, heterogeneous compositions or variables.

3.Instrument Performance and Calibration:

The reliability of an analytical method is closely related to the performance and calibration of the equipment used. Traditional equipment requires regular calibration and quality control using reference standards to ensure accuracy. Changes in equipment performance over time, such as moving parts or aging, can affect measurement reliability. Additionally, variations in sample preparation techniques and operator skill levels can introduce sources of variability in traditional methods.

FT-NIR spectrophotometers also require calibration using known reference samples to create accurate predictive models of analyte concentration. Appropriate calibration and validation methods are essential to ensure the reliability of FT-NIR measurements in different sample types and conditions. Regular maintenance and performance checks of equipment are required to monitor deviations and inconsistencies. Although FT-NIR spectrophotometry has advantages in terms of speed and ease of operation, maintaining instrument reliability requires careful attention to calibration and quality control procedures.

4.Matrix effects and interference:

Both conventional and FT-NIR spectrophotometric methods can face challenges related to matrix effects and interference of compounds present in the sample. In traditional methods, matrix effects can interfere with chemical reactions and chromatographic separations and affect measurement accuracy. For example, sample matrices containing interfering compounds may require additional sample preparation or method development to overcome matrix effects and obtain accurate results. FT-NIR spectrophotometry is sensitive to matrix effects, especially when analyzing complex samples with overlapping absorption bands and spectral interference. To accurately predict analyte concentration, calibration models must account for matrix variations and potential interferences. Strategies such as spectral pretreatment, chemical modeling, and reference standardization can help reduce matrix effects and improve the reliability of FT-NIR measurements.

5. Evaluation of the ease of transferring the method between laboratories of different settings for both traditional methods and FT-NIR spectrophotometers.
To evaluate the applicability and adaptability of both conventional methods and FT-NIR spectrophotometry in analytical chemistry, it is necessary to evaluate the ease of transferring the methods between laboratories and different environments. Method transferability refers to the ability to repeat and consistently perform analytical procedures across multiple locations, instruments, and operators. This evaluation includes an examination of various factors that influence method transfer, such as equipment compatibility, standardization protocols, operator training, and data interpretation.

2.1 Traditional method:

CONVENTIONAL MOISTURE ANALYSIS METHOD OF GROUNDNUT SEEDS

The conventional method of groundnut seed moisture analysis as outlined by the Food Safety and Standards Authority of India (FSSAI) regulations involves a careful and systematic approach to ensure accurate determination of moisture content. This method is essential for evaluating the quality and safety of groundnut seeds because moisture content can affect shelf life, susceptibility to spoilage, and overall product quality.

First, a representative sample of groundnut seeds is collected in accordance with FSSAI guidelines to ensure that it accurately reflects the composition of the entire batch. Careful attention is paid to sampling to avoid contamination and maintain the integrity of the analysis. The sample is collected using appropriate sampling tools and techniques to prevent external absorption of moisture and maintain homogeneity. After sample collection, the next step is sample preparation. The groundnut seeds are cleaned and sorted to remove any extraneous matter such as dirt, debris or damaged seeds that could affect the accuracy of the moisture analysis. The cleaned seeds are then finely ground to increase the surface area available for moisture extraction, ensuring a thorough and efficient analysis.

Once the sample is prepared, it is accurately weighed using a precision balance as per FSSAI guidelines for weighing procedures. The weight of the sample is recorded to the nearest decimal point to maintain the accuracy of the analysis. Careful attention is paid to sample handling to avoid loss or contamination during the weighing process. After weighing, the sample is placed in a designated moisture analysis apparatus such as an oven or moisture balance as per FSSAI specifications. The instrument is calibrated and operated as per FSSAI guidelines to ensure accurate and reliable results. The temperature and duration of the drying process are carefully controlled to prevent degradation of heat-sensitive components and to ensure effective moisture removal.

During the drying process, the sample is carefully monitored to determine when moisture equilibrium has been reached. This is typically indicated by a constant weight, which means that the sample has been sufficiently dried and that further drying will not result in significant changes in weight. FSSAI regulations specify criteria for determining moisture balance and acceptable range of moisture content for groundnut seeds.

Once the moisture equilibrium is achieved, the final weight of the sample is recorded and the moisture content is calculated using the formula prescribed by the FSSAI guidelines. This formula typically involves subtracting the final weight of the dried sample from its initial weight and expressing the result as a percentage of the initial weight. The calculated moisture content is compared with the acceptable range prescribed by FSSAI regulations to assess the quality and safety of the groundnut seeds.

Overall, the conventional method of groundnut seed moisture analysis as per FSSAI regulations is a rigorous and systematic process designed to ensure accurate determination of moisture content. By following established protocols and guidelines, food manufacturers can assess the quality and safety of groundnut seeds and meet regulatory requirements to protect the health and welfare of consumers.

Weigh the petri plate and add 5g of the sample to it and weigh again, note the weight.

↓

Keep it in the hot air oven for 5 hours – 105 degree Celsius.

↓

After 5 hours weigh the petri plate that contains the sample taken and note the weight.

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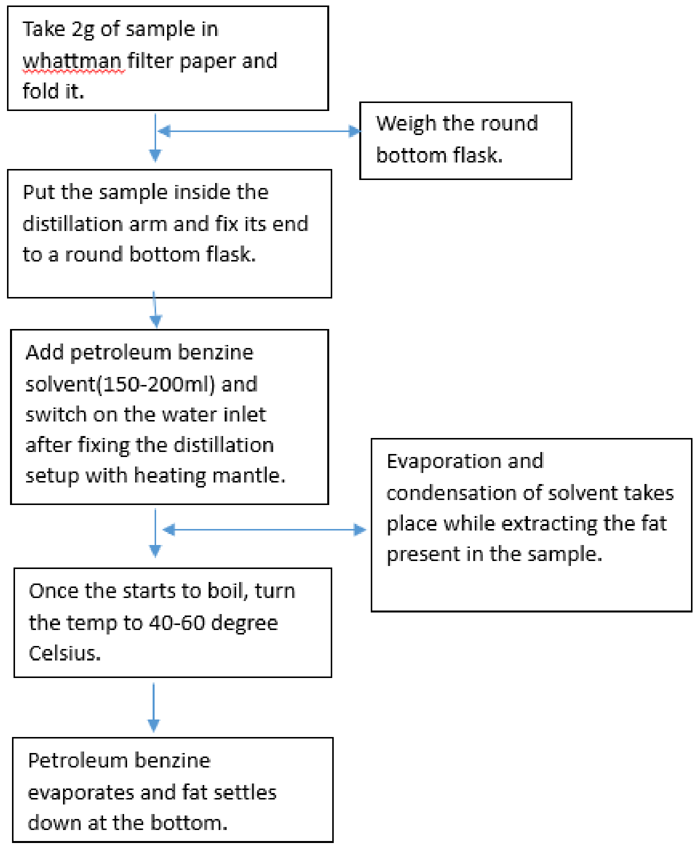
If the sample contains the moisture the weight of the sample will be reduced.

CONVENTIONAL NON-VOLATILE ETHER EXTRACTION METHOD OF GROUNDNUT SEEDS

The conventional non-volatile ether extraction method for groundnut seed raw material, as outlined by the Food Safety and Standards Authority of India (FSSAI) regulations, involves a systematic and careful approach aimed at extracting the desired components from the seeds while following strict safety precautions. and quality standards.

First, a representative sample of groundnut seeds is collected in accordance with FSSAI guidelines to ensure that it accurately reflects the composition of the entire batch. Careful attention is paid to sampling to avoid contamination and maintain the integrity of the analysis.The sample is collected using appropriate collection tools and techniques to minimize externalinfluences and ensure homogeneity.



After sampling, the seeds go through a preparation phase to remove all foreign matter and ensure uniformity. This includes cleaning and sorting the seeds to remove debris, dirt and damaged seeds that can affect the accuracy of the extraction process. The cleaned seeds are then finely ground to increase the surface area available for extraction, facilitating the efficientremoval of the desired components.

Once the sample is prepared, it is subjected to non-volatile ether extraction using a specified solvent such as petroleum benzine as per FSSAI regulations. In this method, non-volatile solvents are preferred to minimize the risk of the presence of volatile compounds and ensure the safety of the extraction process. Extraction is performed in a controlled environment to maintain consistency and reproducibility. The extraction process is usually carried out in a specialized facility under controlled conditions including temperature, pressure and duration as prescribed by FSSAI guidelines. These parameters are carefully monitored to optimize extraction efficiency while minimizing degradation of heat-sensitive components. The ratio of solvent tosample is also carefully controlled to ensure adequate contact between the solvent and the groundnut seed material, facilitating the extraction of the target components.

After extraction, the solvent containing the extracted components is separated from the solid residue using filtration or centrifugation methods as per FSSAI regulations. The separated solvent is then subjected to evaporation to remove the residual solvent and the extracted components are concentrated. This evaporation step is performed under controlled conditions to prevent the loss of volatile compounds and ensure the integrity of the extracted components.

The concentrated extract obtained from the evaporation step may undergo further processing or analysis depending on the desired application. During the extraction process, strict adherence to FSSAI regulations is essential to ensure the safety and quality of the extracted ingredients. Quality control measures, including the use of certified reference materials and regular equipment calibration, help maintain the accuracy of the extraction process and ensure the consistency of the extracted components. Environmental considerations are also important in the extraction process, especially in solvent waste disposal. Proper disposal methods must be used to minimize environmental impact and ensure compliance with regulatory requirements set by FSSAI.

Conventional non-volatile ether extraction method for groundnut seed raw material as per FSSAI regulations is a systematic and precise process designed to extract the desired components while adhering to strict safety and qualitystandards. Conventional non-volatile ether extraction method for groundnut seed raw material as per FSSAI regulations is a systematic and precise process designed to extract the desired components while adhering to strict safety and quality standards. By following established protocols and guidelines, industries can obtain high-quality extracts for a variety of applications while ensuring consumer safety and regulatory compliance.

CONVENTIONAL MOISTURE ANALYSIS METHOD OF MAIDA

Take a representative sample of Maida. Ensure that the sample is properly homogenized to get consistent results. Weigh an appropriate amount of the prepared sample. The weight depends on the expected moisture content and the method's sensitivity. Typically, 5-10 grams of maida should suffice. Preheat the hot air oven to a specified temperature, usually around 105-110°C. Place the weighed sample in a moisture dish or container and record its initial weight.

Transfer the sample to the preheated oven and dry it for a specified period, typically around 5 hours. During this time, the moisture in the sample will evaporate. After the specified drying time, remove the sample from the oven and allow it to cool in a desiccator to prevent reabsorption of moisture from the atmosphere. Once the sample has cooled, weigh it again to determine the final weight. The difference between the initial and final weights represents the moisture lost during drying.

CONVENTIONAL FALLING NUMBER ANALYSIS METHOD OF MAIDA

The traditional method of drop count analysis of raw Maida, regulated by the Food Safety and Standards Authority of India (FSSAI), is an important quality assessment technique used in the flour milling industry to measure enzyme activity, particularly alpha-amylase activity, founding in flour. This method plays a vital role in assessing the quality and suitability of Maida for various food applications, ensuring compliance with FSSAI standards and regulations while maintaining consumer safety and product integrity.

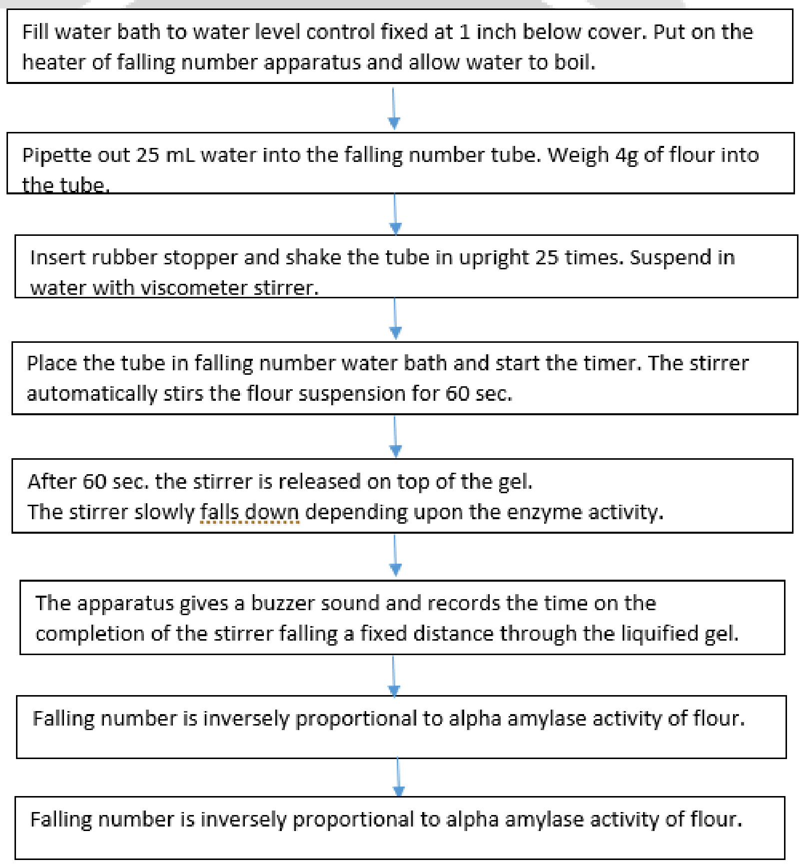
First, a representative sample of maida is collected as per FSSAI guidelines to ensure accuracy and reliability of the analysis. Even small changes in the sample can affect the accuracy of the drop count analysis, so great care is taken in the sample collection procedure to avoid contamination and maintain sample homogeneity.

After the sample is collected, a preparation process is carried out to ensure uniformity and consistency. This may include homogenization and sieving to remove large particles or foreign material that may interfere with analysis. The prepared sample is now ready for drop number testing. Fall count analysis is done using fall count equipment as per FSSAI regulations. This device usually consists of a glass tube filled with Maida slurry and water and a falling weight attached to a piston.

The sample is heated under controlled conditions and the falling weight is dropped through the slurry. As the falling weight descends through the slurry, it encounters resistance due to the starch gelatinization process initiated by the α-amylase enzyme present in the maida. The time (usually expressed in seconds) that it takes for a falling weight to fall a specified distance is recorded as the number of falls. The higher the reduced number, the lower the alpha-amylase activity level, and the lower the number, the higher the enzyme activity.

Numerical reduction analysis provides valuable insight into the enzymatic activity and quality of Maida, which is regulated under FSSAI standards.

The conventional method of falling number analysis for raw material maida, as regulated by FSSAI, is a vital quality assessment technique used in the milling industry to evaluate enzymatic activity and ensure compliance with food safety and quality standards. By adhering to established protocols and guidelines, food manufacturers can maintain product integrity, meet regulatory requirements, and uphold consumer trust in their products.



FALLING NUMBER DETERMINATION IN MAIDA

3. FT-NIR SPECTROPHOTOMETER

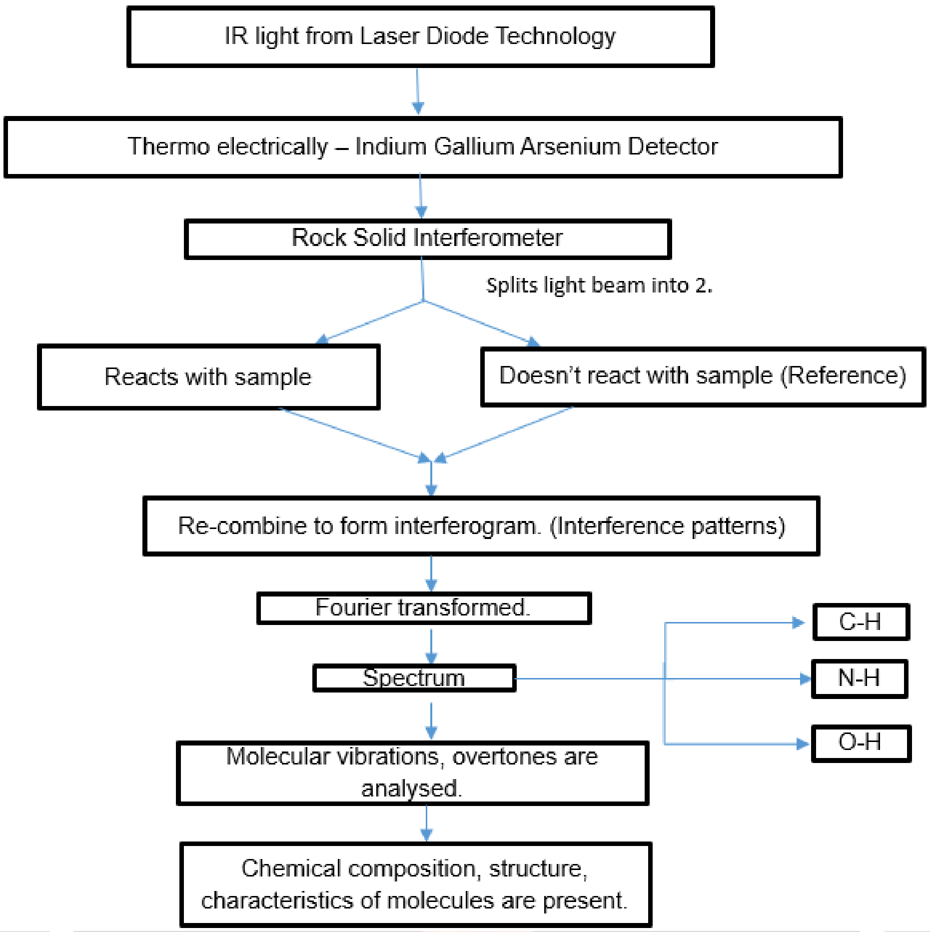
FT-NIR spectrophotometry has advantages over traditional methods in terms of method portability, mainly due to standard instrumentation, non-destructive nature, and the ability to

automatically analyze data. Several factors contribute to the ease of method transfer for FT- NIR spectrophotometry.

- Standard instruments: FT-NIR spectrometers are designed to conform to standard specifications and performance standards, facilitating method transfer between different instruments and manufacturers. Calibration standards and validation methods are usually standardized and allow for consistent measurements across laboratories and environments.
- Non-destructive nature: FT-NIR spectroscopy is a non-destructive technique that does not require sample preparation or modification and minimizes fluctuations during analysis. Samples can be analyzed in situ, reducing the potential for errors associated with sample handling and preparation.
- Automated data analysis: FT-NIR spectrophotometers often include software for automated data collection and analysis, reducing the reliance on operator skill and expertise. Standardized data processing algorithms and chemometric models enable consistent and reproducible results across different laboratories or environments.
- Calibration transfer: Calibration models developed for FT-NIR spectroscopy can be transferred between instruments with minimal modifications, allowing seamless method portability. Spectral libraries and reference databases facilitate calibration transfer and method validation across different sample types and matrices.

Overall, FT-NIR spectrophotometry offers easier method portability compared to conventional methods, primarily due to standardized instrumentation, non-destructive analysis, automated data analysis, and calibration transfer capabilities. These advantages make FT-NIR spectrophotometry suitable for applications requiring consistent and reliable analytical results in different laboratories or environments.

In conclusion, while both conventional methods and FT-NIR spectrophotometry are widely used in analytical chemistry, FT-NIR spectrophotometry offers advantages in method portability, especially for applications requiring standardized instrumentation, automated analysis, and calibration transfer. By considering factors such as instrument compatibility, standardization protocols, operator training, and data interpretation, researchers and analysts can determine the most appropriate analytical approach to achieve consistent and reliable results in different laboratories or environments.



4. CONCLUSIONS

A comparative study of conventional methods and Fourier transform near-infrared (FT-NIR) spectroscopy in the analysis of raw materials, especially Maida seeds and groundnuts, provides insight into the effectiveness, reliability, and feasibility of these techniques in food processing. Insight, insight, insight. industry Through experiments and in-depth analysis, this study contributed to understanding the potential application of FT-NIR spectrophotometry as an alternative to traditional methods for quality assessment.

The results of this study show the importance of accurate evaluation of the quality parameters of Maida seeds and groundnuts, because these seeds serve as essential ingredients in a wide range of foods. By comparing the results obtained from traditional methods and FT-NIR spectrophotometry, this study revealed the strengths and limitations of each technology and provided valuable information to food manufacturers and processors.

The analysis of water content, protein content and oil content of Maida and groundnut seeds showed a high correlation between the values obtained by conventional methods and FT-NIR spectrophotometry. This shows that FT-NIR spectrophotometry can be a reliable and efficient alternative to traditional methods for quality assessment in the food processing industry. In addition, the non-destructive nature of FT-NIR spectrophotometry offers advantages in terms of sample preservation and resource utilization.

The results obtained from this study have practical implications for food manufacturers and processors as they demonstrate the potential of FT-NIR spectrophotometry to simplify the quality assessment process and improve overall efficiency. By adopting FT-NIR spectrophotometry, food companies can reduce analysis time, minimize dependence on specialized staff, and strengthen quality control measures.

However, it is important to acknowledge that further research and validation are necessary to fully realize the benefits of FT-NIR spectrophotometry in the food processing industry. Calibration models must be developed and refined to ensure accurate predictions of quality parameters, and additional studies are needed to assess the applicability of FT-NIR spectrophotometry to other food materials and processing stages.

For heterogeneous samples which are mostly found in food industry a different approach must be taken. NIR is the choice for this seedy, watery material because the Nir beam can penetrate through the material and bounce several times before reaching the detector. After undergoing multiple reflection through the volume of the sample, the beam finally finds it way to the detector and hence absorption spectra represent the bulk of the sample rather than just the touch of the surface when compared with other analyzers.

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