UNDERSTANDING FOOD TEXTURAL ANALYSIS AND HOW TO MEASURE IT

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Introduction

Technological development has enabled food researchers to conduct quantitative interpretation of product quality during R&D. Rigorous laboratory testing and evaluation are done to ensure that the products meet the demand in the consumers' market, especially for the development of new food products. Manufacturers must ensure that their newly developed products possess the expected traits and properties.

For example, they might be interested in developing vegetarian meat products with the same chewiness and texture as the real meat, determining the correct cooking time of dry pasta to achieve 'al-dente' texture or optimizing the baking time and ingredient ratio in bread-making. Although subjective testing has been extensively used in the past, the reliance on human sensory systems to determine the product quality is proven too unreliable and impractical for its applications in the modern manufacturing site. Therefore, technologies are developed to quantify how humans generally distinguish taste in food.

Understanding Food Texture Analysis

Food texture analysis is the science of measuring the physical properties of food products and correlating them with their subjective characteristics. These qualities can be expressed into the following physical characteristics; chewiness, stickiness, hardness, stringiness, adhesiveness, brittleness, springiness, etc. If the tests are performed with adaptable techniques, texture analysis can reveal how the products break, stick, spread, stretch or cut.

Texture analysis is regarded as one of the most cost-effective methods to determine the effect of raw material adjustment and processing parameters on the quality of the end products. This may be during the development of new products or routine quality control across all processing and manufacturing stages. The process may include testing raw materials, semi-finished products, packaging and end-products.

Texture analysis can also assess defects and quality degradation during storage and transportation. Understanding this data allows the manufacturers to work with their supply chain to ensure that the quality of their products is not compromised during transport. Moreover, texture analysis can also serve as a practical quantitative tool for comparing their products with competitive and marketable products. This comparison is essential for food manufacturers to maintain consistent textural quality as their gold standard.

How Food Texture Analyser Works

The food texture analyzer is a specialized material testing machine used to evaluate how food product behaves under forces. The texture analyzer has a measuring arm equipped with a load cell and an extensometer to produce a measurement of force and displacement. These data are presented on a curve to display a “force vs displacement” over time. Analysing the generated curve allows the determination of the textural quality of the products. The test parameters can also be pre-defined as per users' requirements.

Testing accuracy also depends on the movement speed which has to be adjusted proportional to the samples’ dimension. The systems also need to allow large working area to accommodate larger samples and to allow installation of a wide range of food fixtures. Control of the system can be achieved via the software that also possess extensive list of testing standards.

Texture Analysis – The First Step

The first step towards quantitative textural analysis is understanding the consumers’ behaviour towards food. That includes investigation into how they like their food to be eaten to correlate it into measurable properties. Will people prefer meat products to be tender or chewy? Can texture analysis reveal the perfect time in baking bread? Will such a system be flexible enough to work for multiple range of products? Extensive market research done at this level reveals that the key for successful transition is the ability to scale-up the system.

Most food manufacturers have an extensive product range in their manufacturing line. For example, meat processing companies manufacture meat patties, crumbed meat and sauces to complement their main products. It is highly likely that textural analysis is required to understand not only the meat’s tenderness, but also the crispiness of their crumbed schnitzel and the spreadability of the accompanying sauces.

Identifying this step is crucial to define the required tests and their objectives. Texture analyzers generally come with an extensive range of jigs and fixtures for variety of testing applications. Choosing the suitable probes and jigs depends on the shape, property to be measured or test requirement. The fixtures are fixed to the texture analyzers to imitate an action. Users will then preconfigure their required tests to obtain the properties and data for post-analysis.

Choosing the Correct Types of Jigs and Fixtures

Choosing the correct fixtures for specific applications is crucial to measure food textures accurately. Probes must be selected to ensure that the objects are aligned, rated to the valid force range and firm. It must not allow the test sample to slip under any circumstances, producing inaccurate results. Refer to the graph below to view results when slippage occurs due to improper grip.

The next graph shows the results when the appropriate grips are used. Using the correct grips for test sample ensures no slippage during the test and a more accurate and reliable results.

Types of jigs and fixtures commonly used for textural testing

Ball Probes

Ball probes distribute uniform compression force at a normal angle to the surface area of the ball. This setup provides an average force over the local area to be tested with good repeatability and resolution, especially for measuring the hardness or softness of the material. These probes are ideally used for testing on food, vegetables or confectionary products

Cone Probes

These probes come with cone-shaped ends with a range of angles, generally from 15o to 90o. Selecting the appropriate cone probes depends on the consistency of the tested materials or to adhere to the testing standard. Cone probes are ideal for testing for spreadability on products such as butter, margarine and other types of spread.

Cylindrical Probes

Cylindrical probes apply shearing force as the probe comes in contact into the specimen, causing the object to deform or rupture. They are general-purpose compression probes for testing and determining gel strength, gel breaking strength, and elasticity, such as gelatine. The test results are used to determine Bloom's value, which is a recognized standard for gel's strength.

3-point Bend Jigs

The 3-point bend jigs are generally used to test for fracturability and crispiness. They are ideally used for snap testing on fruits, biscuits, chips, and chocolates.

Kramer Shear Cells

Kramer Shear Cell comprises ten parallel steel blades driven down through guide slots into a rectangular container. The blades landed on their corresponding guiding spots allowing them to shear, compress and extrude the objects through the bottom openings. This test simulates the biting process for determining the eating quality of meats, fruits, vegetables, pie fillings, etc.

Magnus Taylor Puncture Probe Sets

Magnus Taylor jigs consist of two sets of cylindrical probes with different sizes that connect directly to the load cell. Each pair has one flat end and one hemispherical end. These probes are designed for puncture tests to measure the hardness of fresh fruits and vegetables.

Ottawa Test Jigs

Ottawa test jigs consist of a square test cell with a solid wall and an open base. The base can be fitted with plates attached to a square plunger that is connected to a load cell for compression testing. The tested sample is weighed before it is placed in the cell fitted with either a slotted plate or a perforated plate. The test is designed to measure the force required to extrude the sample through the plate opening. This setup is ideally used to test beans, fruits fillings, soft vegetables and snack products.

Volodkevitch Bite Sets

Volodkevitch bite set is designed to mimic an actual eating mechanism by using incisor teeth to shear through a food sample. The jigs comprise upper and lower teeth, brought together until nearly touching during the test. Users will measure the force required to bite through the sample. This jig is used to test for tenderness, toughness and firmness of meat products, vegetables and fruits.

Warner Bratzler Shear Blade Sets

Warner Bratzler jigs are made of a rigid frame fitted with interchangeable shear blades; a square-cut blade, a 'V' blade and a 'V' blade with a hole in the apex. The jigs simulate the direct compression force for slicing and shearing through meat products or vegetables. Users can use this system to measure meat tenderness by measuring the force required to shear through the meat.

Software Control

Almost all texture analysers can be fitted with mechanical jigs and fixtures to allow for a wide range of testing options. However, operators need to have access to configure, control and monitor all aspects of the tests.

These can be achieved if the texture analyzer is installed with an analysis platform or package, generally supplied in accompanying software. The software can be loaded with a comprehensive library of industry-standard test such as AACC, ASTM, DIN, EN, ISO. This added capability allows users to easily pre-define tests and configurations for automation. The measurement from the texture analyzers, such as force, distance and time, can be displayed in the software. These data are then used to calculate textural parameters such as adhesion force, adhesiveness, chewiness, firmness, fracturability, springiness, stickness, tenderness and many more.

Another benefit of having powerful analysis software is its capability to enhance the presentation of test results. For example, users can sync the recorded video images with the stress/strain data to be replayed for better analysis. They can also capture still images at a specific point during the test and sync them to the graph for post-test analysis.

Food textures are affected by its inherent properties and external factors such as room temperature and humidity. Temperature and humidity can be evaluated by connecting measurement probes to the systems and reporting the results in the software. This data allows the users to choose the ideal test conditions that have the minimum effect on the measurement. In addition, having a reasonable software control enables the users to manage data traceability and control their test procedures.

Custom R&D Applications

Texture analyser has been used to perform food and textural testing as per defined standard. It is particularly useful for R&D applications, especially during new product development. Research generally involves testing with multiple different standards and in some occasions, these standards may not be readily available in the software. For their applications, researchers look for versatile system that allows them to develop their own test method and load it into the software.

For this purpose, it is extremely important to be able to develop, modify and conduct the required test. They may also require special, customized jigs to perform the experiments. Having these flexibilities allows the users to conduct not only standard food textural testing, but also perform specialized tests such as puncture resistance, peel strength, tearing strength, tensile strength test and many more.

Looking Ahead

The food industry is evolving rapidly to keep pace with the growing customer demand. They face the challenge to ensure that every development generates real value in the return of investment (ROI). The company that takes the leap and harnesses the technological advantage for testing and monitoring will position themselves in a stronger position for the next few years. Scaled-up technologies will generate new opportunities across all stages of their manufacturing process.

Food manufacturers are set to reap the benefit from upscaling and optimizing their R&D testing capabilities. There is evidence that more of the laboratory-engineered food products made their way to the market. They are certified and pass the health screening, however, may face rejections from the consumers if the products taste unfamiliar.

Consumer behaviour is ingrained towards food and products that they are familiar with. Manufacturers are encouraged to confirm this behaviour through market and consumer research rather than making baseless assumption before moving forward with their development. This survey will reveal qualitative data that provides insights into consumers preference. The industries need to match their new products with the consumers preference to realize competitive advantages in the future food market.

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