KINESTHETICS and TEXTURE

Aim of this subject

- This subject is given for getting an idea about ;
  - the principles and applications of texture,
  - measurement of texture
- The principles of human perception and instrumental methods
- Examples of food texture measurement

Why do we measure food texture?

- Texture testing is a well-established technique for evaluating
  - the mechanical and physical properties of materials,
  - food structure,
  - designs, and
  - for pre- and post-quality control checks.
- Texture is an index of quality/ripeness,

Why do we measure food texture?

- To evaluate the resistance of products against mechanical action
  - Such as mechanical harvesting of fruit and vegetables,
  - Wheat hardness for milling
- To determine flow properties of products during processing, handling and storage
- Physical properties of food affect the design of processing equipment.
  - In selecting and adjusting the equipment used to mix, transport and package products.

Why do we measure food texture?

- To establish the mechanical behavior of a product when consumed
- Consumer classifying the food's quality
  - fresh, stale, tender, ripe
  - hard, soft, crisp, moist, dry
- To many people, it is even more important than taste!
- Textural properties affect the consumer's perception;
  - acceptable or
  - unacceptable product.

Consumers Complaints about Food Product Quality

Type of Complaint	Total (%)
Broken or crumbled product	51
Product freshness	47
Contaminated	28
Incorrect carbonation	23
Bulged can	16
Other	9

Texture

- Texture refers to those quality attributes that we can feel either with finger, tongue, palate or teeth.
  - Crisp crackers, potato chips, crunchy celery, hard candy, ice-cream
  - We expect chewing gum to be chewy.
  - Steak to be compressible and shearable between teeth.
- The consumer squeezes melons as a measure of ripeness.
- The consumer squeezes bread to measure freshness.

Texture and Food Acceptability

- Critical texture is the dominant quality characteristic
  - Such as meat, potato chips, and celery
- Texture is important but is not a dominant contributor to the overall quality
  - Such as fruits, vegetables, bread, and candy
  - 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.
- Minor texture makes a negligible contribution to the overall quality
  - Such as beverages and thin soups

Textural Attributes

Consumer expect

- Gum to be chewy,
- Crackers to be crispy,
- Steak to be tender,
- Cookies to be soft,
- Breakfast cereal to be crunchy and etc.

TEXTURE IS A SENSORY PROPERTY

- The texture of food refers to the qualities felt with the fingers, the tongue, or the teeth.
- Textures in food vary widely, but any departure from what the consumer expects is a quality defect.
- It is not related to the chemical of senses of taste or odor.

TEXTURE IS A SENSORY PROPERTY

- Texture is the sensory and functional manifestation of the structural, mechanical and surface properties of foods detected through the senses of
  - Vision (Banana green undesired texture; yellow desired texture),
  - Hearing (We hear how crunchy an apple is as we bite into it and we expect to hear the crispy sounds of crisp snack products),
  - Touch (watermelon, tomato) and
  - Kinesthetics (Honey, milk)

TEXTURE IS A SENSORY PROPERTY

- Only a human being can perceive and describe texture.
  - The texture testing instruments can detect and quantify only certain physical parameters which then must be interpreted in terms of sensory perception.

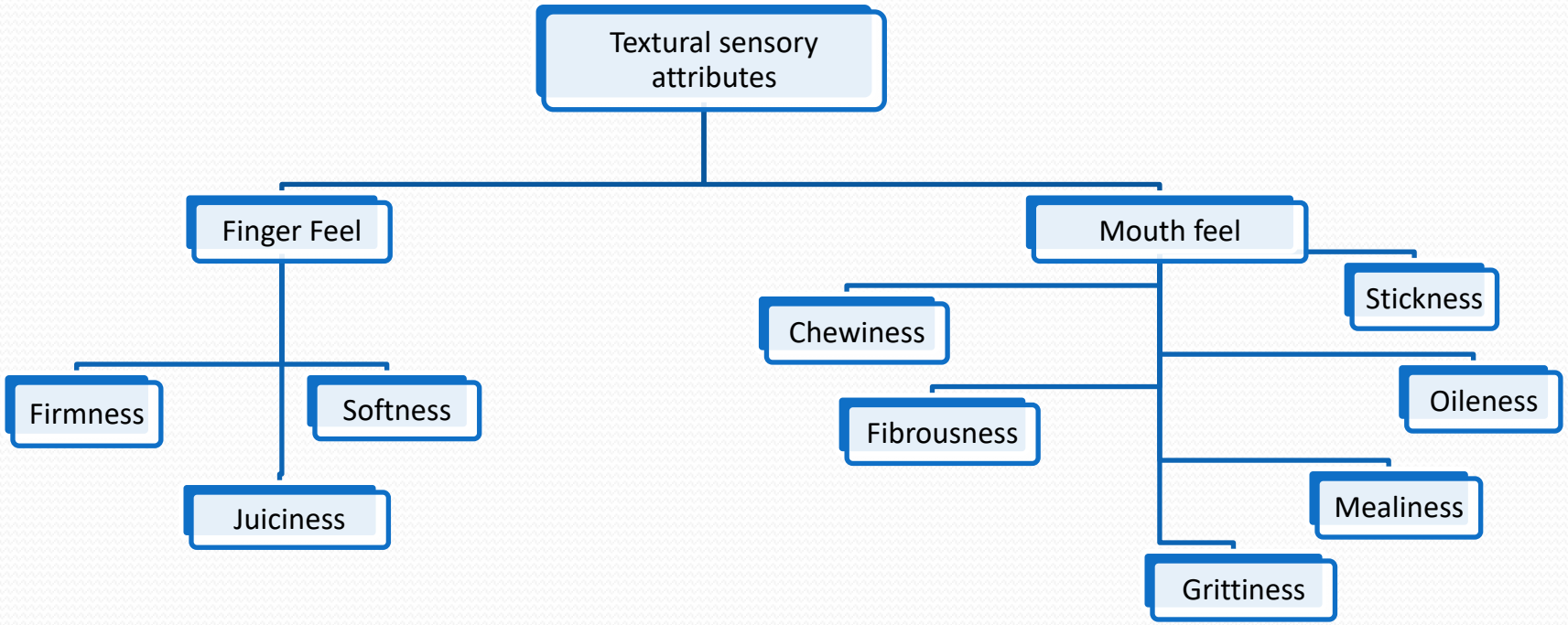
- It is a multi-parameter attribute (LARGE NUMBER OF WORDS USED TO DESCRIBE), not just tenderness or chewiness, but a gamut of characteristics

TEXTURE IS A SENSORY PROPERTY

- It is a group of physical properties that derive from the structure of the food (molecular, microscopic or macroscopic);
- It is detected by several senses, the most important ones being the senses of touch and pressure.
- It belongs under the mechanical or rheological subheading of physical properties

Texture

- Textural attributes can also be thought of as the rheological properties.



Textural Attributes- Finger Feel

- Firmness & Softness are measured physically by compression.
  - How easy it is squeeze?
    - Firm apple
    - Soft plum

- Juiciness measured by puncturing or juice extraction.
  - How much liquid is released when the food is crushed between molars?
    - Matureness of sweet corn.

Textural Attributes- Mouth Feel

- Grittiness sensed by the presence of small grit particles like sand, stone or ice crystals in ice-cream
- Mealiness sensed by presence of starchy compounds.
  - How powdery is the food?
  - e.g. Cooked potato can be very mealy.
- Stickness sensed by chewing foods with adhesive properties
- Oiliness sensed in mouth caused by oily products

Textural Attributes- Mouth Feel

- Chewiness measured by compression and shearing action of the teeth.
  - How many chews does it take to reduce the food to a condition where it can be swallowed?

- Fibrousness sensed by the presence of inedible residue after chewing.

Factors Affecting Texture

- Factors that affect texture include
  - Moisture content
  - Composition
  - Variety
  - pH
  - Product history (maturity)
  - Sample dimensions

Factors Affecting Texture

- Texture of foods does not remain constant, e.g.
  - Fruits or vegetables lose water during storage they lose their turgor pressure, and a crisp apple becomes unacceptable and leathery on outside.
  - Bread can become hard and stale on storage.
  - Ice cream can become gritty due to precipitation of lactose and growth of ice crystal in the freezer temperature is allowed to fluctuate, allowing thawing and refreezing.
- Thermal processing or freezing of some fruits and vegetables usually causes softening, because the cellular structure is modified.

Factor Affecting Texture- Moisture Content

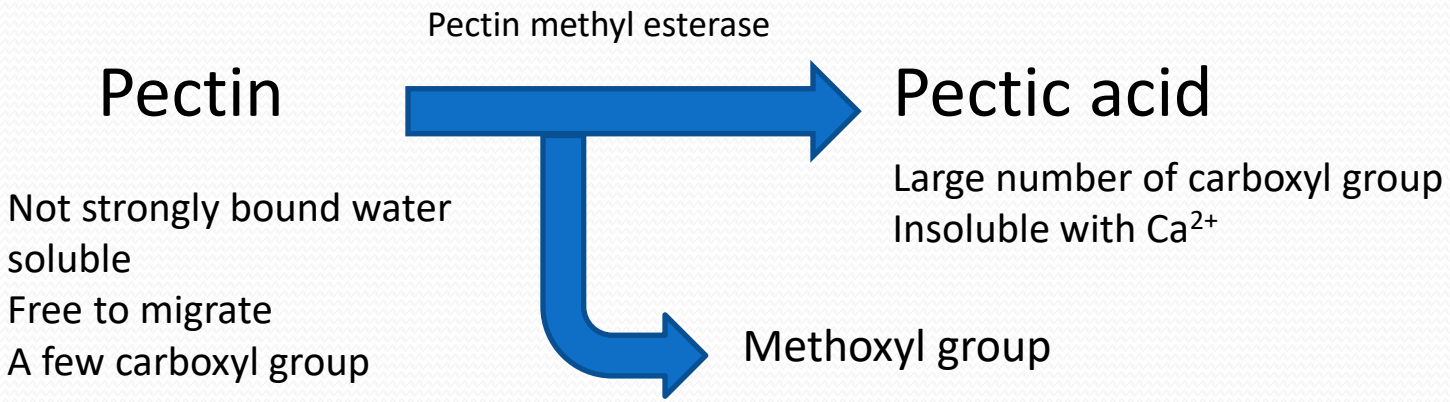
- One of the most important factor on texture is amount of water present in foods.
  - Fresh fruits and vegetables become soggy as cells break down and lose water.
  - If food products lose water, they become dry, tough an chewy. This is desirable in case of dried apricots, raisins.
  - When bread or cake lose water, they become hard (stale). This is a quality defects.
    - Steaming the bread refreshes by softening the texture.
  - On the other hand: crackers, cookies, biscuits must be protected against moisture pick up that would soften texture. They become soft and undesirable.

Factors Affecting Texture-Composition

- The firmness and texture of some vegetables and fruits can be manipulated during processing without the use of direct additives.

- For example, an enzyme, pectin methyl esterase is activated during low-temperature blanching (70-82°C for 3-15 min).

Factors Affecting Texture-Composition



- Firming effects through activation of pectin methyl esterase have been observed for beans, potatoes, tomatoes, cauliflowers, sour cherries.
  - Addition of Ca^{2+} leads firmer texture.
  - Fruits like berries, apple slices are firmed by adding calcium salts before canning or freezing.

Factors Affecting Texture-Chemical Changes

- The chemical changes associated with textural changes in fruits and vegetables include
  - Crystallization of cellulose
  - Degradation of pectin
  - Starch gelatinization

- Texture is also dependent on the dehydration method.
  - High air temperature cause complex chemical and physical changes to the surface and formation of case hardening.

Factor Affecting Texture-Additive

A number of additives can be used to change the texture of food or to bring the food to the desired texture.

- Sugar affects texture differently depending on its concentration
  - Dilute solution: adds body and mouth feel to soft drink
  - Concentrated solution: adds thickening and chewiness
  - Higher concentrated: adds brittleness as in hard candies because of crystallization.

Methods Used to Control Texture of Processed Foods

- Lipids (fats) are softeners and lubricants used in cakes to tenderize.
- Starch and gums are used as thickeners (increase viscosity).
- Protein can also be a thickener, or if coagulated as in baked bread, it can form a rigid structure.
- Depending on its concentration in a product, sugar can add body as in soft drinks or in other products add chewiness, or in greater concentrations it can thicken and add chewiness or brittleness.

Relations Between Textural Parameters and Popular Terms

Primary parameters	Secondary Parameters	Popular Terms
Hardness		Soft → Firm → Hard
Cohesiveness	Brittleness	Crumbly → Crunchy → Brittle
	Chewiness	Tender → Chewy → Tough
	Gumminess	Short → Mealy → Pasty Gummy
Viscosity		Thin → Viscous
Springiness		Plastic → Elastic
Adhesiveness		Sticky → Tacky Gooey
Geometrical characteristics		
Class		**Examples**
Particle size and shape		Gritty, Grainy, Coarse, etc
Particle shape and orientation		Fibrous, Cellular, Crystalline, etc.
Other characteristics		
Primary parameters	**Secondary parameters**	**Popular terms**
Moisture content		Dry → Moist → Wet → Watery
Fat content	Oiliness	Oily
	Greasiness	Greasy

Most important characteristic of texture

Mechanical Properties	Geometrical Properties	Moisture Properties
Hardness - **Firm (compression)** - **Hard (lite)**	- Smooth - Gritty - Grainy - Chalk/powdery - Fibrous - Lumpy/bumpy	- Juicy - Oily - Greasy
Cohesiveness - **Cohesive** - **Chewy** - **Fracturable (Crispy/crunchy)**		
Adhesiveness - **Sticky** - **Smooth**		
Denseness - **Dense/heavy** - **Airy/puffy/light**		
Springiness - **Springy/rubbery**		

How can we measure texture?

- If food is liquid, we could have measured the consistency as a measure of texture.
- If food is solid we need to find another kind of instrument.
- There are number of instruments to measure texture in laboratories.

Work on texture

- involves construction of
  - simple testing instruments and
  - some rudimentary sensory evaluations.
- is concerned primarily with the elimination of defects.
  - Bread, meat, fruits (such as apples and peaches) and vegetables (primarily corn and sweet peas) receive the greatest attention

Types of Tests for Measuring Food Texture

- **OBJECTIVES**
  - **Direct**
    - **fundamental, empirical, imitative**
  - **Indirect**
    - **chemical, optical, acoustical, other**

- **SUBJECTIVE**
  - **Oral**
    - **mechanical, geometrical, chemical**
  - **Nonoral**
    - **fingers, hand, other**

Objective Texture Analysis

- Too expensive
- Accurate, repeatable
- Shorten the product development cycle
- Improve product consistency
- Minimize waste
- Applicable to a broad range of products such as
  - Puddings,
  - Breads,
  - Snack food,
  - Fruits and vegetables
  - Dairy products….

Subjective Texture Analysis

- It can be done
  - Felt with fingers
  - Felt with tongue or mouth
  - Felt with teeth.
- **Non-repeatable**
- **Needs trained judges or expert people**

Fundamental Tests

- Measure well defined rheological properties (viscosity)
- Based upon the action of stress and strain.
- Many of the methods are based on
  - Compression
  - Shearing
  - Shear pressure cutting
  - Tensile strength
- Use small strains; material is isotropic and homogeneous; material uniform and regular in shape
- Slow and do not correlate as well with sensory evaluation as empirical tests

Empirical Tests

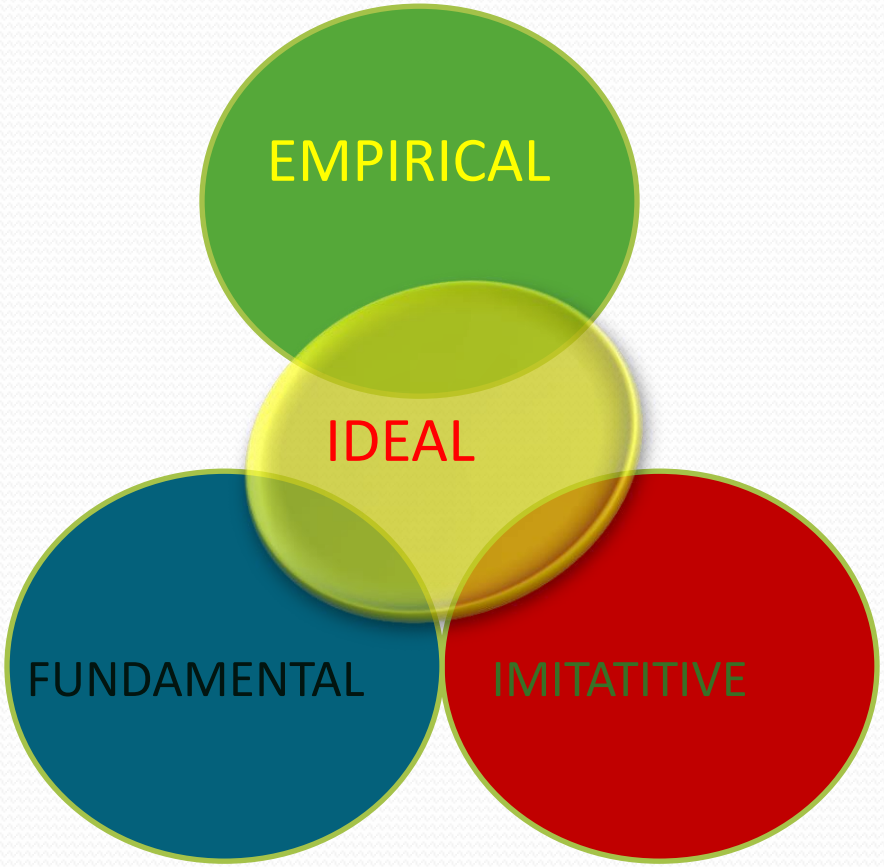
- Measure parameters that are poorly defined
- Most widely used
- Easy to perform,
- Rapid
- Poor definition of what is being measured

Brookfield CT3 Texture Analyzer measures gelatin bloom.

Imitative Tests

- Imitate the conditions to which the food material is subjected in practice
- Texture Profile Analysis (TPA) imitates the chewing action of the teeth
- Farinograph imitates the handling and working of bread dough
- Bostwick Consistometer measures the flow of semifluid foods across the plate, and butter spread

Ideal Texture Measuring Apparatus



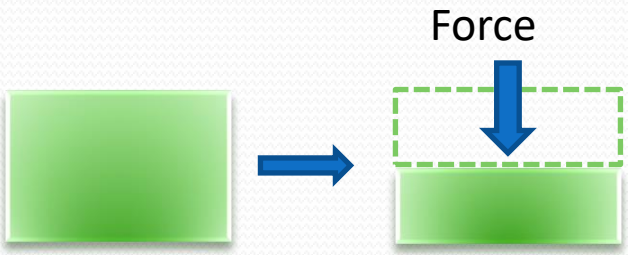
IDEAL SYSTEM

- simple to perform
- rapid
- suitable for routine work
- good correlation
- closely duplicates mastication
- complete texture measurement
- know what is measured
- can use large and small size samples

Principles measurement of texture

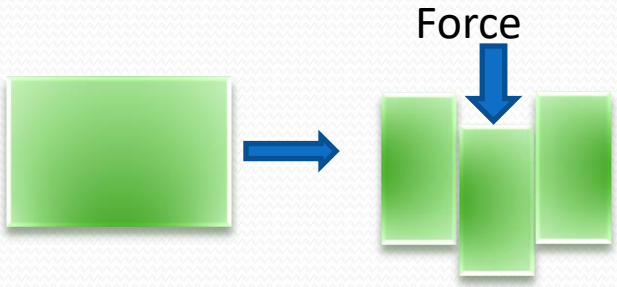
1. If food is squeezed so that it remains as one piece

   ➡ compression



Squeezing bread

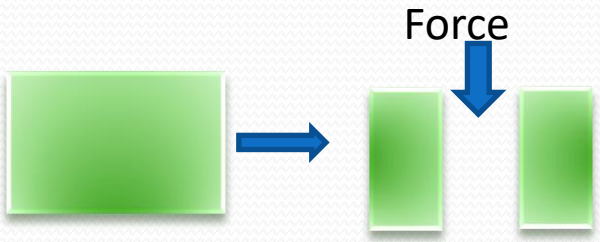
2. If a food is applied so that one part of the food slides on another ➡ shearing



Chewing gum

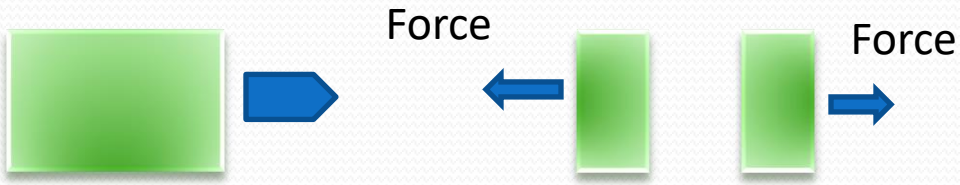
Principles measurement of texture

3. A force that goes through the food so as to divide it causes cutting



Cutting an apple

4. A force applied away from the material results in tearing or pulling apart → measure of tensile strength



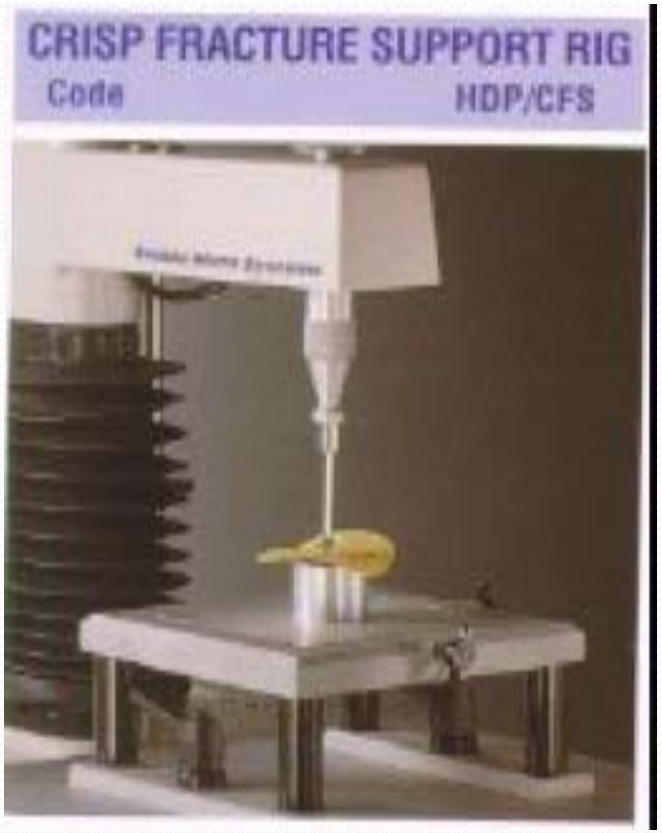
Pulling apart a cake

Texture testing

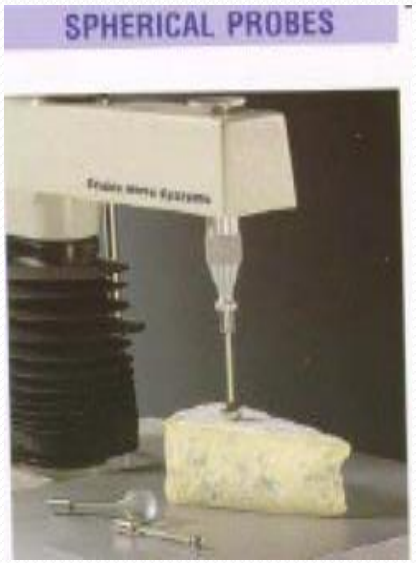
- Texture testing in foods is based upon the action of stress and strain. Many of the methods are based upon compression, shearing, shear-pressure, cutting, or tensile strength.
- The compressimeter was used to determine the compressibility of cakes and other “spongelike” products.
  - the penetrometer, has been used to measure gel strength.
  - The Warner-Bratzler shear apparatus has been the standard method of evaluating meat tenderness.
- The Instron measures elasticity.
- The Brookfield viscometer will measure the viscosity in terms of Brookfield units.
- Other instruments used to measure texture include a succulometer and a tenderometer

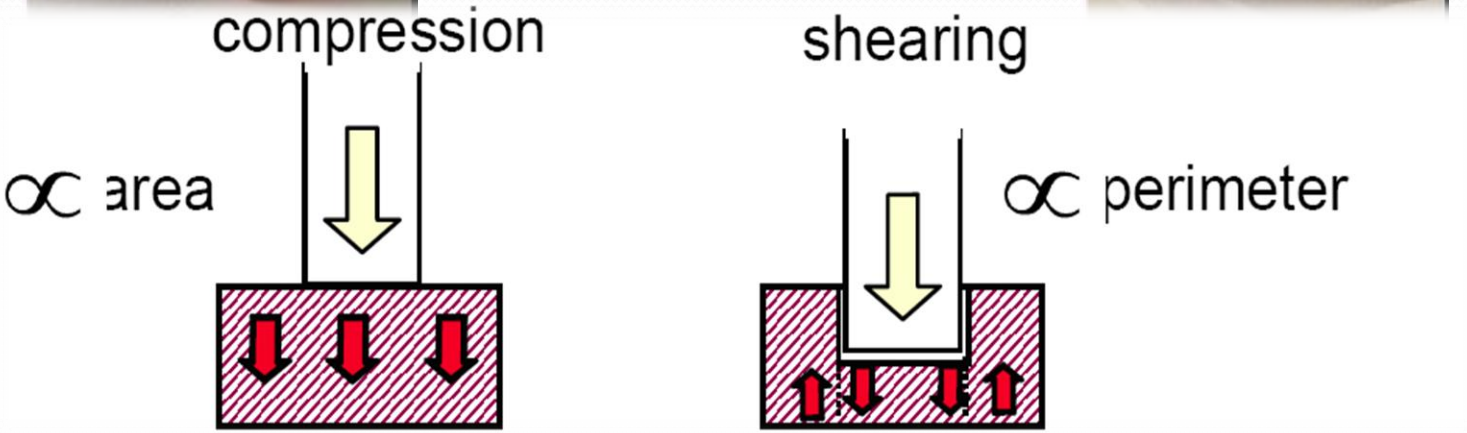
Puncture Testing

- Measures the force required to push a punch or probe into a food measures
- Characterized by: a force, penetration of the probe into food causing crushing, depth of penetration is constant



Puncturing Test





Instruments using Compression

- The Magness-Taylor pressure tester
  - Gives result as force required to press plunger into fruit for given distance
    - Used in fruit industry
    - Disadvantages: damage fruit
    - Many readings must be done to take average

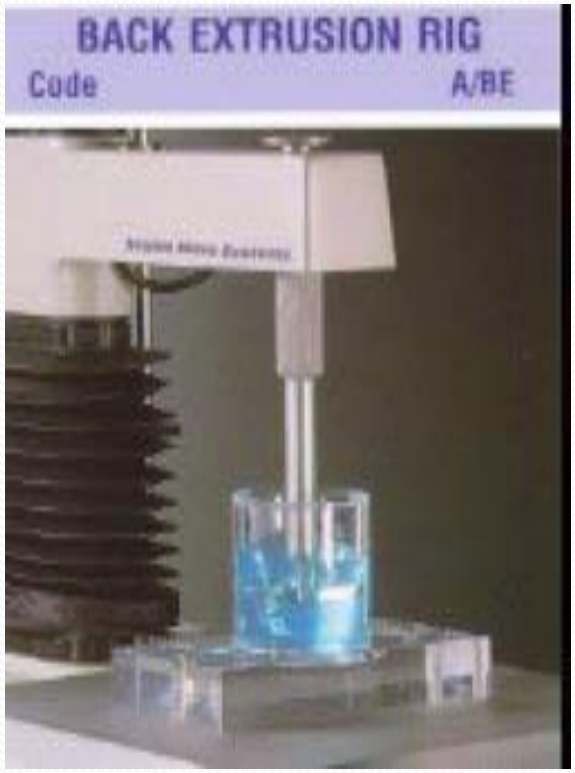
- Puncture tester:
  - Needle was used.
  - Instead of using spring compression to measure force, a volume of liquid was used to provide sufficient weight for penetrating the needle for certain distance

Instruments using Compression

- Ball Compression
  - Develop to measure cheese texture
- Succulometer is another widely used instrument
  - Use compression principle indirectly
  - Measure volume of extractable juice under certain pressure for certain time.
  - Used for measuring maturity of sweet corn, orange, apple, oil and water content of tuna fish.

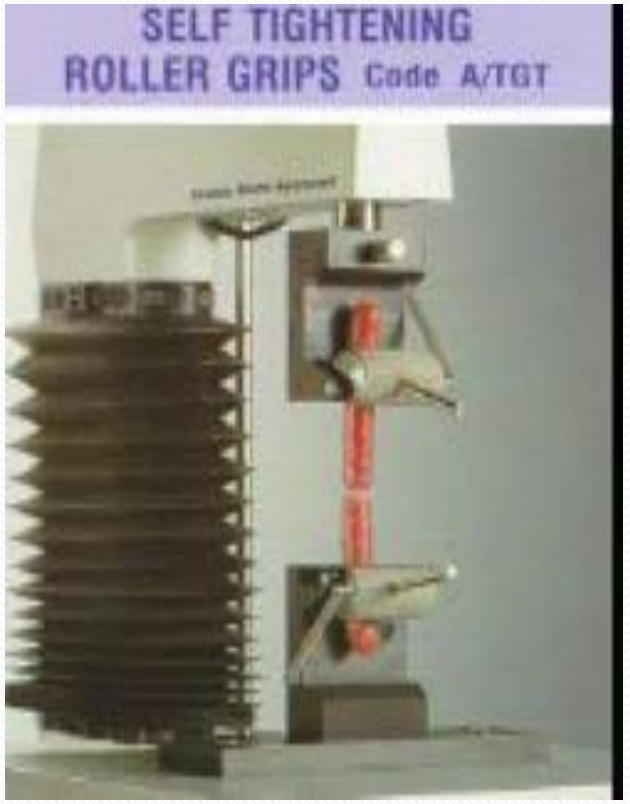
Compression Extrusion Testing

- applying force until it flows through the outlet
- maximum force to extrude the food is an index of texture quality
- used for viscous liquids, gels, fats, fresh and processed fruits and vegetable



Tensile Tests

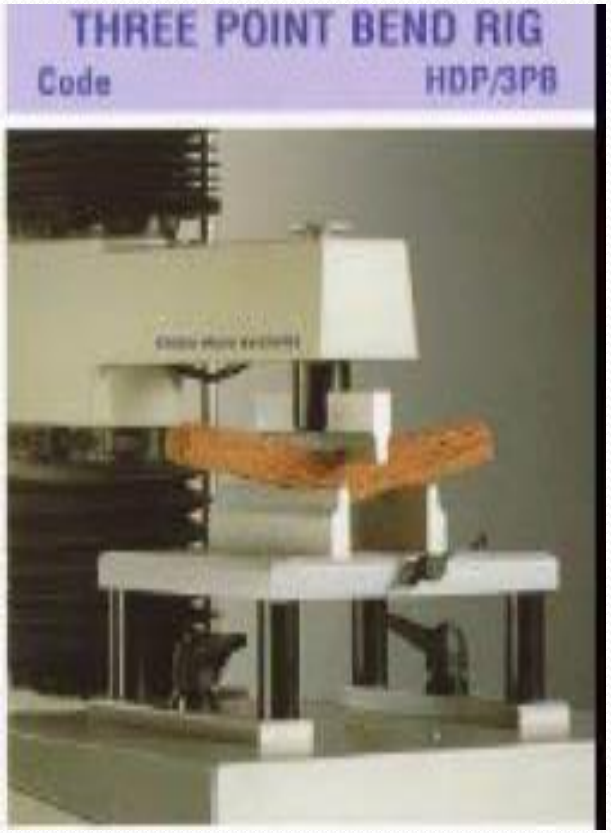
- assumes that the sample fractures almost spontaneously
- the maximum force is the tensile strength of the material



Bending and Snapping

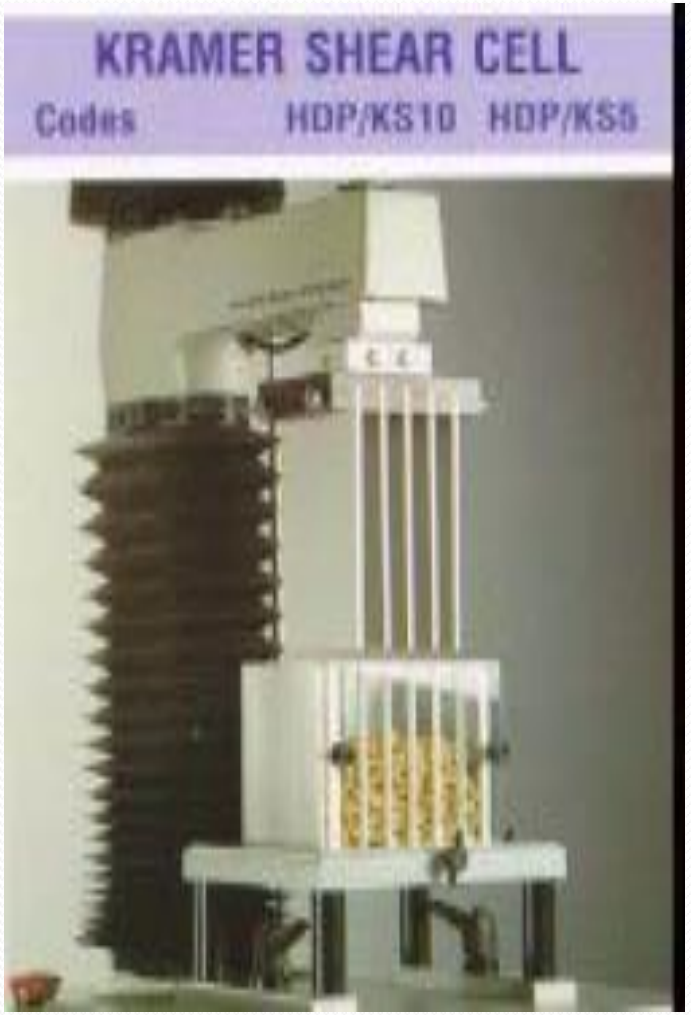
- used to food that is in the shape of bar or sheet used

- the compression bar moves down between the two supports bending the food until it snaps



Kramer Shear Cell

- it is a well established tool for evaluating the composite flow of particulate foods
- contains 5 shear blades
- sample holder is filled with samples and the shear blades are forced into the material
- force on the ram holding the blades are measured over time and correlated to product firmness



Instruments Using Shearing Principles

- Measure combination of shearing force and compression forces
  - Tenderometer
  - Texturemeter
  - Maturometer
    - Used for pea, meat

Instrument for shear pressure

- Food is compressed and shearing during chewing

- Strain gauge denture tenderometer
  - Has a set of plastic teeth
  - Force required to chew sample is transferred to a strain gauge.

Shear Testing Warner-Bratzler Shear

- not a true shear
- it refers to cutting across
- causes tension, compression and shear
- measure the maximum force to cut the product measure
- Meat tenderness

Texture Profile Analysis (TPA)

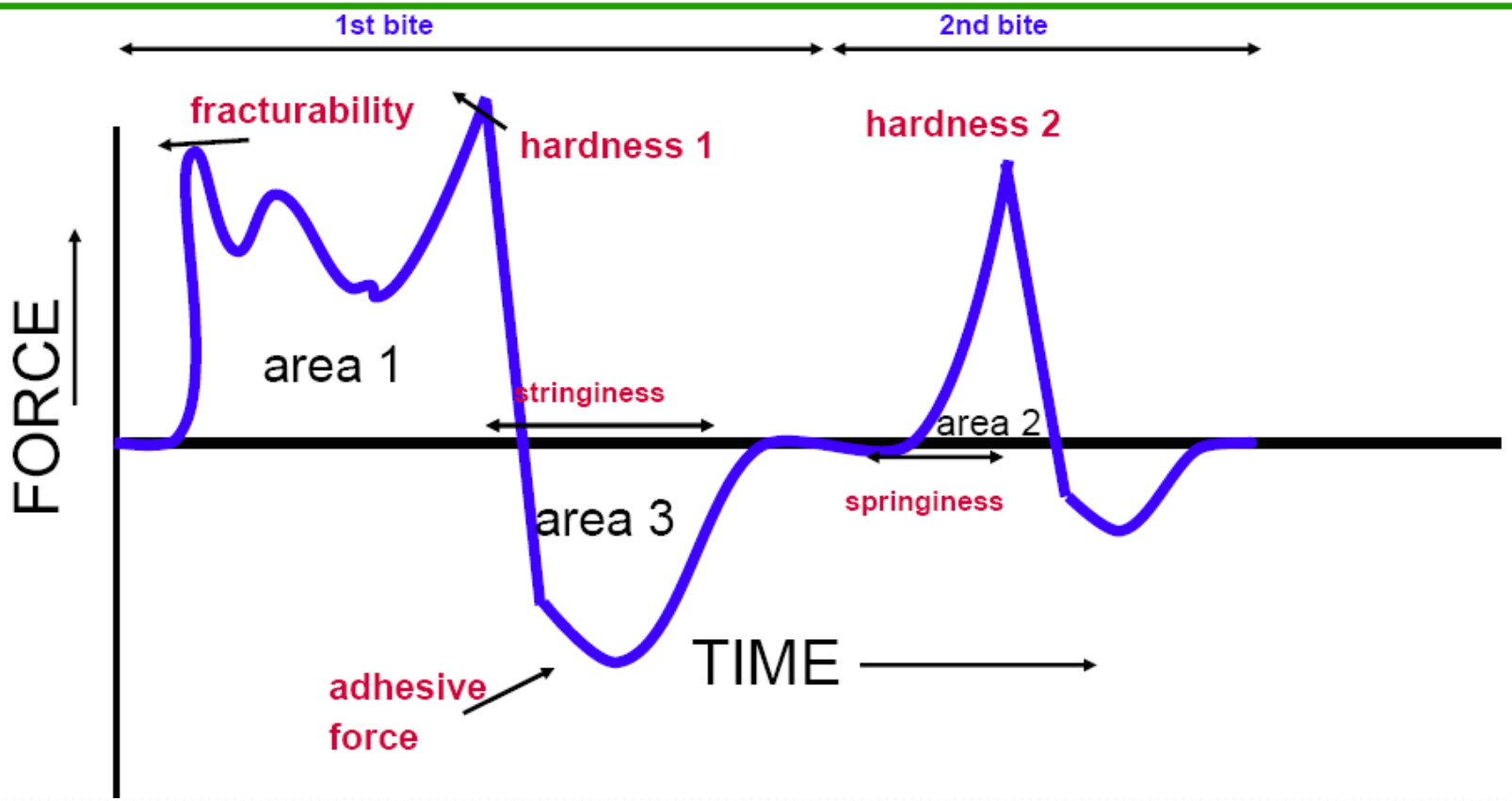
- The classification of textural terms for solids and semi-solids gave rise to a profiling method of texture description (TPA) applicable to both sensory and instrumental measurements
- With the instrumental method, texture profiling involves compressing the test substance at least twice and quantifying the mechanical parameters from the recorded force-deformation curves.
- With temperature sensitive foods, e.g. gelatin gels or chocolate, the profiling should be extended to temperature and tests performed at several temperature levels

Texture Profile Analysis (TPA)

- Test consists of compressing a bite size sample two times imitating the action of jaw pioneered by researchers from General Foods

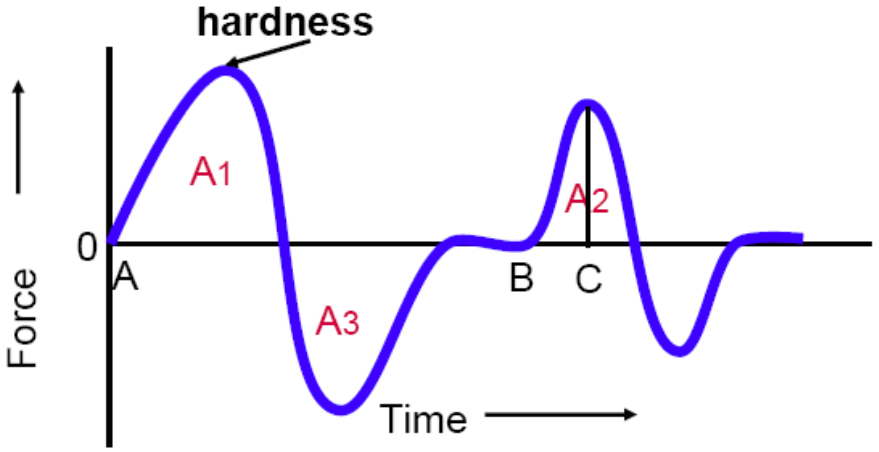
- The resulting force time curve can provide a series of textural parameters that correlate well with sensory evaluation called the General Foods Texturometer

Generalized TPA



TPA Test

- hardness-peak force on the 1st compression circle
- Fracturability (brittleness) -force of the significant break in the curve
- cohesiveness -A2/A1
- adhesiveness-A3
- springiness(or elasticity) -distance BC
- gumminess= hardness X cohesiveness
- chewiness = gumminess X springiness

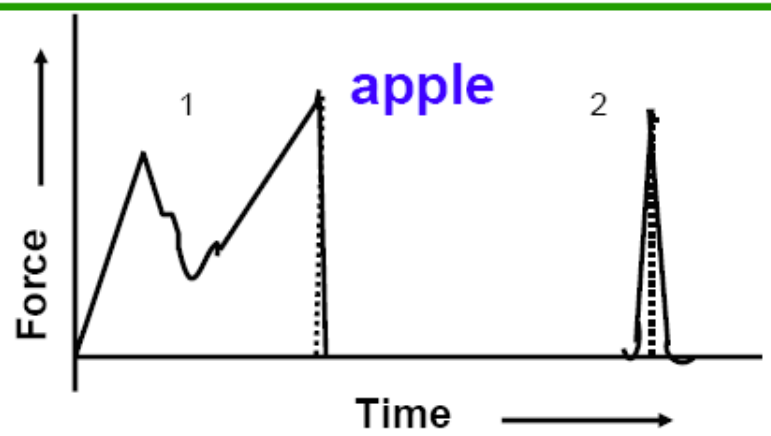


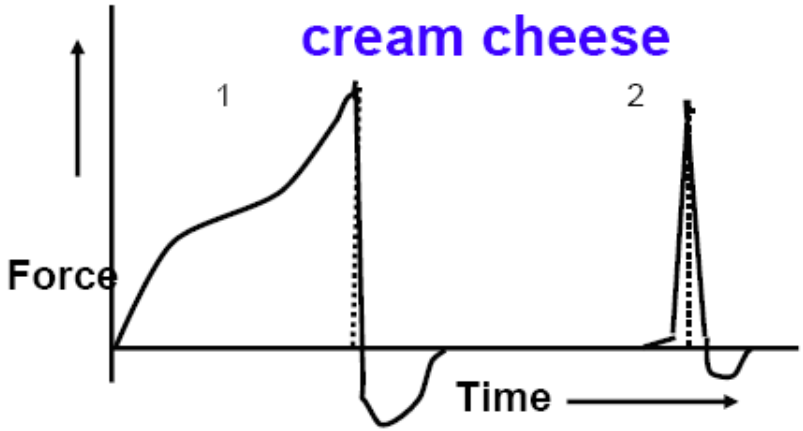
A = 1st compression

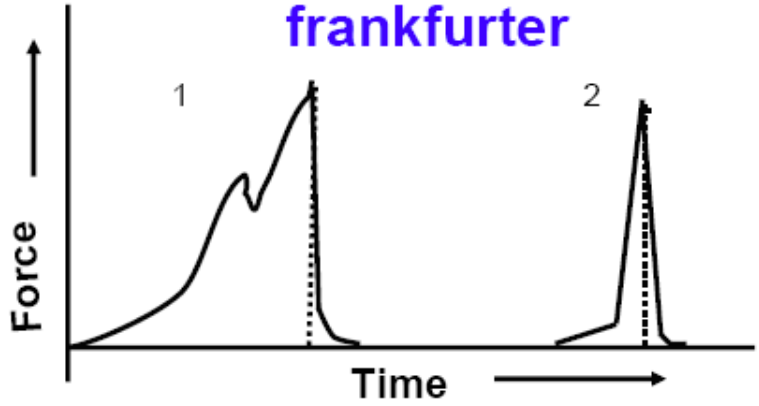
B = 2nd compression

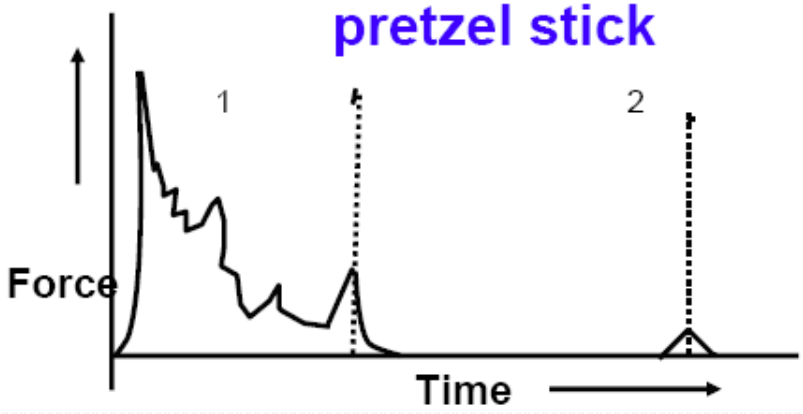
A_1, A_2 and A_3 = areas under the curves

GTPA Obtained From Instrom









- The height of the first peak on the first compression cycle is defined as *hardness*.
- *Fracturability was defined as the force of the significant break in the curve on* the first bite.
- The ratio of the positive force areas under the first and second compressions (A2/A1) was defined as *cohesiveness*.
- The negative force area of the first bite (A3) represented the work necessary to pull the compressing plunger away from the sample and was defined as *adhesiveness*.
- The distance that the food recovered its height during the time that elapsed between the end of the first bite and the start of the second bite was defined as *springiness*.
- *Gumminess was defined as the product of hardness x cohesiveness.*
- *Chewiness was defined as the product of gumminess x springiness.*

Definitions of mechanical parameters of texture

	Physical Sensory	Primary properties
Hardness	Force necessary to attain a given deformation	Force required to compress a substance between molar teeth (in the case of solids) or between tongue and palate (in the case of semi-solids)
Cohesiveness	Extent to which a material can be deformed before it ruptures	Degree to which a substance is compressed between the teeth before it breaks
Viscosity	Rate of flow per unit force	Force required to draw a liquid from a spoon over the tongue.
Springiness	Rate at which a deformed material goes back to its undeformed condition after the deforming force is removed	Degree to which a product returns to its original shape once it has been compressed between the teeth
Adhesiveness	Work necessary to overcome the attractive forces between the surface of the food and the surface of the other materials with which the food comes in contact.	Force required to remove the material that adheres to the mouth (generally the palate) during the normal eating process
Secondary properties		
Fracturability	Force with which a material fractures: a product of high degree of hardness and low degree of cohesiveness	Force with which a sample crumbles, cracks, or shatters
Chewiness	Energy required to masticate a solid food to a state ready for swallowing: a product of hardness, cohesiveness and springiness	Length of time (in sec) required to masticate the sample, at a constant rate of force application, to reduce it to a consistency suitable for swallowing
Gumminess	Energy required to disintegrate a semi-solid food to a state ready for swallowing: a product of a low degree of hardness and a high degree of cohesiveness	Denseness that persists throughout mastication; energy required to disintegrate a semi-solid food to a state ready for swallowing

Physical & Chemical Methods

- Some physical & chemical methods show some correlation with measurement of kinesthetic by using equipments:
  - Moisture content
  - Alcohol Insoluble solids
  - Fiber
  - Density
  - Color
  - Sound

Physical & Chemical Methods

- Sometimes differences in density related to the kinesthetic properties
  - Peabean lighter ⟹ tender
  - Potato starchy heavier

  } By floatation
- Also, color of the food can be measure of kinesthetic properties
  - Therefore color measurement can be done without damaging the food to predict its texture
- Physical measurement of crushing sound-sonic measurement

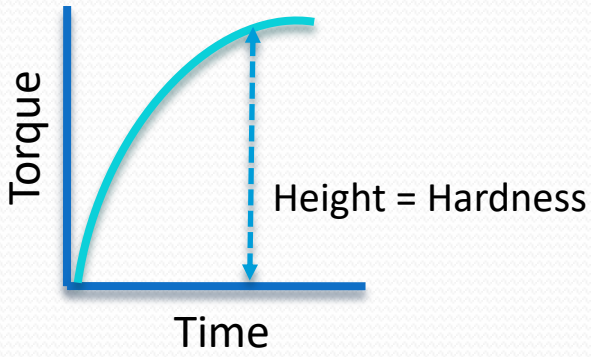
Application of Rheology Cereals

- Kernel Hardness
  - Affected by moisture content and protein content.
  - If the kernels are extremely hard
    - Increase power required during milling
    - Reduce yields of flours of acceptable quality (ash, color)
- Methods
  - The Smetar hardness test
    - Penetrate a diamond shaped solid into a section of kernel; measure the length of penetration

Kernel Hardness

- Brabender Hardness Tester
  - Measure amount of work required to mill a known weight of grain.

- How?
  - Torque is measured to operate the mill as the grain is ground. Result is plotted on a graph (Farinograph) against time.



Application of Rheology

Dough

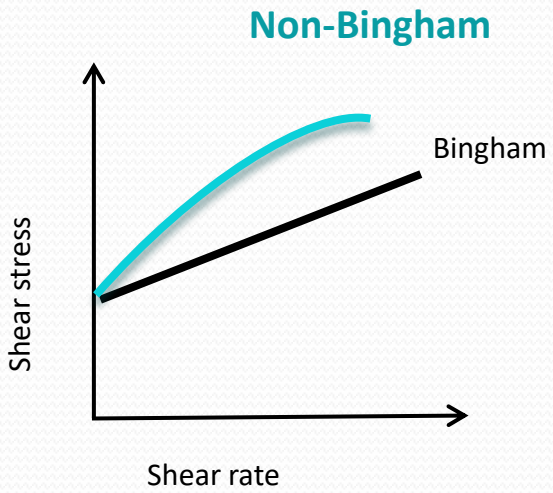
- Rheological properties of dough are particularly important for several reasons
  - Dough (preparation) is one of the main stages in bread making.
  - Dough properties are important from mechanical viewpoint.
  - Flour quality depends on measurement of physical dough properties
  - Analysis of physical properties of dough correlates baking quality.

Dough

- Dough is partially elastic
- In other words; if we deform dough and hold in in that form for some time, elastic property is lost
- Dough behaves like a Bingham body requires a yield value.

Physical Dough Testing

- Physical dough testing devices are most useful in evaluation and prediction of quality of wheat milling and bread making.
- Physical dough testing curves can be affected considerably by
  - Flour varieties and
  - By certain additives.



Dough

- Farinogram :
  - water absorption
    - amount of gluten damaged starches, particle size
  - Resistance of dough to kneading
    - gluten quality

- Load Extension Meters
  - Dough mixed and shaped under standardized conditions is stretched until rupture, curve of load vs. elongation is recorded.
    - From this curve
      - Resistance to deformation
      - Extensibility
      - Energy needed to rupture

      } are computed

- Examples:
  - Brabender extensograph
  - Research extensometer
  - The Alveograph (Chapin extensometer)

Starch Products

- Importance
  - The alterations of rheological properties during pasting
  - Hot-paste viscosity and its changes with time
  - Change in rheological properties during and after cooling of paste
- To study the complex rheological changes in starch pasting, it is essential to heat the paste under standardized conditions and record changes continuously.
- A series of instruments are developed for starch.

Brabender Amylograph

- Is a kind of torsion viscometer measure viscosity as Temp increase by 1.5 C/min.
  - Used to predict baking performance of rye flour
  - To control malt supplementation
  - To control quality of potato flakes

- Corn Industries Recording Viscometer
  - Disadvantages large amount of starch required (about 100 g)
  - Large volume of sample beaker (about 1 L)

Starch Products

- The VI Viscometer
  - Adv: Cheap and simple
  - Disadv: Paste temperature determination is difficult: so Temp. control is difficult.
  - Used in textile and paper industry
- Main observation time-temperature of initial rise in viscosity
  - Temperature and height of maximum viscosity
- All the instruments differ in performance and utility

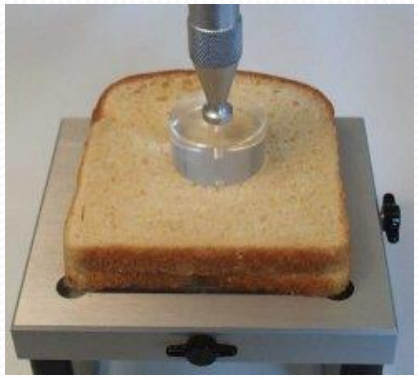
Bread

- Softness is a measure of bread freshness and quality.
- The methods based on three principles:
  - Crumb is subjected to a load for fixed time
    - Deformation is measured to find a softness index.
  - The force required to give a fixed deformation yield crumb firmness (distance constant).
  - The crumb firmness is subjected to a shearing or squeezing forces.

Other Cereals

- On the other hand, for
  - Cookies
  - Macaroni's
  - Breakfast cereals
  - Snack foods
  - Fried and baked crispies

The texture can be measured by the methods which measure the forces to break a piece of material



Dairy Products

- Measurement of viscosity of milk were tried as an index of quality
  - Avoiding lenghtly analyses
- This hope has never fulfilled, because the viscosity can not be measured accurately because of creaming.
- Cream shows a variety of rheological abnormalities
- Rheological properties of butter are important for quality of butter.

Butter

- Spreadability
- Eating texture
- Consistency

} affect consumer evaluation

- Butter should have a good spreadability with some elasticity
- Butter should be firm enough not to collapse, but no too firm to break down into pieces.
- Butter should not be oily, sticky, mealy, or sandy in taste
- Methods include
  - Penetrometer
  - Plastometers (deformation under certain loads)
  - Cutting methods
  - Organoleptic method (expert people)

Cheese

- Texture is defined as rigidity of cheese surface or resistance of the curd to compression
  - American Curd-O-Meter (combines these factors)
  - Viscometer for renneted milk (rotating viscometers)

Meat

- Tenderness is the most important factor affecting quality.
  - Affected by
    - Fibrousness
    - Ft content
    - Collagen content
- Meat tenderness correlated with
  - Shear
  - Penetration
  - Bitting
  - Mincing
- Equipments
  - Warner-Bratzler shear
  - Grinder tendometer — all measure tenderness
  - Denture tendometer

Fruits and Vegetables

- The textural characteristics are crispness and firmness
- Texture measuring devices
  - Comprise penetrometers
  - Compressimeters
  - Shearing devices
  - Cutting devices
  - Masticometers
  - Penetrometer
  - Katton Firm-O-Meter
  - Sonic techniques

Fruits and vegetables

- Fibrousness is an important indication of texture measured by fibrometer or analytical methods.
- Alcohol Insoluble Solids (AIS) determination is widely accepted method.
- Sucrose, invert sugar
  - Newtonian fluids
  - Any type of viscometer can be used
  - Correlation between viscosity & concentration of soluble solids

Potatoes and Carrots

- Texture is an important characteristic of vegetables, and it changes during thermal processing due to the breakdown of cellular material.
- Potato has a relatively uniform granular tissue structure and high starch composition,
- Carrot has a fibrous tissue structure and low starch composition.
- These structural and compositional differences can affect the textural changes of potatoes and carrots with thermal processing.
  - TPA Analysis give information about the texture of potatoes and carrots

Cooked Beef

- In order to assure qualities such as
  - texture,
  - mouthfeel,
  - tenderness,
  - juiciness,
- fat content is necessary in beef. The fat level can affect the texture of cooked beef.
  - TPA Analysis give information about the texture of cooked beef

Chocolate texture

- As well as the taste, the texture of chocolate is also very important.
- To describe the texture of chocolate "Smooth, velvety, creamy, soft, hard, crispy… " terms can be used.
- Some people prefer their chocolate at cold temperature.
- Texture of chocolate are mostly affected from crystal structure of cocoa butter. This fat component has a very precise melting point range which corresponds to about body temperature.
- This is why chocolate readily melts in your mouth but not at room temperature.

Gelatin Gel

- In the food industry, particularly the confectionery industry, gelatin is commonly used for processing gelled products.
- Gelatin is a soluble polypeptide derived from insoluble collagen, and it shows a reversible sol-gel change with temperature.
- The gelling quality of a gelatin is measured by measuring the gel strength as a function of gelatin concentration.
  - Rheological properties are determined by bloom gelometer
  - TPA