

Quality Control

FOREIGN OBJECTS



Texture probe kit: Cones, cylinders, punches, balls, blade, wire.

simply by handling the food product. The properties of flavor, aroma, audible crispness, and mouth feel all become important. Producers must be able to measure and control all of these properties within a range of acceptable limits, or they won't succeed in the marketplace.

The idea of controlling physical properties implies some means of measuring them. For food products there are historically two means of measuring properties: sensory methods and instrumental methods. Rigorous sensory methods are well developed by professional sensory scientists and are used by many food companies, usually larger ones. These companies can also afford lab instrumentation to measure many types of food properties, each of which requires a different lab instrument and method. Recently, the cost of some of this equipment has dropped to within the reach of small and even startup food companies. The best example of this is the uniaxial compression tester known as a texture analyzer (see Figure 1).

Instruments that compress and/or pull apart items are known as uniaxial testers. Many companies that manufacture this type of device produce a range of force-measurement capability in such instruments.

The food industry is concerned with relatively low force levels when using these machines for testing. Typical forces relate to squeezing a food object with your hand, biting into an apple with your front teeth, or chewing a piece of meat several times before swallow-

Get a Feel for Texture

Versatile and cost-efficient analyzers are critical product evaluation tools for food companies of all sizes

BY LEONARD THIBODEAU

The most important physical properties of food quality are probably those related to consumer perception. Freshness of bread is commonly evaluated by lightly squeezing the loaf on the shelf. Its density is evaluated by feeling its weight, from which a consumer may imply something about chewiness.

When shopping, we commonly evaluate our potential purchases by examining their physical properties while handling them. Feel and appearance affect our initial purchasing decision, so it is imperative that manufactured products be produced with acceptable values for these physical properties. These values can be measured to quantify what consumers find acceptable about a particular food product.

A customer's decision to buy the same food item again and again involves a more complex set of physical properties than those that can be evaluated



Figure 1. Brookfield CT3 Texture Analyzer measures gelatin bloom.

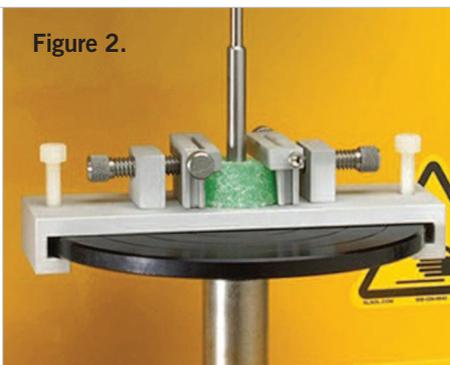
ing. Consequently, this particular type of uniaxial tester has become known as a texture analyzer.

The first of the basic techniques for conducting a texture test involves choosing a probe that can penetrate into a food item. The choice of probe (cone, cylinder, punch, blade, ball, or wire) depends on the shape of the food item and the nature of the consumer action that is being simulated. For example, the cone or blade probe can mimic the front or eye teeth biting into a candy bar; the wire can cut cheese or butter. The control parameters are the speed with which the probe moves into the food item and the penetration distance once the probe makes contact. The measured parameter is the resistance the probe experiences as it pushes down into the item, recorded as grams of force.

Texture analyzers can work in stand-alone mode and report the maximum force, or peak load, measured by the probe. Alternatively, they can work under software control and show the force-versus-time or force-versus-distance graph of the probe's movement into the food item.

Food scientists have agreed upon a number of physical properties that relate to textural properties. These measurements are accomplished using a texture analyzer and customized applications software that calculates sensory-related properties from the load profile data generated by the machine. Firmness, cohesiveness, springiness, chewiness, and resilience are five useful parameters, defined as follows:

- **Firmness:** The maximum force required to compress a food between the teeth. For example, how firm does the product feel upon the initial bite?
- **Cohesiveness:** The property that allows baked products to be handled,



Adjustable vice fixture for holding small samples for puncture test.

sliced, and served without crumbling.

- **Springiness Index:** The ratio of the height to which the sample springs back after the first bite relative to total compression distance of the bite. This calculation can apply to how springy the sample feels to the touch as well as in the mouth.
- **Chewiness Index:** The energy required to chew a solid food to the point required to swallow it.
- **Resilience:** How the sample recovers from compression relative to the dis-

tance it is compressed and the speed with which it was compressed.

Let's see how this works with a few common food products:

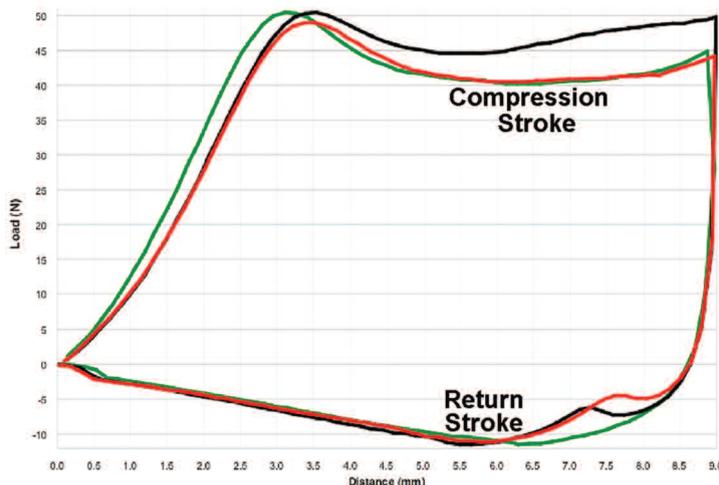
Gluten-Free Baguettes

Most authorities agree that the gluten-free market is one of the fastest-growing food group segments. While the texture properties of wheat-based baked products are difficult to mimic without gluten, new product development in the gluten-free market is making rapid improvements. Most gluten-free products are made with blends of rice flour and tend to be much more dense and less compressible than wheat flour products.

Local Oven in Sunnyvale, Texas, uses Citrafiber to improve the texture of its baguettes. We evaluated the five properties given above using three types of wheat bread as a reference for Local Oven's gluten-free baguettes and a separate retail gluten-free product from another manufacturer (see Table 1).

For these five physical properties, the

Figure 3.



Measurement of firmness (compression stroke) and stickiness (return stroke) on three energy snack foods.

Table 1. Texture Analysis of 5 Breads

	FIRMNESS	COHESIVENESS	SPRINGINESS	CHEWINESS	RESILIENCE
	PEAK STRESS				
Product	kPa	Ratio	Index	Index	Ratio
Healthy Multigrain	10.5	0.59	0.88	5.4	0.25
Double Fiber	21.3	0.55	0.85	10.0	0.21
Country White	12.0	0.44	0.83	4.4	0.15
Local Oven GF	37.7	0.25	0.56	5.2	0.073
Retail GF bread	108.3	0.073	0.069	0.6	0.022

Local Oven product scored much closer to wheat bread than the other retail gluten-free bread. A quick survey of the gluten-free marketplace shows that many new products are introduced every month. The properties of these products are getting closer and closer to those of traditional wheat products. This is good news for the gluten-intolerant population, as well as for those who simply choose to be gluten free.

Energy Snacks

Recently, we have seen a growing number of high-energy snack foods introduced to the market. Fruit flavors seem to dominate these brands. The products themselves are often bite-sized, chewy nuggets containing fruit juice, sugar, and other quick-energy supplements.

Every brand is distinguishable from the others, at least partially, by a collection of physical properties: firmness, chewiness, and stickiness. Compression testing is a great way to measure these properties and can be done easily using a texture analyzer. Bite-sized pieces of soft and somewhat sticky snacks must be held in place for such testing. The device shown in Figure 2 is an adjustable vice that provides a convenient way to quickly position and secure samples. Of the physical properties we can address with a texture analyzer, firmness and stickiness can be measured with a single compression test by penetrating the sample with a small cylindrical probe. Firmness is measured on compression stroke and stickiness on the return stroke (see Figure 3). This test, which is quick and easy, appears to detect significant differences between two of the three samples.

Pie and Pasta Filling

The quality and consistency of the filling inside ready-to-eat pasta and pies is of great concern to manufacturers and consumers. There are texture accessories available to make testing easy for both smooth fillings like cheese in ravioli and pie fillings containing chunks of fruit (see Figure 4a and Figure 4b). Both are best measured using extrusion fixtures. During a test, the analyzer records the force required to squeeze the filling through an aperture or across a mesh that is chosen according to the size of the solids. The maximum force and the total work of ex-

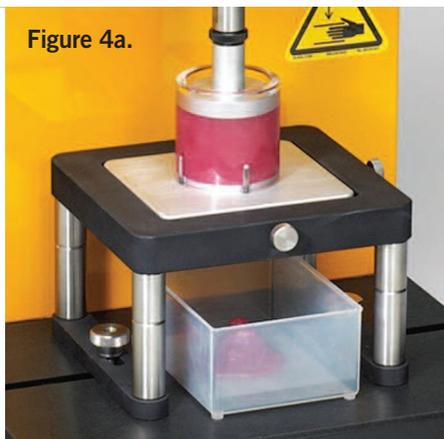


Figure 4a.

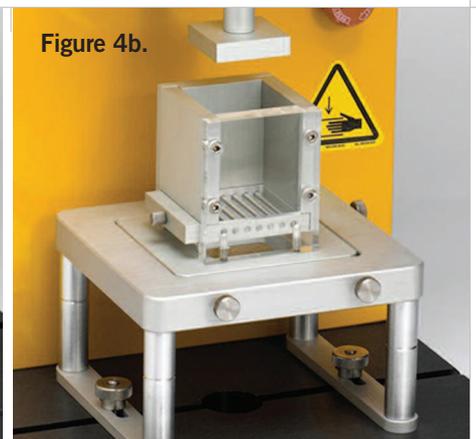
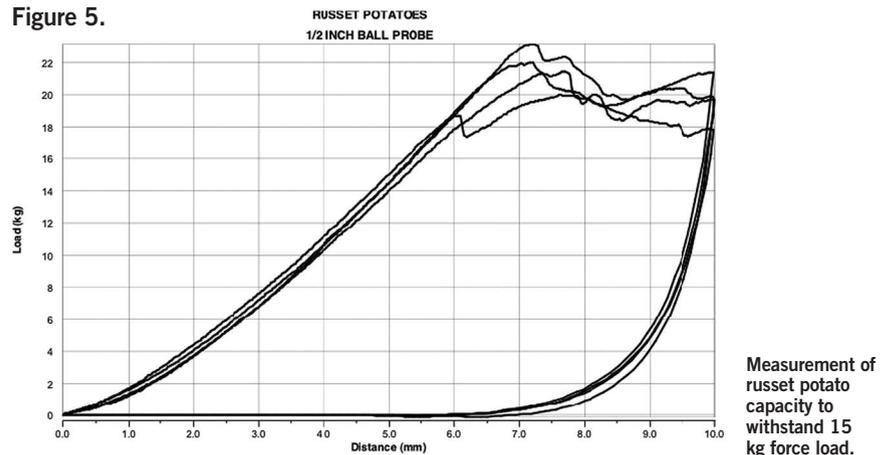


Figure 4b.

Figure 4a: Back extrusion used to measure fruit purée. Figure 4b: Ottawa cell for extruding assorted soft samples through one of two interchangeable bases.

Figure 5.



truding the filling are the important result parameters.

Dips and Spreads

Pourable dips can be measured for viscosity but, if the sample is too thick to pour, a spreadability test may be more appropriate. A set of matched cones allows sensitive measurements of spreadability between samples to be evaluated. Several female cone-shaped cups are supplied with the set. Each is filled with sample material and set aside to be conditioned if needed. During the test, the male cone is driven into the sample, forcing the material out in a back extrusion process. Because of the conical shape of the matched probe and cup, the load force resulting from driving the cones together typically shows a nearly exponential increase. Differences in spreadability can easily be seen on the resulting graph and the measured/calculated parameter. Peak force and work area, respectively, are the important parameters.

Fresh Vegetables

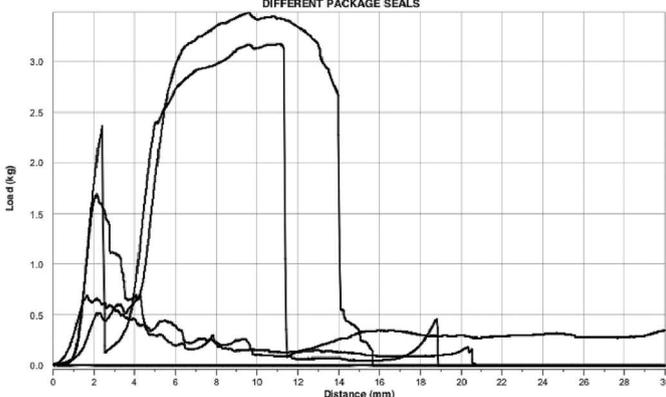
Fruits and vegetables are commonly tested for ripeness or firmness using radius-tipped probes known as Magness Taylor probes. These probes are used in a penetration test. Firmer products, like young crisp apples, result in higher loads. Other types of tests can yield additional, interesting information for the researcher. For example, a university conducting shipping research on russet potatoes wished to know the forces that fresh russets can withstand without damage. The higher they are piled, the greater the force upon the potatoes at the bottom becomes. A half-inch ball probe was used to approximate the smallest radius by which one potato would press against another. Figure 5 shows several repeatable tests indicating that potatoes can withstand more than 15 kg of force applied by this small radius probe before damage occurs. Such information can help assure transportation without damage.

Packaging

In addition to the food products, a texture analyzer—essentially a uniaxial compression and tensile machine—can also test packaging for such properties as puncture resistance and seal integrity. Puncture strength requires the packaging to be secured in a flat fixture over a smoothly rounded hole. An increasing biaxial stress is applied with a spherical probe recording force until the packaging fails. Spherical probes in various sizes are available for this test.

Seal integrity is also an important test for packaging. For this test, a strip of packaging is cut so the seal is in the center of the strip. Each end of the strip is secured in the appropriate grips. As the grips separate, the seal is peeled open and tensile force is recorded (see Figure 6). Different packaging materials and the related sealing technologies will show variations in force profiles while the seal is being pulled apart. Such tests are good for quality control of packaging processes

Figure 6. DUPLICATE TESTS OF TWO DIFFERENT PACKAGE SEALS



Tensile force required to pull open seal for four packages.

and can easily detect whether the sealing process is damaging the package.

Today’s food lab, whether in its research and development or quality control departments, relies on the broad test capability of the texture analyzer. In the past, many of these tests were done by hand and relied on subjective evaluation by the person performing the experiment. Given the versatility and force-measurement range of the latest physical test equipment, as well as the selection of probes/fixtures

available, there is every reason to consider the use of this equipment on a daily basis. The final and most convincing factor is that the price of this instrumentation now starts around \$5,000, an extremely affordable investment for any food manufacturer. ■

Leonard Thibodeau has been with Brookfield Engineering for eight years, the last five as product manager of the texture analysis group. He frequently publishes application articles on texture analysis and is active in the ASTM E-18 committee on sensory evaluation; he serves as chairman of E-18’s task group on instrument correlations.

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